United States Department of Agriculture
NRCS Natural Resources Conservation Service

Final

Supplemental Environmental Impact Statement
East Locust Creek Watershed Revised Plan

Prepared By:
United States Department of Agriculture
Natural Resources Conservation Service

In Cooperation With:
North Central Missouri Regional Water Commission
Locust Creek Watershed District
Putnam County Commission
Sullivan County Commission
Putnam County Soil and Water Conservation District
Sullivan County Soil and Water Conservation District

Cooperating Federal Agencies:
U.S. Army Corps of Engineers
U.S. Department of Agriculture Rural Development
Federal Highway Administration

December 2020

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DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
EAST LOCUST CREEK WATERSHED REVISED PLAN
SULLIVAN COUNTY, MISSOURI

PREPARED BY:

U. S. Department of Agriculture - Natural Resources Conservation Service

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AUTHORITY:

This document was prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law (PL) 83-566, as amended (16 U.S.C. 1001-1008).

ABSTRACT:

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has prepared this draft supplemental environmental impact statement (DSEIS) for the proposed East Locust Creek Watershed Revised Plan. A final environmental impact statement (FEIS) and Record of Decision (ROD) were completed in 2006 (NRCS 2020). This DSEIS is intended to supplement and update information presented in the FEIS, including an expanded alternatives analysis that complies with the National Environmental Policy Act (NEPA) and Clean Water Act Section 404(b)(1) guidelines.

The FEIS and DSEIS identified three project purposes: to provide a public water supply source for a 10-county region of north-central Missouri; to provide water-based recreation opportunities for the same region; and to reduce flood damages along a 22.5-mile reach of East Locust Creek. Lack of a dependable, long-term water supply is a health, safety, and human welfare issue for north-central Missouri. A needs analysis determined that a project is necessary to provide a dependable, affordable water supply that meets an estimated long-term demand of 7 million gallons per day; provides approximately 61,000 user-days of water-based recreational opportunities; and reduces annual flood damages by approximately $86,800.

This DSEIS considered a wide range of alternatives for each of the three project purposes. Alternatives were screened to determine if they met the project purposes and alternatives were evaluated for impacts to the environment. Alternatives were combined as necessary to meet all three purposes. Multipurpose alternatives considered included East Locust Creek Reservoir and four other reservoir locations, as well as the No Action alternative. Four other reservoir locations were evaluated in combination with the Floodplain Acquisition alternative to meet the three project purposes.

The Preferred Alternative, determined from the analyses in the FEIS and this DSEIS, is the East Locust Creek Reservoir. This alternative creates a 2,328-acre multipurpose reservoir that would meet the project purposes of water supply and water-based recreation in the 10-county region served by the North Central Missouri Regional Water Commission (NCMRWC) and reduces flood damages along East Locust Creek. This alternative was determined in the FEIS to be the National Economic Development alternative. The No Action and Action alternatives were included in a detailed evaluation of potential impacts to social, economic, and natural resources.

COMMENTS AND INQUIRIES:

Comments and inquiries must be received by November 23, 2020. Submit comments and inquiries to: Chris Hamilton, Assistant State Conservationist (Water Resources), Missouri NRCS State Office, 601 Business Loop 70 West, Suite 250, Columbia, Missouri 65203, telephone: 573.876.9416; email: chris.hamilton@mo.usda.gov. USDA is an equal opportunity provider, employer, and lender.

Table of Contents

1.0 Introduction and Purpose and Need 1
1.1 Introduction 1
1.2 History and Background 4
1.3 Authority 7
1.4 Purpose of this Analysis 7
1.5 Project Purpose and Need for Action 8
2.0 Alternatives Analysis 48
2.1 Water Supply Alternatives Development 53
2.2 Flood Damage Reduction Alternatives Analysis 94
2.3 Water-based Recreation Alternatives Analysis 112
2.4 Multipurpose Alternative Analysis 124
3.0 Affected Environment and Predicted Environmental Consequences 143
3.1 Resources Not Evaluated in Detail 143
3.2 Climate 143
3.3 Land Use 145
3.4 Farmland Resources 147
3.5 Forest/Woodland Resources 149
3.6 Residential 150
3.7 Commercial/Industrial/Infrastructure/Utilities/Other 151
3.8 Water Resources 154
3.9 Fisheries 165
3.10 Terrestrial Vegetation 166
3.11 Wildlife 166
3.12 Threatened and Endangered Species 169
3.13 Economic and Social Resources 174
3.14 Recreation and Visual Resources 176
3.15 Public Safety and Hazardous Materials 176
3.16 Air Quality and Noise 179
3.17 Cultural Resources 180
3.18 Environmental Justice 182
4.0 Cumulative and Growth-inducing Effects 186
4.1 Cumulative Effects Boundaries 186
4.2 Past, Present, and Reasonably Foreseeable Future Projects 186
4.3 Cumulative Effects Analysis 186
4.4 Growth-inducing Effects 196
5.0 Comparison of Alternatives and Mitigation 198
5.1 Comparative Impacts of Alternatives 198
5.2 Irreversible and Irretrievable Resource Changes 198
5.3 Unavoidable Adverse Effects 198
5.4 Mitigation Measures 198
5.5 Relationship of Short-term Uses and Long-term Productivity 204
6.0 Applicable Laws and Policies 207
6.1 Federal Laws, Regulations, and Policies 207
7.0 Public Involvement 213
7.1 Agency Coordination 213
7.2 Public Involvement 217
7.3 Comments on the Notice of Intent 218

7.4 Public Review and Comments on the Draft Supplemental Environmental Impact Statement (DSEIS) 218
7.5 Intended Uses of the Draft Supplemental Environmental Impact Statement (DSEIS). 218
7.6 Document Recipients 218
7.7 Elected Officials and Representatives 218
8.0 References 221
9.0 List of Preparers 230
10.0 Distribution List 232
10.1 Federal Agencies 232
10.2 State Agencies 232
10.3 Local Units of Government 232
10.4 Local Libraries 233
10.5 Elected Officials 233

List of Tables

Table 1.5.1.1-1. Primary Water Source Water Systems in the 10-county Region. 13
Table 1.5.3-1. Calculation of Total Annual User-days for Fishing. 39
Table 1.5.3-2. Calculation of Total Annual User-days for Boating/Sailing/Canoeing/Kayaking. . 40
Table 1.5.3-3. Annual User-days Demanded by the Relevant Population. 40
Table 1.5.3-4. Lake and River Access Parking Spaces. 41
Table 1.5.3-5. Average Annual Recreation Use – U.S. Army Corps of Engineers Lakes. 43
Table 1.5.3-6. Missouri Department of Conservation Data Correction. 44
Table 1.5.3-7. Missouri Department of Conservation Data Annual Lake Use. 44
Table 2.1.3-1. Summary of Water Supply Alternatives Screening Criteria Results. 91
Table 2.2.5-1. Summary of Flood Damage Reduction Screening Criteria Results. 112
Table 2.3.2-1. Expand Existing Public Lakes – Description. 116
Table 2.3.2-2. Private Lakes within the Recreation Market Area. 121
Table 2.3.3-1. Summary of Water-based Recreation Screening Criteria Results. 123
Table 2.4.1-1. Comparison of Individual Alternatives Meeting the Screening Criteria. 127
Table 2.4.2-1. Multipurpose Alternatives Comparison. 131
Table 2.4.2-2. Multipurpose Alternatives Impacts to Streams. 132
Table 2.4.2-3. Multipurpose Alternatives Impacts to Wetlands. 134
Table 2.4.2-4. Multipurpose Alternatives Wetland Acres by Function. 135
Table 2.4.2-5. Threatened and Endangered Bat Species Habitat. 136
Table 2.4.2-6. Alternative and Life Cycle Cost. 137
Table 2.4.3-1. Ranking of Least to Most Environmental Impacts and Cost. 139
Table 3.2.1-1. 2006 – 2016 Sullivan County Climate Patterns from Kirksville Weather Station. 144
Table 3.5.1.2-1. Project Forest Impacts. 149
Table 3.12.1-1. Federal- and State-listed Species in Sullivan County. 169
Table 4.3.2.2-1. 10-county Region Ecological Sites. 187
Table 4.3.2.2-2. Sullivan County Ecological Sites. 187
Table 4.3.2.2-3. 10-county Region 2011 National Land Cover Database Land Cover. 188
Table 4.3.2.2-4. Sullivan County 2011 National Land Cover Database Land Cover. 188
Table 4.3.2.2-5. Land Cover Change in the 10-county Region. 189
Table 4.3.2.2-6. . Land Cover Change in Sullivan County. 190

Table 5.2-1. Comparative Impacts. 198
Table 7.1-1. Administrative Record. 213

List of Figures

Figure 1.1-1. East Locust Creek Watershed (Hydraulic Unit Code 10), and 10-county Region... 3
Figure 1.5.1.1-1 Nineteen Public Water Systems and the Consecutive Systems Supported. 11
Figure 1.5.1.1-2. Cost of Water Relative to Median Household Income in Missouri Counties (Missouri Rural Water Association [MRWA] 2014 and Missouri Public Utility Alliance [MPUA] 2012). 15
Figure 1.5.1.1-3. Adequacy of 10-county Region Water Systems.....21
Figure 1.5.2-1. East Locust Creek 100-year Floodplain. 31
Figure 1.5.2-2. Milan 100-year Floodplain. 32
Figure 1.5.3-1. Lakes Within Recreation Market Area. 37
Figure 1.5.3-2. Stream Access Within Recreation Market Area. 38
Figure 2.0-1. Water Transmission Lines. 51
Figure 2.1.3-1. 1950s Geologic Exploration by Missouri Geologic Survey. 58
Figure 2.1.3-2. Missouri River Alluvial Well Field. 61
Figure 2.1.3-3. Mississippi River Alluvium Water Supply Alternative. 63
Figure 2.1.3-4. Grand River Alluvium Water Supply Alternative. 65
Figure 2.1.6-1 Mark Twain Lake Pipeline. 75
Figure 2.1.7-1. Offline Reservoir Water Supply Alternative.....78
Figure 2.1.7-2 Alternative Lake Location Water Supply Alternative – Big Locust Creek Site. 81
Figure 2.1.7-3. Alternative Lake Location Water Supply Alternative – Little East Locust Creek Site. 83
Figure 2.1.7-4. Alternative Lake Location Water Supply Alternative – West Fork Locust Creek Site. 85
Figure 2.1.7-5. Alternative Lake Location Water Supply Alternative – Yellow Creek Reservoir. 87
Figure 2.1.7-6. Water Supply Alternative – East Locust Creek Reservoir. 90
Figure 2.2-1. Flood Damage Reduction Area (URS Corporation 2014). 96
Figure 2.2-2. Location of and Average Annual Damage to Bridges within Flood Damage Reduction Area. 97
Figure 2.2.3-1. Stream Conveyance Conceptual Plan. 102
Figure 2.2.3-2. Construct Levees and Raise Bridges Conceptual Plan. 104
Figure 2.2.4-1. Wetland Storage Areas Conceptual Plan. 106
Figure 2.2.4-2. Large Dry Dam Conceptual Plan – 100-year Storage. 108
Figure 2.2.4-3. Small Detention Dams Conceptual Plan. 110
Figure 2.3.2-1. Water-based Recreation – Create New Stream Access Alternative. 115
Figure 2.3.2-2. Water-based Recreation – Forest Lake (Thousand Hills) Expansion. 117
Figure 2.3.2-3. Water-based Recreation – Green City Lake Expansion. 118
Figure 2.3.2-4. Water-based Recreation – Hazel Creek Lake Expansion. 119
Figure 2.3.2-5. Water-based Recreation – Elmwood Lake Expansion. 120
Figure 3.3.3-1. National Land Cover Database Land Use in the Project Area. 146
Figure 3.4.1.2-1. Prime Farmland in the Project Area. 148
Figure 3.7.1.2-1. Proposed Utility and Road Corridors. 153
Figure 3.8.1.1-1. Typical East Locust Creek Photos.....155

Figure 3.8.1.3-1. Stream Impacts in the Project Area. 158
Figure 3.8.3.1-1 Wetland Impacts in the Project Area. 161
Figure 3.8.3.1-2. Typical East Locust Creek Wetland Photographs.....162
Figure 4.3.7-1. Potential Development Around the Project. 194
Figure 5.4.3-1. Project Utilities and Transportation Relocation. 200

Appendices

Appendix A	Costs
Appendix B	Supporting Documentation
Appendix C	North Central Missouri Regional Water Source Evaluation
Appendix D	East Locust Creek Reservoir Water Budget Model
Appendix E	BUILD Grant Road Improvements and Relocations
Appendix F	Emergency Wetland Reserve Program Replacement
Appendix G	Shoreline Protection Plan
Appendix H	Source Water Protection Plan
Appendix I	Mitigation Conceptual Planning Assumptions
Appendix J	Public Comments
Appendix K	Record of Decision

List of Acronyms

AF	Acre-Foot; Acre-Feet
BGEPA	Bald and Golden Eagle Protection Act
BMPs	Best Management Practices
BVCP	Brownfields Voluntary Cleanup Program
CA	Conservation Area
CB&Q	Chicago Burlington & Quincy Railroad
CCWWC	Clarence Cannon Wholesale Water Commission
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
COA	Conservation Opportunity Area
CPWSD	Consolidated Public Water Supply District
CWA	Clean Water Act
DNR	Department of Natural Resources
DSEIS	Draft Supplemental Environmental Impact Statement
DTL	Default Target Level
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
EWRP	Emergency Wetland Reserve Program
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FPPA	Farmland Protection Policy Act
FWRs	Floodwater Retarding Structures
gpcd	Gallons per Capita Day
gpm	Gallons per Minute
HEC-HMS	Hydrologic Engineering Center’s Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center’s River Analysis System

HHW	Household Hazardous Wastes
HUC	Hydrologic Unit Code
LEDPA	Least Environmentally Damaging Practicable Alternative
MBTA	Migratory Bird Treaty Act
MDC	Missouri Department of Conservation
MDED	Missouri Department of Economic Development
MDNR	Missouri Department of Natural Resources
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MGS	Missouri Geological Survey
MMU	Macon Municipal Utilities
MO	Missouri
MoDOT	Missouri Department of Transportation
MPUA	Missouri Public Utility Alliance
MRBCA	Missouri Risk-Based Corrective Action
MRWA	Missouri Rural Water Association
MSL	Mean Sea Level
NASA	National Aeronautics and Space Administration
NCMRWC	North Central Missouri Regional Water Commission
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
NWPM	National Watershed Program Manual
O&M	Operation and Maintenance
PCC	Project Capital Cost
PEM	Palustrine Emergent
PER	Preliminary Engineering Report
PFO	Palustrine Forest
PL	Public Law
PPWV	Project Present Worth Value
PSS	Palustrine Scrub-shrub
PUB	Palustrine Unconsolidated Bottom
PWSD	Public Water Supply District
RBTL	Risk-based Threshold Levels
RCRA	Resource Conservation and Recovery Act
RD	Rural Development
REC	Recognized Environmental Condition
RESOP	Reservoir Operation Study Computer Program
RMA	Recreation Market Area
ROD	Record of Decision
ROW	Right-of-Way
RRWA	Rathbun Regional Water Association
RUS	Rural Utilities Service
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SEIS	Supplemental Environmental Impact Statement

SWPPP	Storm Water Pollution Prevention Plan
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WNS	White-nose Syndrome

SUMMARY
(OFFICE OF MANAGEMENT AND BUDGET FACT SHEET)

Draft Supplemental Environmental Impact Statement (DSEIS)
East Locust Creek Watershed Revised Plan
Sullivan County, Missouri
Missouri Sixth Congressional District

Authority: This document was prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law (PL) 83-566, as amended (16 U.S. Code 1001, *et seq.*).

Sponsors: North Central Missouri Regional Water Commission (NCMRWC); Locust Creek Watershed District; Putnam County Soil and Water Conservation District; Putnam County Commission; Sullivan County Soil and Water Conservation District; Sullivan County Commission.

Lead Federal Agency: U.S. Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS)

Cooperating Federal Agencies: U.S. Army Corps of Engineers (USACE), U.S. Department of Agriculture Rural Development (RD), and Federal Highway Administration

Reason for Preparing a Supplement: This draft supplemental environmental impact statement (DSEIS) updates the 2006 final environmental impact statement (FEIS) to satisfy National Environmental Policy Act (NEPA) requirements and to comply with the USACE 404(b)(1) guidelines. The 2006 FEIS is available from the Missouri NRCS website (NRCS 2020).

Proposed Action: The proposed action would create a water supply that meets the project purposes and needs. Water supplied by the proposed action would be transferred by transmission pipelines to Milan, Missouri, which is the location of the existing NCMRWC water treatment plant. Recreational facilities would be created to support recreational opportunities generated by the proposed action, and flood damages would be reduced along the 22.5-mile reach of East Locust Creek between the toe of the dam and the confluence of Locust Creek. Connected actions include modifications and upgrades to the existing water treatment plant over the 100-year reservoir life to support a 7 million gallons per day (MGD) water supply, and water distribution pipelines from the water treatment plant to water systems within NCMRWC in the 10-county region.

Purpose and Need for Action: The sponsor and NRCS have identified three project purposes for the proposed action: water supply, water-based recreation, and flood damage reduction. The NCMRWC and the Missouri Department of Natural Resources (MDNR) have identified the need for an adequate, dependable, and high-quality water supply system for the rural areas and municipalities in a 10-county region of north-central Missouri. This region has been affected by droughts and water shortages several times in the recent past, including the drought of record in the 1950s. In addition, there is a need to reduce damages from flooding on 22.5 miles of East Locust Creek, where localized flooding occurs routinely and where major flooding has occurred in the area in 2010, 2013, and 2014. Furthermore, there is a need to meet the unmet demand for water-based recreational opportunities in the 10-county region.

Description of Proposed Action: The Proposed Action is to build a 2,328-acre multipurpose reservoir located northeast of Milan, Missouri, that would support water supply and water-based recreation for the 10-county region and reduce flood damage along a 22.5-mile reach of East

Locust Creek from the toe of the dam to Locust Creek. The reservoir would provide 7 MGD of water supply and approximately 92,000 annual user-days of recreation. The annual flood damage reduction benefits would total $86,800. The lake size was adjusted from 2,235 acres in the 2006 FEIS to 2,328 acres in this DSEIS. The change in estimated normal pool size is because of the use of more accurate elevation data to estimate the normal pool size and elevation. The 2006 FEIS used photogrammetry measurements and the DSEIS was based on 2009 lidar measurements. The proposed action includes an earthen dam, normal pool, raw water line, existing water treatment plant with upgrades, road and utilities relocations and improvements, BUILD-funded road improvements, utility corridors, and a water intake structure. A connected action includes water transmission lines to adjoining public water systems.

Resource Information:

Latitude and Longitude: 40.270517 degrees north latitude, -93.081655 degrees west longitude

Hydrologic Unit Code 8-digit Number and Name: 10280103 – Lower Grand

Climate and Topography: The proposed project is located in a continental climate with annual precipitation of approximately 45 inches. The topography consists of undulating hills and flat riparian corridors.

Watershed Size (10-digit Hydrologic Unit Code): 1028010306 – East Locust Creek, 79,500 acres

Current Land Cover in the Hydrologic Unit Code-10 Watershed (Homer et al. 2015):

Cropland – 6,160 acres
Grassland – 48,300 acres
Forestland – 13,900 acres
Brush, woodland – 5,020 acres
Wetland – 2,750 acres
Open water – 1,240 acres
Urban – 2,030 acres
Other – 30 acres

Land Ownership (in the 10-county North Central Missouri Regional Water Commission Region):

Private – 98 percent
Federal, state, and local government – 2 percent

Population (in the 10-county North Central Missouri Regional Water Commission Region) and Demographics: The population of the 10-county NCMRWC region is 107,130 (U.S. Census 2010). The population demographics are approximately 96 percent white, 1.5 percent Black or African American, 0.6 percent Asian, 0.2 percent American Indian or Alaska Native, 0.1 percent Native Hawaiian and other Pacific Islander, 0.4 percent some other race, and 1.2 percent two or more races.

Alternative Plans Considered: Alternatives were identified for each individual purpose and then screened to determine if the individual alternative met the individual purpose. Individual alternatives were then combined (if needed) with alternatives from the other purposes to create multipurpose alternatives that met all three purposes and needs. In addition to the No Action alternative and the Proposed Action alternative, the evaluation for purpose and need included 19 water supply

alternatives; 10 flood damage reduction alternatives; three water-based recreation alternatives; and five alternatives for the dual purposes of water supply and recreation. The screening process for each purpose and need is described in the following sections.

Water Supply Purpose

The water supply alternatives were developed after defining the water supply project purpose, which is:

> Provide a dependable, affordable, long-term water supply to meet the water demand for the 10-county region of north-central Missouri including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties.

An additional drinking water source in north-central Missouri is needed to meet the existing and future needs of water suppliers and water users in the region and to provide resiliency against uncertainty in future water demands and climate change.

Alternatives evaluated to meet the water supply purpose included groundwater sources, connections to existing systems, streams and rivers, existing lakes, the creation of a new reservoir, or a combination of these alternatives. A No Action alternative was also evaluated. All the alternatives were screened for their ability to meet the water supply purpose and need by using the following criteria:

- Reliably provide at least 7 MGD average daily demand during a drought equivalent to the drought of record
- Provide a feasibly attainable water supply
- Provide a water supply through the willing participation of stakeholders
- Meet current MDNR Minimum Design Standards for Missouri Community Water Systems

Flood Damage Reduction Purpose

The flood damage reduction alternatives were developed after determining the flood damage reduction project purpose, which is:

> Reduce flooding damages by at least 50 percent on 22.5 miles of East Locust Creek above the confluence with Locust Creek.

Alternatives were developed to address the flood damage reduction purpose. Alternatives evaluated included Zoning, Floodplain Acquisition, Conservation Measures, Wetland Storage Areas, Conveyance, Levees and Raising Bridges, Small Detention Dams, and a combination of alternatives. These alternatives were screened by the following criteria:

- Provide at least 50 percent flood damage reduction
- Comply with existing state and federal codes and regulations
- Decrease or maintain current peak flows.

Recreation Purpose

The recreation alternatives were developed after determining the recreation project purpose, which is:

> Provide water-based recreation to meet the unmet demand for the 10-county recreation management area including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties.

Alternatives that were considered to meet recreation needs include creating new stream access, expanding existing public lakes, expanding and improving existing private lake access, and developing an alternative reservoir location. These alternatives were screened by comparing reasonable efforts necessary to implement the alternative while still meeting the purpose and need. Alternatives were screened by the following criteria:

- Allow for fishing and boating/sailing/canoeing/kayaking
- Provide a full range of water-based recreational activities
- Meet or exceed 5 percent (61,000 annual user-days) of the presently unmet annual user-day demand for adequate water-based recreational opportunities
- Be available for public use and have public access, including reasonable parking and walking lanes for access to water-based recreation

Multipurpose Alternatives Considered: Following screening of alternatives that meet the three individual project purposes (water supply, water-based recreation, and flood damage reduction), the alternatives that passed the screening criteria were combined (if necessary) to meet the three purposes for the project. The new alternatives are identified as multipurpose alternatives because they meet all of the three project purposes. The multipurpose alternatives identified and evaluated include the following:

- No Action (Carried forward)
- Proposed Action – East Locust Creek Reservoir (Carried forward)
- Little East Locust Creek Reservoir and Floodplain Acquisition (Eliminated)
- Big Locust Creek Reservoir and Floodplain Acquisition (Eliminated)
- West Fork Locust Creek Reservoir and Floodplain Acquisition (Eliminated)
- Yellow Creek Reservoir and Floodplain Acquisition (Eliminated)

Proposed Action Costs: The Proposed Action 75-year life cycle costs are detailed in Appendix A and are based on a range of assumptions that are used in the alternatives analysis. The funding sources are projected to include:

- 46 percent – USDA – NRCS
- 31 percent – USDA – RD
- 15 percent – Local
- 7 percent – State
- 1 percent – Miscellaneous

The costs breakdown is projected to include:

Construction:	$40,800,000
Engineering:	$6,400,000
Relocation:	$5,300,000
Real Property Rights:	$19,500,000
Operation and Maintenance (nonfederal):	$4,000,000
Mitigation:	$7,300,000
Other:	$19,600,000
TOTAL COSTS:	**$102,900,000**

Water supply, flood damage reduction, and recreational economic benefits were estimated in accordance with the Water Resources Planning Act of 1965 (Public Law [PL] 89-80), as amended (42 U.S. Code 1962a-2 and d-1), the Watershed Protection and Flood Prevention Act (PL 83-566), as amended (16 U.S. Code 1001-1008), and NRCS policy found in the National Watershed Program Manual (NWPM) (Title 390, Parts 500-506) and the National Resource Economics Handbook, Water Resources Handbook for Economics (Title 200, Part 611). PL 89-80 requires specific methods for calculating benefits and costs that are developed by the U.S Water Resources Council and published in Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. PL 83-566 requires that agriculture and rural communities must account for at least 20 percent of the total benefits of the project. Water Resources Council and NRCS policy requires procedures be used to identify alternative project National Economic Development benefits and National Economic Development costs, using viable alternative solutions consistent with local, regional, and national objectives.

Comparison of Benefits and Costs 2006 FEIS Discount Rate (5.125%)						
Proposed Action	Average Annual Benefits				Average Annual Cost	Benefit/ Cost Ratio
	Water Supply Benefits	Flood Damage Reduction Benefits	Recreation Benefits	Total Benefits		
East Locust Creek Reservoir (MA1)	**$3,514,800**	**$83,100**	**$2,652,900**	**$6,250,800**	**$5,721,100**	**1.09**

Comparison of Benefits and Costs FY 2020 Water Resources Discount Rate (2.75%)						
Proposed Action	Average Annual Benefits				Average Annual Cost	Benefit/ Cost Ratio
	Water Supply Benefits	Flood Damage Reduction Benefits	Recreation Benefits	Total Benefits		
East Locust Creek Reservoir (MA1)	**$2,114,900**	**$83,100**	**$2,652,900**	**$4,850,900**	**$3,442,400**	**1.41**

Proposed Action Benefits: Proposed Action benefits include improved quality of life resulting from installation of an affordable, adequate, and dependable water supply system, reduced flood damages, and increased recreational opportunities.

Water Supply Benefits. The NCMRWC and MDNR have determined that an adequate and dependable water supply is not available to the citizens of north-central Missouri. If the 1950s drought of record occurred today, the water supply could not meet even current demand, much less projected future demand. This inadequacy contributes to the high cost of water as a percent of income in the area, compared to elsewhere in the state of Missouri. Providing affordable, dependable water is a human health, safety, and quality of life issue. The Proposed Action would provide a regional water supply that could reduce costs and provide a dependable water supply during the drought of record. Many water suppliers in the region have closed or face challenges meeting drinking water standards. A regional water system that provides an adequate and dependable water supply would lower costs through economies of scale, meet the current water demand during the drought of record, provide resilience to climate change, promote business

development, and allow for population growth. Though not a project purpose, the Proposed Action may support agricultural water demands.

Water-based Recreation Benefits. The Proposed Action would provide water-based recreational opportunities to help meet the unmet demand in the 10-county region. The Proposed Action will provide all types of boating opportunities, as well as fishing and wildlife recreational opportunities. It also will provide habitat for aquatic and terrestrial species associated with reservoirs. The reservoir will feature a wide range of habitats including open water, shallow mud flats, flooded timber, and lacustrine riparian areas. Warm water fish species such as largemouth bass, walleye, crappie, catfish, and bluegill could be stocked in coordination with the Missouri Department of Conservation (MDC) and would provide fishing opportunities. Avian species including bald eagles, migratory waterfowl, and shorebirds could benefit from the increased variety of aquatic habitats and would provide birding and wildlife viewing opportunities. Increased recreational opportunities can also provide economic benefits by diversifying the local economy to provide visitor services.

Flood Damage Benefits. Flood damages have been documented frequently along a 22.5-mile reach of East Locust Creek above the confluence with Locust Creek. Flooding along this reach has affected the City of Milan, agricultural operations, and infrastructure along this reach. The Proposed Action would reduce flood damages to the municipalities and landowners affected by East Locust Creek flooding, and it would reduce risks to life and property as a result.

Environmental Impacts

This DSEIS evaluates potential impacts from the Proposed Action.

Farmland

Under the Farmland Protection Policy Act (FPPA), federal agencies must identify and consider the adverse effects of federal programs on the preservation of prime or unique farmland. Whenever a federal agency's time or money is used in the direct or indirect conversion of farmland to nonagricultural uses, the agency must report the conversion to USDA on Form AD-1006. Approximately 270 acres of cropland and approximately 1,080 acres of hay and pastureland in the 2,328-acre normal pool would be inundated by the Proposed Action. This totals 1,350 acres, compared with 54,500 acres of total farmland within the East Locust Creek watershed, representing approximately 2.5 percent of the total farmland within the watershed. Approximately 50 acres of prime farmland and 440 acres of farmland of statewide importance would be converted to non-farmland use under the Proposed Action. The East Locust Creek watershed contains 1,170 acres of prime farmland and 10,000 acres of farmland of statewide importance. NRCS is responsible for reporting this conversion on FORM AD-1006.

Forest

The East Locust Creek watershed has approximately 18,900 acres of forest, brush, and woodland habitat. Forestland within the watershed is highly fragmented, consisting mainly of riparian corridors and upland drainageways, with larger blocks of forest greater than 20 acres in size scattered throughout the area. Based on aerial photograph interpretation, the Proposed Action would affect approximately 1,410 acres of forest habitat, which is 7 percent of the forest habitat within the watershed.

Wetlands

Based on the National Wetlands Inventory (NWI) data (USFWS 2020), there are 1,981 acres of wetlands including 635 acres of emergent (herbaceous) wetlands and 1,346 acres of forested wetlands in the 79,500-acre East Locust Creek (HUC-10) watershed. NWI wetlands within the proposed normal pool included 216 acres (11 percent) of wetlands – including 110 acres (17 percent) of emergent wetland and 106 acres (8 percent) of forested wetland.

Wetland delineations within the normal pool were completed in 2015 and 2016 and identified 362 acres, including 273 acres of emergent wetlands, 79 acres of forested wetlands, and 10 acres of scrub-shrub wetlands. Wetland delineations are not available for the East Locust Creek HUC-10 watershed for comparison. Wetlands that are currently or were previously farmed or that are comprised of over 50 percent reed canarygrass (*Phalaris arundinacea*) total 225 acres or 62 percent of the wetland acres in the normal pool. An additional 28 acres of unconsolidated bottom waters (ponds) were also identified. Unavoidable impacts to wetlands resulting from the Proposed Action will be mitigated in accordance with USACE compensatory mitigation requirements.

Streams

The normal pool of the reservoir associated with the construction of the Proposed Action would permanently inundate approximately seven miles of the main stem of East Locust Creek. Based on MDNR stream classification data, there are 200.1 miles of stream (typically excludes ephemeral streams) in the East Locust Creek watershed (CSR 2014). Streams and tributaries within the normal pool were delineated in 2015 and 2016. Approximately 49.1 miles of stream channel including approximately 12.6 miles of intermittent stream, 8.9 miles of perennial stream, and 27.6 miles of ephemeral stream were delineated. A preliminary jurisdictional determination has been provided for the normal pool by the USACE. Stream impacts would result from utilities relocations and road relocations and improvements. A total of 0.2 mile of temporary and permanent road and utility impacts were identified by National Hydrography Dataset (NHD) data.

A portion of East Locust Creek is considered by the State of Missouri to be impaired. East Locust Creek from Pollock to south of Milan is included on the draft of Missouri's 2018 303(d) List of Impaired Waters for low dissolved oxygen and the presence of *E. coli* bacteria.

Changes in flow regime and water temperature below the reservoir may adversely affect aquatic species that are sensitive to these characteristics. Releases from the proposed reservoir will be managed to mimic natural flow conditions to the extent possible. No threatened or endangered aquatic species have been identified for Sullivan County.

Terrestrial Vegetation

Terrestrial vegetation provides habitat for many wildlife species. The most common land cover types that would be affected by the Proposed Action are cultivated cropland, grassland, and deciduous forest. The herbaceous land cover primarily consists of introduced cool-season grass pasture with a substantially lesser acreage of native warm-season grass pasture. The deciduous forest consists of a variety of species including oaks, hickory, and cottonwood.

Wildlife

Typical wildlife for the areas affected by the normal pool includes white-tailed deer, coyote, raccoon, opossum, striped skunk, squirrels, snakes, turtles, and frogs. Forested areas, trees, and brush thickets associated with the riparian corridor may provide nesting habitat for nesting

migratory bird and eagle species. The deciduous forest may provide nesting, foraging, and cover habitat for many species of birds, raptors, bats, deer, coyote, and small mammals. Vegetation removal for construction of the Proposed Action would decrease the amount of upland habitat available in the project area. Mobile species, such as most birds and larger mammals, would be expected to move out of the project area once construction activities commence.

Threatened and Endangered Species

Mead's milkweed (*Asclepias meadii*), Indiana bat (*Myotis sodalis*), and northern long-eared bat (*Myotis septentrionalis*) are the federally listed species for Sullivan County. The plains spotted skunk (*Spilogale putorius interrupta*) is a state-listed species in Sullivan County. Mead's milkweed surveys for the area of the normal pool were conducted through field verification. The field verification did not identify any occurrence of the species. Several surveys were conducted to determine the presence of Indiana bat and northern long-eared bat within the project area. Survey methodology included acoustic monitoring, mist netting, radio tracking, emergence counts, and bat habitat assessments. These studies concluded that Indiana bats and northern long-eared bats are present within the proposed normal pool, as is Indiana bat foraging and maternity roost tree habitat.

A biological assessment (BA) related to federally listed species has been developed and has been submitted to the U. S. Fish and Wildlife Service (USFWS) and can be found on the NCMRWC website (NCMRWC 2016). Coordination and consultation with USFWS on potential impacts to the bat species have been ongoing and has resulted in a draft Biological Opinion (BO) from USFWS. According to MDC records, no recorded sightings of the plains spotted skunk have occurred within 10 miles of the Proposed Action. MDC coordination has been completed and best management practices were received. No surveys have been recommended.

Major Conclusions: The Proposed Action would address the problems of an inadequate, undependable water supply and unmet demand for recreational opportunities in the 10-county region of north-central Missouri and floodwater damages downstream of the toe of the dam. The water supply and recreational benefits will serve over 100,000 citizens in the 10-county region. Unavoidable environmental impacts have been identified related to dam construction and the inundation of 2,328 acres. Following avoidance and minimization, the adverse impacts to wetlands, streams, and forest habitat resulting from the Proposed Action will be mitigated in accordance with an approved mitigation plan. As identified in the 2006 FEIS, the Proposed Action is the National Economic Development alternative.

Areas of Controversy: No significant unresolved issues or controversies have been identified.

State and Local Project Support: MDNR has expressed support for the Proposed Action. In 2016, MDNR Director Sara Parker Pauley provided a letter of support to the NCMRWC. The letter stated that MDNR expresses, "support of the full design capacity of East Locust Creek Reservoir." Director Pauley also stated, "the Department agrees that the current design yield of 7 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir" (Appendix B). In 2017, the newly appointed MDNR Director Carol Comer, also provided a letter of support. Director Comer's letter stated, "... the Department agrees that the current design yield of 7 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir" (Appendix B).

Local citizens supported the project by passing a tax to provide funding for the local share of project costs. In 2010, the citizens of Sullivan County passed a half-cent sales tax increase to provide funding for the Proposed Action. Additionally, the following water systems, individuals, and entities provided letters of support (Appendix B) to the NCMRWC.

- City of Brookfield (Associate Member)
- City of Chillicothe (Associate Member)
- City of Kirksville (Associate Member)
- City of Lancaster (Associate Member)
- City of Marceline (Associate Member)
- City of Milan (NCMRWC Member)
- City of Princeton (Associate Member)
- City of Trenton (Associate Member)
- Consolidated Public Water Supply District (CPWSD) Number 1 – Linn County (Associate Member)
- CPWSD Number 1 – Schuyler County (Associate Member)
- Macon Municipal Utilities (MMU; Associate Member)
- Public Water Supply District (PWSD) Number 1 – Adair County (Associate Member)
- PWSD Number 1 – Macon County (Associate Member)
- PWSD Number 1 – Mercer County (Associate Member)
- PWSD Number 1 – Putnam County (Associate Member)
- PWSD Number 2 – Chariton County (Associate Member)
- PWSD Number 3 – Linn-Livingston Counties (Associate Member)
- PWSD Number 3 – Chariton and Linn Counties (Associate Member)
- Sullivan County Farm Bureau
- Sullivan County Commission
- Caldwell County Commission
- U.S. Senator Roy Blunt
- U.S. Senator Claire McCaskill
- Under Secretary for Natural Resources and Environment, Robert Bonnie, USDA
- University of Missouri
    - Water Resources Research Center
    - Missouri Climate Center

East Locust Creek Reservoir Administrative Record

The table below is a summary of the Administrative Record of federal and state agency and jurisdictional approvals, notices, and actions to date.

Date	Record Type	What
1987	Report Published	Original East Locust Creek Watershed Plan-Environmental Assessment. (Included 49 additional small floodwater retarding structures but no multipurpose reservoir.)
1995	Report Published	Rhodes Engineering Company Inc. – Preliminary Engineering Report for North Central Missouri Regional Water Supply.
08-01-2003	Report Published	Burns & McDonnell Water System Feasibility Study – evaluated groundwater, four streams, four existing suppliers, and five reservoir locations. Recommended East Locust Creek Reservoir.
11-01-2003	Report Published	Burns & McDonnell Water System Master Plan – conceptual design of reservoir and review of environmental impacts.
05-20-2004	Report Published	Water Use Study of North Central Missouri Regional Water Commission – Report from Department of Natural Resources (DNR), resulted in increased firm yield requirement from 4.5 to 8.5 MGD.
09-22-2006	Regulatory Decision	Environmental Protection Agency (EPA) publishes a statement in the Federal Register (Volume 71, Issue 184) stating, "EPA's previous concerns have been resolved; therefore, EPA does not object to the proposed action." This is regarding the original Environmental Impact Statement (EIS) and the East Locust Creek Watershed Plan.
09-27-2006	Regulatory Decision	Notice of Intent (NOI) of the Record of Decision to proceed with the installation of the East Locust Creek Watershed Revised Plan was published. This revised plan provided for a firm yield of 7.0 million gallons of raw water per day.
01-01-2007	Report Published	East Locust Creek Watershed Revised Plan and EIS completed (NRCS 2006) – Reviewed the 2003 Water System Feasibility Study, concurring with its evaluation of 22 alternatives and its further consideration of eight of the alternatives and resulting recommendation for East Locust Creek Reservoir. Then, refined the alternatives analysis with a detailed analysis of four alternatives revolving around the proposed East Locust Creek Reservoir and small floodwater retarding structures.
05-19-2010	Meeting (Permitting)	Project team met with U.S. Army Corps of Engineers (USACE) district regulatory staff including Mark Frazier and state regulatory staff.
10-01-2010	Meeting (Permitting)	Allstate consultants and Brad Scott met informally with Jim Ptacek and Ward Lenz to discuss project status. Stream impact factor was first identified as a big issue at this meeting.
10-14-2010	Meeting (Permitting)	Allstate consultants met with USACE state regulatory staff in Jefferson City, Missouri, to discuss preliminary mitigation numbers.
11-18-2010	Meeting (Permitting)	The Project team met with EPA for a general project update and discussion.
11-18-2010	Meeting (Permitting)	Project team met with USACE Kansas City district in Kansas City, Missouri.
12-22-2010	Regulatory Decision	USACE notified the reservoir team that the Missouri Stream Mitigation Method linear impact factor can be based on the stream segment length instead of on the cumulative total of all affected lengths
03-21-2011	Meeting (Permitting)	Project team, Natural Resources Conservation Service (NRCS), and USACE met with Colonel Hoffman and left a list of 10 requests.
08-04-2011	Regulatory Decision	Email from Mark Frazier that contained responses to questions.
01-26-2012	Meeting (Permitting)	Project team, DNR, and USACE met in Jefferson City, Missouri, to introduce the project to Shelly Carter. Included in the discussion was the need for separate alternatives analysis for each purpose.
10-25-2013	Regulatory Decision	East Locust Creek Reservoir Preliminary Engineering Report approval letter from DNR.

Date	Record Type	What
03-07-2014	Meeting (Permitting)	East Locust Creek Reservoir and Little Otter Creek Reservoir teams, NRCS, Green Hills Regional Planning Commission, and DNR met with Colonel Sexton and Mark Frazier in Trenton, Missouri.
11-13-2014	Regulatory Decision	USACE signed letter agreeing to be a cooperating agency.
12-08-2014	Regulatory Decision	NOI to start the Draft Supplemental Environmental Impact Statement (DSEIS) process published in the Federal Register.
12-29-2014	Report Draft Submitted to Regulators	NRCS submitted first draft jurisdictional determination document on a 167-acre subarea.
02-04-2015	Report Draft Submitted to Regulators	Draft purpose and need section submitted to regulatory agencies (USACE, EPA, U.S. Fish and Wildlife Service [USFWS], DNR, etc.).
02-25-2015	Comments Received	USACE commented on purpose and need.
02-25-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting held with regulatory agencies.
03-31-2015	Meeting (Permitting)	Jurisdictional determination guidance meeting held with USACE and EPA
05-20-2015	Meeting (Permitting)	East Locust Creek Reservoir Draft SEIS (DSEIS) meeting held with agencies (MDNR, USFWS, EPA, USACE, and NRCS)
5-26 – 5-27-2015	Meeting (Permitting)	Project team and regulatory agencies (EPA, USACE) field check one region to refine jurisdictional determination process.
07-22-2015	Report Draft Submitted to Regulators	Revised purpose and need section, screening criteria section, and list of alternatives for consideration submitted to regulatory agencies.
08-06-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting with regulatory agencies scheduled, but then cancelled to allow more time for review.
08-14-2015	Regulatory Decision	Letter from U.S. Department of Agriculture (USDA) waived $341,000 payment in original NRCS contract for inundated PL-566 structures.
09-10-2015	Comments Received	Comments from USACE on DSEIS received.
09-15-2015	Regulatory Decision	Mark Frazier sent letter to Harold Deckerd regarding the coordination of reviews of DSEIS.
09-22-2015	Report Draft Submitted to Regulators	Project team submitted proposed DSEIS review plan to regulatory agencies.
09-25-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting held with regulatory agencies to discuss coordination.
09-25-2015	Comments Received	Received comments on the purpose and need from USACE. Comments questioned population projections.
10-08-2015	Comments Received	Received comments on the purpose and need from EPA. Comments questioned future demand projections.
10-13-2015	Comments Received	Comments received from EPA on purpose and need section of DSEIS.
01-07-2016	Report Draft Submitted to Regulators	Revised purpose and need section provided to regulatory agencies.
01-26-2016	Comments Received	Received comments on the purpose and need from USACE. Included objection to including “7 MGD” in the purpose.
02-08-2016	Regulatory Decision	Letter from Director of DNR, Sara Parker Pauley, to Brad Scott affirming the state’s support of the need for 7 MGD. (Copied to Colonel Sexton.)
02-26-2016	Comments Received	Received comments on the purpose and need from EPA. EPA requested we remove a specific quantity of water supply from the purpose statement.
02-29-2016	Meeting (Regulatory)	Aaron Ball and Jim Ptacek discussion.
03-24-2016	Meeting (Permitting)	Project team and agencies hold conference call to discuss USACE and EPA comments.

Date	Record Type	What
09-16-2016	Meeting (Permitting)	Project teams for East Locust Creek and Little Otter Creek reservoirs and various agencies met with Colonel Guttormsen.
09-19-2016	Meeting (Permitting)	Met with the U.S. Fish and Wildlife Service.
12-02-2016	Report Draft Submitted to Regulators	Revised purpose and need section provided to regulatory agencies.
01-09-2017	Comments Received	Received comments on the purpose and need from USACE. Comments revolve around declining population and potential alternatives for water supply.
01-18-2017	Comments Received	Received comments on the purpose and need from the EPA.
01-23-2017	Regulatory Decision	Preliminary Engineering Report approval extension granted by MDNR.
02-08-2017	Meeting (Permitting)	Teleconference to discuss agency comments with agencies (USACE, EPA, USFWS, NRCS, and MDNR). Project team informed to take the comments under advisement and move forward.
03-10-2017	Response to Regulatory Comments	North Central Missouri Regional Water Commission (NCMRWC) submitted responses to USACE and EPA comments to the NRCS. I have the letter on Commission letterhead, but not a confirmation of sending.
06-05-2017	Meeting (Permitting)	NRCS met with Colonel Guttormsen to discuss schedule for East Locust Creek Reservoir and Little Otter Creek projects. Agreed to consider revised schedule and submittal of East Locust Creek Reservoir DSEIS in its entirety instead of a piece at a time.
07-26-2017	Regulatory Decision	DNR Director Carol Comer sent letter of support affirming the need to design the reservoir for 7 MGD.
10-06-2017	Meeting (Permitting)	Project team met with USFWS to discuss fence clearing.
10-24-2017	Meeting (Permitting)	Project team met with USFWS and NRCS to discuss existing Indiana bat maternity roosts on Cunningham property.
01-18-2018	Comments Received	Comments received on DSEIS from NRCS.
04-11-2018	Meeting (Permitting)	Project team met with MDNR to discuss source water protection and mitigation.
04-16-2018	Regulatory Decision	USDA provided draft Letter of Conditions establishing conditions for gap funding of local share of costs.
07-31-2018	Comments Received	NRCS National Water Management Center provided comments to the project team on the East Locust Creek Reservoir DSEIS
08-23-2018	Regulatory Decision	DNR approved PER for East Locust Creek Reservoir.
10-04-2018	Report Draft Submitted to Regulators	Biological assessment submitted to USFWS.
11-14-2018	Report Draft Submitted to Regulators	DSEIS to submitted to agencies.
11-26-2018	Regulatory Decision	Letter of approval of multipurpose water resources fund plan.
11-27-2018	Regulatory Decision	USDA RD – Draft Letter of Conditions – updated
11-27-2018	Regulatory Decision	Missouri Department of Natural Resources (MDNR) approves of Source Water Protection Plan
01-28-2019	Report Draft Submitted to Regulators	DSEIS submitted to NRCS – added Rathbun letter
01-31-2019	Regulatory Decision	USFWS approved clearing for fences.
02-04-2019	Report Draft Submitted to Regulators	DSEIS submitted to agencies
03-01-2019	Comments Received	Received DSEIS comments from USACE.

Date	Record Type	What
04-16-2019	Comments Received	Received DSEIS comments from USFWS.
07-11-2019	Comments Received	Received additional comments on the draft biological assessment from USFWS.
10-11-2019	Regulatory Decision	NCMRWC approved resolution affirming commitment to meeting USFWS obligations.
10-23-2019	Report Draft Submitted to Regulators	Biological assessment submitted to USFWS.
12-04-2019	Comments Received	USFWS commented on biological assessment.
02-14-2020	Report Draft Submitted to Regulators	Biological assessment submitted to NRCS for distribution to USFWS.
02-28-2020	Report Draft Submitted to Regulators	Biological assessment and request for formal consultation sent to USFWS.
03-27-2020	Comments Received	Received comments from USFWS on the biological assessment indicating that USFWS needed a few more things before we can enter consultation.
04-07-2020	Meeting (Permitting)	Project team met with NRCS and USFWS to discuss biological assessment and consultation.
04-09-2020	Regulatory Decision	Federal Highway Administration (FHWA) became a cooperating federal agency for the DSEIS.
05-01-2020	Report Draft Submitted to Regulators	Biological assessment submitted to NRCS for distribution and USFWS for information.
05-12-2020	Report Draft Submitted to Regulators	DSEIS from NRCS to FHWA, Missouri Department of Transportation (MoDOT), USFWS, USACE, USDA-RD, and EPA
05-20-2020	Report Draft Submitted to Regulators	Missing appendices from 2020-05-12 DSEIS sent to agencies.
05-27-2020	Comments Received	EPA comments received on DSEIS.
05-28-2020	Meeting (Permitting)	Met with NRCS and USACE to discuss DSEIS, mitigation, and construction access.
6-10-2020	Comments Received	Received USFWS comments on the biological assessment.
6-11-2020	Comments Received	Comments received from USACE.
6-16-2020	Meeting (Permitting)	Project team met with USACE to discuss DSEIS and alternatives analysis.
6-16-2020	Meeting (Permitting)	Project team met with USACE to discuss mitigation.
8-07-2020	Meeting (Permitting)	Project team met with with Colonel Hannan (USACE), NRCS, and Senator Roy Blunt's staff to provide Colonel Hannan an overview of the project and discuss permitting.
8-13-2020	Report Published	Final biological assessment sent to NRCS, USDA-RD, and USFWS.
8-19-2020	Report Draft Submitted to Regulators	DSEIS submitted to USACE.
08-19-2020	Report Draft Submitted to Regulators	Updated DSEIS submitted to USACE.
08-21-2020	Meeting (Permitting)	Project team met with NRCS and USACE to discuss permitting and construction access.
08-27-2020	Meeting (Permitting)	Project team met with NRCS and USACE Planning and Regulatory Division to discuss Garden of Eden mitigation project modelling.
09-07-2020	Meeting (Permitting)	Project team met with MDNR and NRCS to give an update on the mitigation plan and 401 certification.

Date	Record Type	What
10-23-2020	Notice of Availability	Notice of availability published on the federal register.
10-23-2020	Final Biological Opinion	Final biological opinion received from USFWS.
10-01-2020	Meeting (SEIS)	Project team met with EPA to discuss their comments on the SEIS.
11-02-2020	Comments Received	Comments received from USDA RD.
11-10-2020	Public Hearing	NRCS, USACE, NCMRWC, Olsson, and Allstate held a public hearing to address questions and receiving comments on the SEIS and 404 permit application.
11-12-2020	Meeting (SEIS)	Project team met with NRCS and USDA RD to discuss their comments on the SEIS.
11-30-2020	Comments Received	Comments received from EPA.
12-02-2020	Meeting (SEIS)	Project team met with NRCS and EPA to discuss their comments on the SEIS.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

1.0 Introduction and Purpose and Need

1.1 Introduction

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has prepared this draft supplemental environmental impact statement (DSEIS) for the proposed East Locust Creek Reservoir (Proposed Action). This DSEIS updates information and analyses contained in the final environmental impact statement (FEIS) for the East Locust Creek Watershed Revised Plan, which was announced in the Federal Register August 11, 2006. A Record of Decision (ROD) was signed September 14, 2006. The NRCS is the lead federal agency and the U.S. Army Corps of Engineers (USACE), Federal Highway Administration (FHWA), and USDA Rural Development (RD) are cooperating federal agencies. The North Central Missouri Regional Water Commission (NCMRWC) is the local project sponsor.

The 79,500-acre East Locust Creek Watershed (Hydrologic Unit Code [HUC] 1028010306) is located in north-central Missouri approximately 30 miles west of Kirksville in Sullivan County (Figure 1.1-1) with small portions of the watershed in neighboring Putnam and Linn counties. East Locust Creek is a tributary to Locust Creek which drains to the Grand River and then to the Missouri River. Several communities are located within the watershed boundary; the largest is the City of Milan, population 1,960 (U.S. Census 2010). Milan is located in the middle of the East Locust Creek watershed. The eastern edge of the incorporated area of Milan is in the floodplain of East Locust Creek; the western part of town extends beyond the western boundary of the watershed.

The recommended plan of the 2006 FEIS identified the Proposed Action, a 2,328-acre multipurpose reservoir located on the main stem of East Locust Creek approximately 4 miles north of Milan. The 2006 FEIS described the reservoir as providing 7 million gallons per day (MGD) of rural water supply, developing water-based recreational facilities, and reducing flood damages.

The Proposed Action will require the discharge of fill material into jurisdictional waters of the U.S., necessitating a permit from the USACE under Section 404 of the Clean Water Act (CWA). The USACE requested that a supplemental environmental impact statement (SEIS) be prepared to evaluate potential alternatives to the Proposed Action in addition to the ones considered in the 2006 FEIS. It is the intent of this SEIS to help the USACE render its permit decision, thus the CWA Section 404(b)(1) alternative analysis requirements are also included as part of the alternative development in this DSEIS.

This DSEIS provides an objective and thorough assessment of reasonable alternatives that meet the project purpose and need and their potential impacts to social, economic, and natural environmental resources. As required by the Section 404(b)(1) analysis for the least environmentally damaging practicable alternative (LEDPA), the supplemental information in this document focuses on complying with the CWA, updating the list of environmental resources, and considering the public interest. The analysis will consider whether alternatives are reasonable and practicable. The Council on Environmental Quality (CEQ) defines reasonable alternatives as alternatives that substantially meet the agencies purpose and need (CEQ 2007); practicable alternatives are “available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes” (EPA 2019). The goal of the analysis

is to identify a reasonable and practicable alternative that meets the project purposes and needs as established in the 2006 FEIS while minimizing impacts to resources.

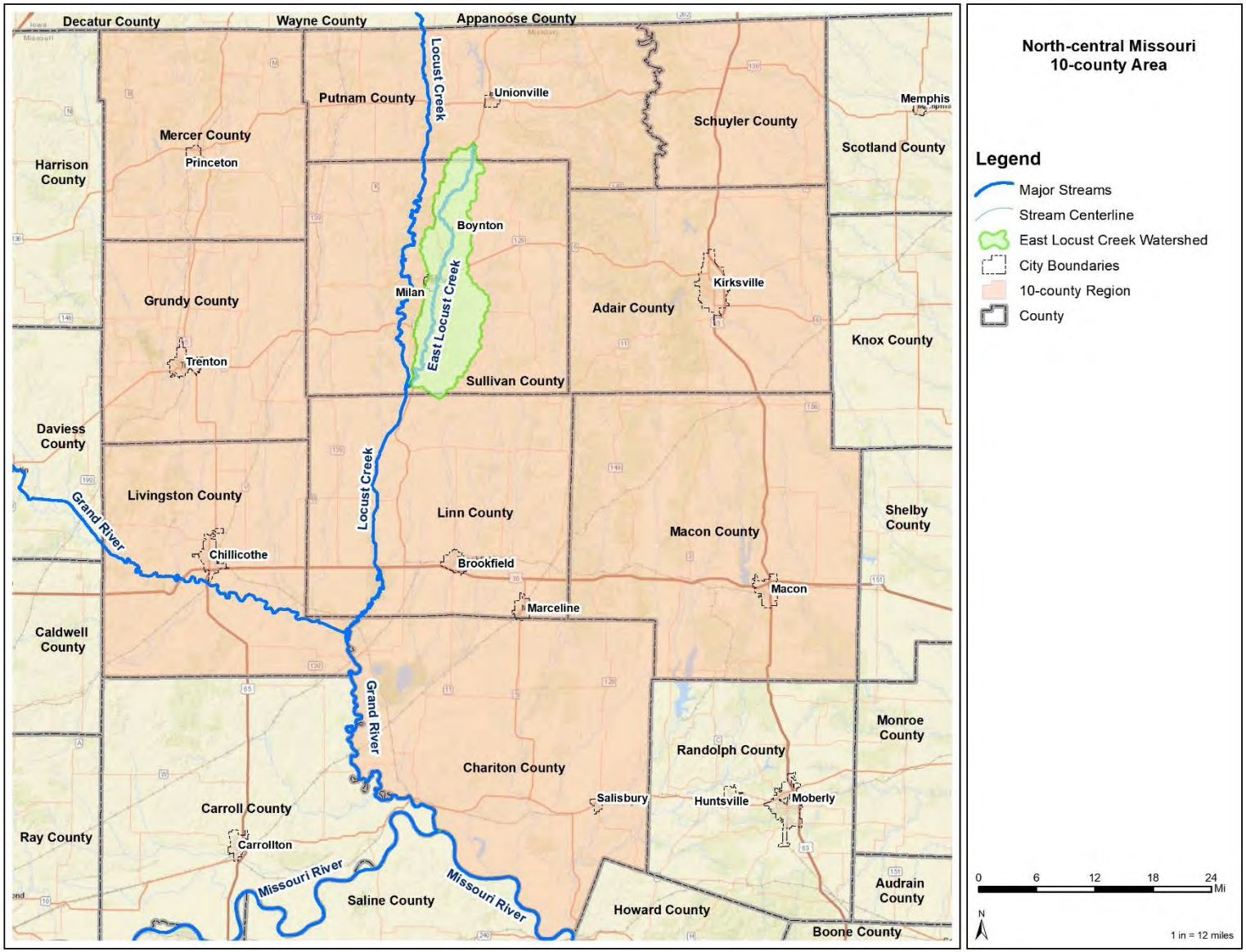


Figure 1.1-1. East Locust Creek Watershed (Hydraulic Unit Code 10), and 10-county Region.

1.2 History and Background

Early Planning

The Sullivan and Putnam counties commissions and the Sullivan and Putnam counties soil and water conservation districts initially applied for federal watershed planning assistance in the East Locust Creek Watershed in 1974. Missouri Governor Christopher Bond approved their application that same year. The U.S. Soil Conservation Service (later renamed and hereafter referred to as NRCS) collected pre-authorization planning data and analyzed the East Locust Creek Watershed as part of the larger 1982 *Northern Missouri River Tributaries Study*.

In March 1984, NRCS began planning activities for the East Locust Creek Watershed under the authority of the Watershed Protection and Flood Prevention Act of 1954, Public Law (PL) 83-566, as amended (USC 2012). NRCS completed the East Locust Creek Watershed Plan-environmental assessment (EA) in 1986. The plan recommended one large and 120 small floodwater retarding structures to reduce soil erosion and flood damages. A finding of no significant impact was published in the Federal Register July 17, 1986. Local sponsors signed the Watershed Agreement in November 1986 and assistance for installation was authorized August 1987.

Federal funding was provided under the PL 83-566 program by the NRCS to reduce flooding damages. Of the 121 small floodwater detention dams planned, 72 were constructed. The structures in East Locust Creek watershed decreased estimated annual crop and pasture flood damages from $2,200,000 to $822,300 in 2005 dollars (NRCS 2006). There are seven floodwater detention dams inundated by the proposed East Locust Creek Reservoir and an additional seven dams that will have the normal pool at the downstream face of the existing dams; the seven dams that will retain normal pools will be armored to make sure they remain functional as sediment basins.

Formation of Local Sponsor and 2006 East Locust Creek Revised Watershed Plan

Recognizing that the large lake proposed in the 1986 EA could help meet the regional need for a dependable water supply, in November 2000 the Locust Creek Watershed Board requested an NRCS study to revise the 1986 East Locust Creek Watershed Plan-EA and include a public water supply reservoir. Supporting the need for a dependable regional water supply, the *Missouri Drought Plan* classified the 10-county region as having “severe surface and groundwater supply drought vulnerability” (MDNR 2002).

Following authorization, NRCS began planning activities in July 2003 and completed the East Locust Creek Watershed Revised Plan March 2006. NRCS issued a notice of intent (NOI) to prepare an environmental impact statement (EIS) in September 2004 (Federal Register 2004). The East Locust Creek Watershed Revised Plan found the present water supply systems for the neighboring 10-county region inadequate and vulnerable to drought conditions. In addition, the East Locust Creek Watershed Revised Plan documented annual flood damages to crop and pastureland, fences, roads, and bridges and identified the need for additional water-based recreational opportunities in the surrounding area. The revised plan recommended the construction of a multipurpose reservoir that would provide a water supply, water-based recreation, and flood prevention. The reservoir would be located on the main stem of East Locust

Creek approximately 4 miles north of Milan, Missouri, and would provide 7 MGD of raw water to be treated for public consumption (NRCS 2006).

NRCS announced a ROD to proceed with installation of a multipurpose reservoir September 2006. November 10, 2005, the 109th Congress passed PL 109-97, H.R. 2744, Section 726, which states, "Notwithstanding any other provision of law, the Natural Resources Conservation Service shall provide financial and technical assistance through the Watershed and Flood Prevention Operations program to carry out the East Locust Creek Watershed Plan Revision in Missouri, including up to 100 percent of the engineering assistance and 75 percent cost share for construction of the site…". Subsequently, an agreement between the NRCS and NCMRWC was reached to provide federal funding for land acquisition of East Locust Creek Reservoir. All land for the proposed East Locust Creek Reservoir location has been purchased without the need for condemnation.

The NCMRWC became a local sponsor of the planning effort and in 2003, it contracted with Burns & McDonnell to complete a water system feasibility study. The study developed current and projected water use estimates and evaluated alternative water sources that would allow the NCMRWC to provide water to the area (Burns & McDonnell 2003).

The NCMRWC is a joint municipal utility commission formed in 2001 with assistance from the Missouri Department of Natural Resources (MDNR) "to provide an abundant source of low-cost, pure, quality water for the residents of North Central Missouri" (NCMRWC 2017). The water suppliers that joined to form the commission are the City of Green City, the City of Milan, Public Water Supply District No. 1 of Sullivan County, and the City of Green Castle. Member systems have administrative, operational, capital, and maintenance responsibilities that will ensure the continued health, welfare, and safety of their citizens. Small rural water systems often lack the economic means to adequately meet these responsibilities.

Community water systems may be eligible for state or federal grant assistance if they are determined to be "disadvantaged communities." A disadvantaged community is one with a population of less than 3,300 whose user rates are at or above 2 percent of the median household income (MHI), and the community's MHI is at or below 75 percent of the state average MHI (10 CSR 60-13.020(4)(C)(3)). NCMRWC member systems have been analyzed and determined to meet the threshold for disadvantaged community status.

In 2015, MDNR Water Resources Center published the East Locust Creek Reservoir Water Rate Analysis, which shows the 10-county region as having water rates $5.26 – $37.82 higher than the state average water rate ($27.85 per 5,000 gallons) and MHI's between 15.0 – 26.8 percent below the state average MHI ($49,109). The rural residential customers of the NCMRWC have lower average household incomes than other areas of the state, yet pay disproportionately more for water.

Since 2010, a half-cent retail sales tax has generated approximately $240,000 annually. These funds have been applied to the local funding match for project-related expenses not covered by state and federal funding. The NCMRWC is dependent on federal and state financing assistance to develop a dependable water source for its citizens.

Missouri Department of Natural Resources Study and Support

MDNR completed a study in 2004 that set an acceptable range of design yield from 4.5 to 8.5 MGD (MDNR 2004). In 2013, MDNR approved the preliminary engineering report (PER) and said to "proceed toward the construction of the surface water source capable of 7 MGD average daily design flow demand." An extension of the PER approval was received by the NCMRWC in 2017. MDNR directors have provided four letters supporting the construction of a reservoir in north-central Missouri. Three of the letters were provided by former directors Stephen Mahfood or Sara Parker Pauley (Appendix B), and the latest letter is from current Director Carol Comer (Appendix B). Additionally, Michael Wells, the MDNR deputy director for water resources, wrote a letter in 2010 to the NCMRWC that endorses the Burns & McDonnell Water System Feasibility Study, gives priority to regional water supply systems, recognizes the water supply shortages near Sullivan County, and commends the NCMRWC in developing, "a long-term sustainable water system for the region" (Appendix B).

Former Director Pauley said, "Sullivan County and the north-central Missouri region often experience the most critical water supply shortages in the state." She also stated, "the department agrees that the current design yield of 7 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir." Current Director Comer stated, "surface water supplies in the 10-county region of North Central Missouri are vulnerable to drought, and the use of groundwater in northern Missouri is limited, not only because of a lack of quantity, but also because of its poor quality." Director Comer also stated, "the Department agrees that the current design yield of 7 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir" (Appendix B).

Draft Environmental Impact Statement Agency Comments

The DEIS was reviewed by multiple agencies and comments were received and addressed. September 22, 2006, the Environmental Protection Agency (EPA) published a notice in the Federal Register (EPA 2006) related to the 2006 FEIS that stated, "EPA's previous concerns have been resolved; therefore, EPA does not object to the proposed action." The Proposed Action has not substantially changed since the 2006 FEIS.

The U.S. Fish and Wildlife Service (USFWS) provided comments related to aquatic resources, endangered species, and specific comments related to the DEIS (USFWS, letter to Mr. Roger A. Hansen, Appendix B in NRCS 2006). The comments related to aquatic resources requested additional descriptions of the wetlands affected by the project, provided concerns about the wetlands along the reservoir fringe, requested additional information on replicating downstream flow of East Locust Creek, requested wetland and stream mitigation be described in detail, and requested an explanation on how the project sponsor will implement long-term operation and maintenance of fish and wildlife habitat. The comments related to endangered species requested NRCS consult with the USFWS's Columbia, Missouri, Ecological Services Office. The specific comments were related to clarifying specific sentences or paragraphs (USFWS, letter to Mr. Roger A. Hansen, Appendix B in NRCS 2006).

The USACE commented on the recommended plan in the DEIS and stated, "this section should include a discussion as to how and why the Proposed Action was selected and how the project site was determined. The discussion should justify the selected alternative as the least

environmentally damaging practicable alternative that meets the overall project purpose" (USACE, letter to Roger Hansen, Appendix B in NRCS 2006).

The East Locust Creek Reservoir administrative record is summarized above and contains a list of meetings and coordination with federal agencies.

1.3 Authority

This document was prepared under authority of the Watershed Protection and Flood Prevention Act, PL 83-566, as amended (16 U.S. Code [USC] 1001-1008), and in accordance with Section 102(2)(c) of NEPA of 1969, PL 91-190, as amended (USC 1992), and the Federal Water Pollution Control Act, as amended in 1972. Responsibility for complying with NEPA rests with the NRCS. Responsibility to issue or deny a Section 404 permit under the CWA for impacts to jurisdictional waters rests with the USACE and the EPA.

The Proposed Action is funded through the Watershed Protection and Flood Prevention Act of 1954 (PL 83-566), administered by USDA-NRCS and sponsored by the NCMRWC. Additionally, the PL 83-566 authority was extended by an act of Congress to specifically allow construction of the proposed East Locust Creek Reservoir project (RW1) with special cost-share rates. November 10, 2005, the 109th Congress passed PL 109-107, H.R.2744, Section 726, which states: "Notwithstanding any other provision of law, the Natural Resources Conservation Service shall provide financial and technical assistance through the Watershed and Flood Prevention Operations program to carry out the East Locust Creek Watershed Plan Revision in Missouri, including up to 100 percent of the engineering assistance and 75 percent cost share for construction cost of site RW1 [Proposed Action]". All references to "East Locust Creek Reservoir" in this document pertain to Site RW-1 as described in PL 109-107 and in the 2007 East Locust Creek Watershed Revised Plan & Environmental Impact Statement.

Sections 3 and 4 of PL 83-566 provide for federal assistance for multiple authorized project purposes including the following, which are the basis for the NEPA and 404(b) alternative analysis project purposes described herein.

- Flood Prevention (flood damage reduction)
- Public Recreation
- Agricultural Water Management (including agricultural water supply in rural communities)

Other PL 83-566-authorized project activities that may occur include the following:

- Watershed Protection
- Public Fish and Wildlife

1.4 Purpose of this Analysis

This DSEIS document is intended to update the 2006 FEIS and provide information to comply with the USACE 404(b)(1) guidelines (40 CFR 230). The updates focus on information that has changed since the 2006 FEIS and do not intend to duplicate information provided in the 2006 FEIS. Readers should reference the 2006 FEIS document as the primary document and use the DSEIS to supplement the 2006 FEIS. Copies of the 2006 FEIS can be found on the Missouri NRCS website (NRCS 2020).

Both the NEPA requirements and the 404(b)(1) guidelines require determining project purposes and needs and the review of a reasonable range of alternatives, with the goal of identifying a Proposed Action. To update the 2006 FEIS, this DSEIS document focuses on the project purposes and needs, on the alternatives analysis, and on a preliminary review of impacts of alternatives to social, economic, and natural environmental resources.

The CWA 404(b)(1) guidelines require the identification of the LEDPA, which primarily evaluates impacts to aquatic resources such as wetlands and streams and only secondarily considers other resources in a public interest evaluation. The alternatives analysis in this DSEIS provides information to aid the USACE in its Section 404 permit decision.

1.5 Project Purpose and Need for Action

The project purpose and need for action statements have been slightly altered from the 2014 NOI based on information gathered in interagency meetings. Regulatory agencies want to assure that the purpose and need is not so narrowly defined that it excludes legitimate alternatives. The original purposes of water supply, flood damage reduction, and recreation remain unchanged. The multiple purposes of the East Locust Creek project are the following:

- Provide a dependable, affordable long-term water supply to meet the water demand for the 10-county region of north-central Missouri, including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties (Section 1.5.1).
- Reduce flooding damages on 22.5 miles of East Locust Creek above the confluence with Locust Creek (Section 1.5.2).
- Provide water-based recreation to meet the unmet demand for the 10-county recreation management area including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties (Section 1.5.3).

PL 83-566 does not impose restrictions on how individuals or municipal users can use a treated public water supply.

1.5.1 Need for Dependable, Affordable Long-term Water Supply

An additional drinking water source in north-central Missouri is needed to meet the existing and future needs of water suppliers and water users in the region during drought conditions and to provide resiliency against uncertainty in future water demands and climate change. The lack of a dependable, long-term water supply poses health, safety, and human welfare issues for north-central Missouri. The NCMRWC and MDNR have identified the need for an adequate, dependable, and high-quality water supply system for the rural areas and municipalities of north-central Missouri. The area to be served by the NCMRWC includes 10 counties in north-central Missouri, which are listed above.

Many of the 10-county regions' suppliers need alternative water sources to provide a dependable, long-term water supply. Some examples are as follows:

- Green City was mandated in 2003 by the MDNR to abandon its existing water plant because it could not meet the state drinking water standards. Consequently, the city has signed on as a charter member of the NCMRWC (Burns & McDonnell 2003). Reasons for the MDNR mandate were not reported in the Burns & McDonnell report, but Appendix C (Allstate 2016) pages 4-7, describes typical reasons why plant closures may occur.

Reasons include the inability to keep up with increasingly stringent trihalomethane, disinfection, turbidity, and security.

- The City of Milan has been under voluntary or mandatory water conservation for several years and has been required to purchase water from Trenton when the current supply lake is lower than 48 inches, per an MDNR mandate (Brad Scott, personal correspondence to Jennifer Hoggatt, October 2017).
- Other water suppliers in the region experience problems that increase the cost of water while limiting water availability. A 2016 study of water supply in 17 counties in north-central Missouri (including all 10 counties that will be served by the proposed reservoir) coordinated by USACE and MDNR, reported that ” every system expressed confidence in the reliability of their source; however this is not likely realistic” (HDR Inc. 2016). The report expands on that statement by describing factors leading to presumably unanticipated reductions in the capacities of existing systems in the region. In addition to unanticipated reductions in capacity, water systems also tend to underestimate their susceptibility to extended droughts as described in Appendix C (Allstate 2016). The Regional Water Source Evaluation (Allstate 2016, Appendix C) analyzed the systems in the 10-county region for their current ability to continue to produce water during the drought of record. Figure 1.5.1.2, taken from the Regional Water Source Evaluation (Allstate 2016, Appendix C), shows the systems that are expected to run out of water during the drought of record resulting in the loss of 67 percent of the region’s water supply.
- From 1980 to 2015, 28 former water source suppliers in the 10-county region either closed their water treatment plants and now buy water on the wholesale market from other water sources or have been folded into other water supply systems (Allstate 2016, Appendix C). Reasons for closing their plants include the following:
    - Declining yield
    - Water high in iron
    - Silt in groundwater well
    - Diminished reservoir capacity because of siltation
    - Inadequate water treatment plant
    - Struggle with disinfection by-products
    - Difficulty maintaining a qualified water treatment plant operator

At present, the 10-county region is supplied by a total of 56 water systems. Of these water systems, only 19 water producers have their own sources: 16 water producers in the region, and three water producers outside the region. The loss of 28 water producers since 1980 (Allstate 2016, Appendix C) represents a 60 percent decrease in the number of water sources within the 10-county region. The loss of this amount of systems points to the increasing lack of long-term, dependable water supplies.

A long-term, dependable water supply will provide adequate water to the 10-county region for at least the next 100 years and will not fall short during a drought equivalent to the drought of record.

1.5.1.1 Inadequacy of Existing Water Supply

The existing water supply in the region is inadequate for a number of reasons, including the following:

- An inability to meet even the current demand during the drought of record
- A lack of capacity to meet future contingencies that require higher volumes of water
- More recently, less severe droughts that have caused hardship for the region

The following sections discuss some of the reasons for these inadequacies.

Current Water System Unplanned "Clusters"

The 10-county region's primary water producers pump water from a groundwater or surface water source and sell water to their retail customers and other (consecutive) water systems. Consecutive water systems do not have a water source, rather they buy water from primary water producers (or even second or third systems that bought water from producers) to sell to their retail customers. The consecutive water systems are limited in the amount of water they can purchase by whether they have interconnections with other water systems and by the size of the interconnection pipes.

The 10-county region is served by 19 primary water-producing water systems. Three of those water systems—Clarence Cannon, Livingston County Public Water Supply District (PWSD) No. 4, and Rathbun – are located outside the 10-county region. The interconnections of producers and consecutive systems can be complicated, but by grouping systems using the same raw water source(s) into "clusters," the regional availability of water can be displayed more clearly and accurately. The 19 water systems and the consecutive systems they support are grouped as clusters separated by geographical region served, and by their source of raw water, specifically groundwater producer, surface water producer, or an out-of-region producer (Figure 1.5.1.1-1).

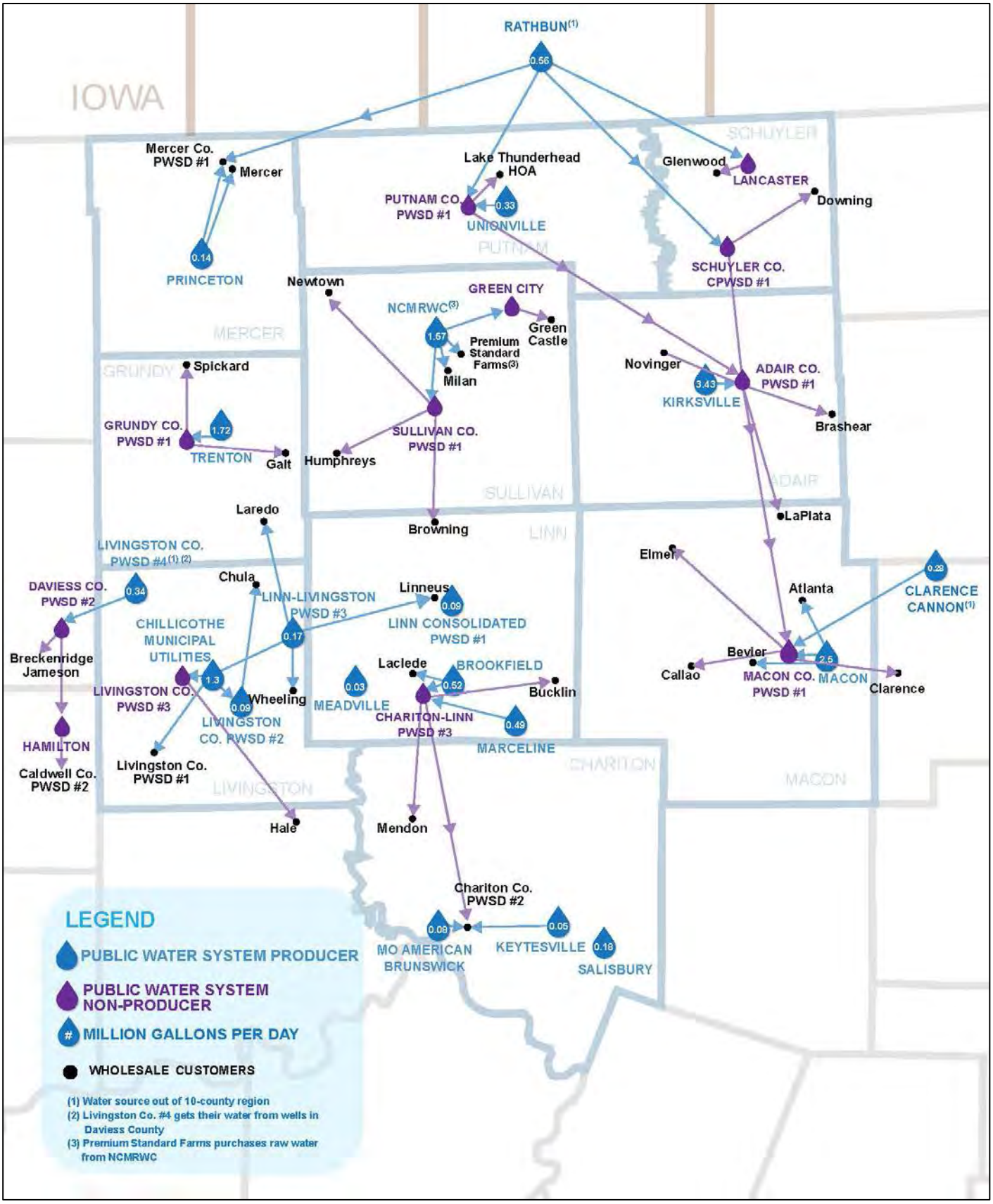


Figure 1.5.1.1-1 Nineteen Public Water Systems and the Consecutive Systems Supported.

Although Brookfield and Marceline are separate water systems, they serve an overlapping geographic region and system of interconnections, so they are grouped together in the analysis below.

As indicated above, many systems that once produced their own water now must buy water from other systems. These consecutive systems form an unplanned regional water system around a nearby water-producing system. The producing water systems serving the systems around them were not designed to serve the larger, unplanned cluster. For example, Keytesville is a primary water system that produces its own water and sells water to Chariton County PWSD No. 2. Keytesville uses 0.031 MGD, and Chariton County PWSD No. 2 uses 0.022 MGD of Keytesville's water, for the total of 0.053 MGD shown in Table 1.5.1.1-1. Chariton then purchases additional water from Missouri American Water Company in Brunswick. The consecutive water systems and water purchases are described in the Regional Water Source Evaluation (Allstate 2016, Appendix C).

Although the clusters may or may not have capacity to meet average daily needs, infrastructure, peak demands, and drought planning are often not considered in detail as consecutive water systems are added to the service area of the water producer (Allstate 2016, Appendix C). Table 1.5.1.1-1 lists all the water systems that provide water to the 10-county region and the amount of water they provide to the 10-county region. The average daily water supplied to the 10-county region includes water used by the primary water system and water directly or indirectly sold to other water systems within the 10-county region. Any water sold outside the region is not included in the 10-county region water supply. For example, Livingston County PWSD No. 4 sells 0.14 MGD outside the 10-county region that is not included in the 10-county region water supply.

Although an individual water system's water supply may be greater than the amount of water used by the individual water system, additional water is only available to the individual water system and not to other systems in the 10-county region that may need the water. Thus, the overall system capacity does not increase because an individual water system has more water than it uses. For example, Chillicothe uses 1.3 MGD and has an additional 1.34 MGD in additional capacity. The additional 1.34 MGD is not available to the other water systems because either the infrastructure is not available or the water system does not wish to sell the water.

Table 1.5.1.1-1. Primary Water Source Water Systems in the 10-county Region.

Water System	Source	Average Daily Water Supplied to 10-county Region (MGD)
Brookfield and Marceline	Brookfield Lake, Yellow Creek, Marceline Lake, Old Marceline Lake, Mussel Fork Creek	1.014
Chillicothe Municipal Utilities	Groundwater wells	1.300
Clarence Cannon Wholesale Water Commission	Mark Twain Reservoir	0.278
Keytesville	Groundwater wells	0.053
Kirksville	Forest Lake, Hazel Creek Lake	3.432
Linn County CPWSD No. 1	Groundwater wells	0.085
Livingston County PWSD No. 2	Groundwater wells	0.087
Linn-Livingston PWSD No. 3	Groundwater wells	0.168
Livingston County PWSD No. 4	Groundwater wells	0.200
Macon Municipal Utilities (MMU)	Long Branch Lake	2.500
Meadville	Groundwater wells	0.034
Missouri American Water Company – Brunswick	Groundwater wells	0.084
NCMRWC	Elmwood/Golf Course Lake, Locust Creek	1.572
Princeton	Groundwater wells	0.137
Rathbun Regional Water Association (RRWA)	Rathbun Lake	0.557
Salisbury	Groundwater wells	0.175
Trenton	Thompson River	1.718
Unionville	Unionville Lake	0.330
	10-COUNTY REGION TOTAL	**13.724**

Source: Allstate 2016, Appendix C

High Cost of Water

The cost of water in north-central Missouri is higher, relative to income, than in other locations in the state. The higher cost is because of a number of issues including the need to move water from one system to another and the inadequacy or lack of water sources for many systems. The high cost of water relative to median household incomes is shown in Figure 1.5.1.1-2.

In a region where public water supply systems without a source of water outnumber those with a water source by nearly two to one, systems often receive water via “wheeling” (Allstate 2016, Appendix C). Wheeling is a term that describes how wholesale treated water is delivered from one system, through a second system, and on to a third system, because there is no direct pipeline connection between systems one and three. Although this water is provided to the third system at a wholesale rate, it is usually at a higher-than-basic wholesale rate because the second (middleman) system typically charges a wheeling fee to cover operation and maintenance, administrative, and debt service costs for the water provided. Because of the lack of dependable water sources in the region, the few systems with water are overextending their source’s capacity through wheeling. These sources have become unintended regional supplies that were never

designed to fully serve additional water systems. The lack of adequate infrastructure and water sources in unintended regional systems leads to a shortage of water during a drought, a lack of emergency supplies, and higher water costs.

The higher retail water rates from nonregional systems that supply water to consecutive systems, like those in the 10-county region, are caused by the additive effects of connecting several smaller systems and the cost of wheeling. Small-volume producers have a higher per-unit cost of water. This, coupled with the costs associated with delivery through one or more systems, means that the end users ultimately pay higher water rates than those charged by systems closer to the source. In contrast to the small-volume producer, a regional, large-volume producer can provide water at a lower baseline cost than a small-volume producer. The end user for both a large-volume and a small-volume producer is still paying more than those located closer to a water source, but the baseline rates are more affordable for the large-volume producer. Research indicates that larger water systems can cut costs by anywhere from 10 to 50 percent over small water systems (Shih et al. 2006).

Higher water costs are evident in the 10-county region. The Missouri Rural Water Association's (MRWA) 2014 Water Rate Survey Results lists the cost per 5,000 gallons of water for the 10-county region as $55.40, which equals a 39 percent premium when compared to the state average of $39.81 (MRWA 2014). The increased costs are especially difficult for residents of the 10-county region, which has an average MHI that is 20 percent lower than the state average (U.S. Census 2010). Customers within the region spend a higher percentage of their monthly incomes on water than water customers elsewhere in the state. The data from these studies indicate that approximately 17 percent of Sullivan County residents live at or below the poverty level, and these residents are paying as much as 6 percent of their annual income for water.

Figure 1.5.1.1-2 uses the MRWA 2012 Missouri rate study and the Missouri Public Utility Alliance (MPUA) 2012 Missouri rate study to calculate the average water rate for Missouri counties.

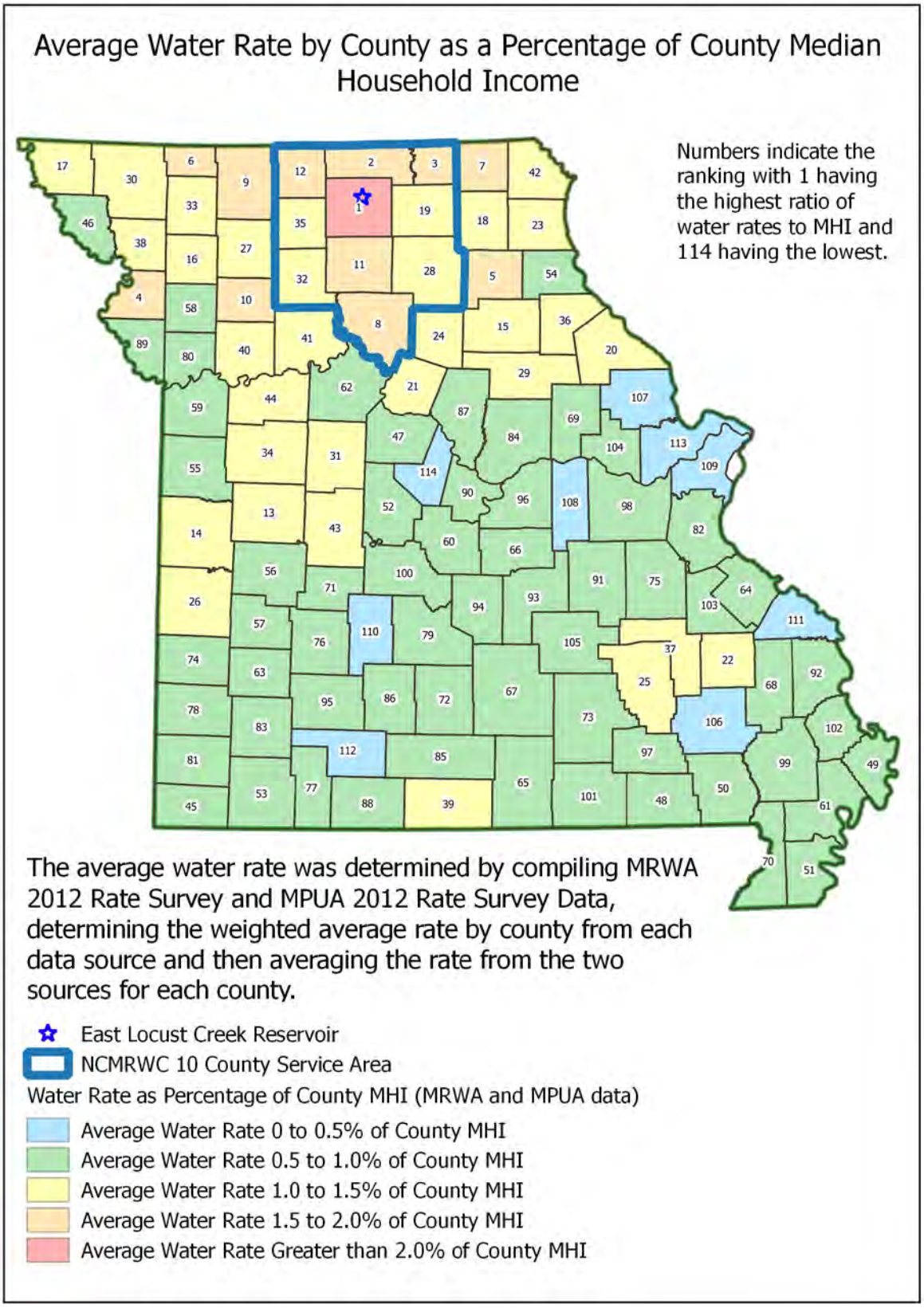


Figure 1.5.1.1-2. Cost of Water Relative to Median Household Income in Missouri Counties (Missouri Rural Water Association [MRWA] 2014 and Missouri Public Utility Alliance [MPUA] 2012).

Inadequacy of Existing Water Systems in the 10-county Region During Drought

A 2016 water study, titled North Central Missouri Regional Water Source Evaluation, assessed the long-term dependability of the primary water systems (Allstate 2016, Appendix C). The study evaluated the ability of a surface water system to provide water during the 1950s drought of record and the dependability of groundwater wells. Key points of the study included surface water evaluation, groundwater evaluation, and out-of-region water evaluation during the drought of record (Allstate 2016, Appendix C).

A drought of record is the worst recorded drought since compilation of meteorologic and hydrologic data began. In terms of severity and duration, the devastating drought of the 1950s is considered the drought of record for Missouri. It is critical that the 10-county region water supply be dependable enough to meet the demand for water in the event of a similar drought. MDNR drinking water design standards require designing water systems for the drought of record (MDNR 2013a). However, even shorter-term droughts have put stresses on the water supply in this region, as discussed below.

Drought in Missouri

This 10-county region has long been identified as a drought critical area (MDNR 2002). The impact of the constant threat of drought was summed up by the Missouri Department of Economic Development (MDED) in a report that stated the following:

"The major infrastructure problem in non-metro Missouri is providing safe drinking water for residents. Many areas are without public water and many communities have serious water quality problems. Lower income residents often don't have the financial resources to get decent water. Even when assistance is provided, there is often a void in knowing what strategy to follow for developing proper water source, supply and treatment on a long-range as well as short-term basis. The drought of 1988 made it clear that the non-entitlement communities of Missouri, especially in the north one-half of the state, do not presently have the capacity to supply water to residents in critical periods of stress" (MDED 1995).

Few water supply improvements have been made in the region and no water supply lakes have been created since the MDED report was published. MDNR Deputy Director for Water Resources Michael Wells noted the following in a 2010 letter to the NCMRWC:

"While many of the communities in the region have addressed their short-term water shortage needs in recent years, studies have shown that these short-term solutions are not sustainable through extended periods of drought nor will they support long-term economic growth in the region."

"During periods of extended drought in Missouri, the Missouri Drought Assessment Committee, which I chair, has recognized that communities in and near Sullivan County often have the most critical water supply shortages in the state."

Recent droughts like the 2011 t – 2012 drought have caused hardship on Missouri (Office of Governor Jay Nixon 2013); however, these droughts were exceeded by the drought of record. The drought of record occurred between 1951 and 1959 (MDNR 2011a). During the 5-year period of 1953 – 1957 during the drought of record, the precipitation deficit was 60.64 inches (University of Missouri 2016). Over a 5-year period leading up to and including the 2011 – 2012 drought, a precipitation surplus of 23.32 inches was recorded (University of Missouri 2016).

The shortage of water during drought was a hardship to the agricultural industry and residents. The importance of Missouri agriculture has been documented by the Office of Governor Jay Nixon (2013): "Missouri's farmers have long led the nation in agricultural production, nationally ranking second in the number of farms and in cattle and calves, as well as in the top 10 for poultry, horses, hogs, corn and soybeans. Farmers and farm families' contributions to their communities have also made them economic engines by supporting youth programs, providing jobs and strengthening Missouri's rural areas."

The 2011 – 2012 drought caused an estimated statewide loss of $547 million in livestock and poultry. The state emergency operation center was activated, and a federal disaster declaration was made for all Missouri counties including the 10-county region (Office of Governor Jay Nixon 2013). Emergency assistance was granted to 38 applicants across eight of the 10 counties in the region to connect agribusinesses to rural public water systems. A total of 52 counties in the state and a total of 201 approved projects statewide received cost-share connection assistance. Nineteen percent, or nearly one in five of these projects were within the 10-county region. As of November 15, 2012, 2,126 wells were drilled or deepened throughout the state through the cost-share program. Because of unfavorable underlying geology, only six deepened well projects, or 0.2 percent of the state total, were in the 10-county region (Office of Governor Jay Nixon 2013).

The lack of dependable water was evident in the short-term drought of 2012. While the drought of record's severity and impacts on the current economy and water systems are difficult to predict, recent less severe droughts provide insight into the potential impacts. Planning for a long-term dependable water source includes providing water during drought emergencies of equal severity to the drought of record.

Dependability of Surface Water Systems During Drought

The six surface water system clusters in the 10-county region include the following:

- Brookfield and Marceline
- Kirksville
- Macon Municipal Utilities (MMU)
- NCMRWC
- Trenton Municipal Utilities
- Unionville

The MDNR's Minimum Design Standards for Missouri Public Water Systems define two methods for evaluating the dependability of a surface water source: the Reservoir Operation Study Computer Program (RESOP), and the evaluation of the lowest seven-day average flow that occurs on average once every 10 years (7Q10). These methods are used with other MDNR design criteria such as the following:

- The ability to provide sufficient water through the drought of record and maintain 120 days of additional storage for public confidence (for reservoirs)
- The ability to maintain other water volume use requirements (for reservoirs)
- The ability to maintain adequate downstream flow for instream flows (MDNR 2013a)

RESOP analysis calculates the reservoir yield capacity, which is the amount of water that can be withdrawn from a reservoir on a daily basis and endure drought of record conditions without depleting the supply. When compared to the normal demand, which is the current average daily use according to data, only those sources with a reservoir yield greater than the normal demand of their cluster were determined to provide an adequate water supply.

A 7Q10 threshold is used by MDNR to protect the integrity of streams. By definition, the flow in the stream will be lower during the drought of record, because a drought of record is much more severe than a drought that occurs on average every 10 years (i.e.,10 percent chance of occurrence in a given year). If a stream flow source is to be considered dependable, users must be able to withdraw water at a rate that will not cause the stream flow to be lower than the 7Q10 threshold. By definition, the stream will already have average flows below the 7Q10 threshold in a drought that occurs on average every 10 years, without any withdrawals.

If a surface water source was not able to provide adequate water based on the approved MDNR methods, the surface water source was considered at risk of running out of water completely during an event of equal magnitude and duration to the local drought of record. Analysis of the Regional Water Source Evaluation (Allstate 2016, Appendix C) found that five of the six surface water clusters were determined to have an inadequate water supply; they accounted for 76.3 percent (8.066 MGD) of the total demand (10.556 MGD) provided by in-region, surface water sources in 2015 (see Table 1.5.1.1-1) The inadequate clusters are the following:

- Brookfield and Marceline (1.014 MGD)
- Kirksville (3.432 MGD)
- NCMRWC (1.572 MGD)
- Unionville (0.330 MGD)
- Trenton Municipal Utilities (1.718 MGD)

RESOP and 7Q10 calculations are included in the 2016 North Central Missouri Regional Water Source Evaluation Study (Allstate 2016, Appendix C).

Dependability of Groundwater Systems

The nine groundwater systems in the 10-county region include the following:

- Chillicothe Municipal Utilities
- Keytesville
- Linn County Consolidated Public Supply Water District (CPWSD) No. 1
- Livingston County PWSD No. 2
- Linn-Livingston PWSD No. 3
- Meadville
- Missouri American Water Company – Brunswick
- Princeton
- Salisbury

The MDNR's Minimum Design Standards for Missouri Public Water Systems do not directly stipulate drought of record or reserve capacity for groundwater wells. It does require the source capacity to meet or exceed design maximum-day demand and that all systems serving over 500 people have redundant water sources (MDNR 2013a). However, the development of redundant and replacement wells that provide sufficient yield to be considered dependable is difficult in north-central Missouri (MDNR 1997).

Analysis of groundwater from the Regional Water Source Evaluation (Allstate 2016, Appendix C) was based on regional and local geology, historical data, and engineering design criteria. Specific well analysis cannot definitively predict how long or at what rate a well will yield water or what the water quality will be. In northwest Missouri, the groundwater yield is so highly mineralized that, for practical purposes, it is not a dependable source in most locations. Miller and Vandike (1997) divided Missouri into groundwater provinces and subprovinces. They state, "Bedrock formations in the Northwestern Missouri groundwater province older than Pennsylvanian-age yield highly mineralized water. Usable quantities of groundwater are locally available from Pennsylvanian strata, but yields are typically low and the water quality is marginal" (Miller and Vandike 1997).

Historical records of the region document the difficulty of developing a well of adequate quality and yield. The available groundwater well data from MDNR lists 28 public water supply wells that have been plugged, inactivated, or modified to be observation wells in the 10-county region. Six of the nine groundwater systems have been determined to have an inadequate water supply; they account for 26.5 percent (0.563 MGD) of the total supply (2.122 MGD) provided by in-region, groundwater sources in 2015. They are as follows:

- City of Keytesville (0.053 MGD)
- City of Meadville (0.034 MGD)
- City of Princeton (0.137 MGD)
- Linn CPWSD No. 1 (0.085 MGD)
- Linn-Livingston PWSD No. 3 (0.168 MGD)
- Livingston County PWSD No. 2 (0.087 MGD)

Groundwater evaluations are included in the 2016 North Central Missouri Regional Water Source Evaluation Study (Allstate 2016, Appendix C).

Dependability of Out-of-region Water Systems

The following three systems provide water from outside the 10-county region:

- Rathbun Regional Water Association (RRWA; Rathbun Lake)
- Livingston County PWSD No. 4
- Clarence Cannon Wholesale Water Commission

In 2015, out-of-region treated water supplies accounted for 7.5 percent or 1.035 MGD of the total 13.723 MGD of water produced in the 10-county region. Of the 1.035 MGD, approximately 54 percent, or 0.557 MGD, was supplied by RRWA, of Centerville, Iowa.

The RRWA has indicated that they do "not believe that the available water supply storage allocation in Rathbun Lake will allow us to provide potable water to customers outside of our association's current service territory" (Glenn 2019). Additionally, the dependability of RRWA is limited by an Iowa law that restricts conveyance of water across state lines. The availability of water during emergencies is restricted in a specific order as stipulated in Iowa Administrative Code 455B.266 Priority Allocation:

> "…the department may suspend or restrict usage of water by category of use on a local or statewide basis in the following order:
>
> *a.* **Water conveyed across state boundaries.** (emphasis added)
> *b.* Uses of water primarily for recreational or aesthetic purposes.
> *c.* Uses of water for the irrigation of hay, corn, soybeans, oats, grain sorghum or wheat.
> *d.* Uses of water for the irrigation of crops other than hay, corn, soybeans, oats, grain sorghum or wheat.
> *e.* Uses of water for manufacturing or other industrial processes.
> *f.* Uses of water for generation of electrical power for public consumption.
> *g.* Uses of water for livestock production.
> *h.* Uses of water for human consumption and sanitation supplied by rural water districts, municipal water systems, or other public water supplies as defined in Section 455B.171."

When there is a shortage, water conveyed across state boundaries is the first usage that Iowa must cut. Because water could be suspended or restricted during a drought emergency, Rathbun Lake is not a dependable water source for Missourians.

Summary of Inadequacy of Existing Water Systems

Based on the evaluation of the 19 primary water systems serving the 10-county region, only six water systems have a dependable water supply that can be expected to provide enough water to meet the current water demand for the next 100 years and during the drought of record. These six water systems can provide only a total of 4.537 MGD of the 13.724 MGD water demand for the 10-county region, or approximately one-third of the volume of water needed. These systems, and their water sources are the following:

- Chillicothe Municipal Utilities (1.3 MGD) – Groundwater
- Clarence Cannon Wholesale Water Commission (0.278 MGD) – Out-of-region
- Livingston County PWSD No. 4 (0.2 MGD) – Out-of-region
- MMU (2.5 MGD) – Surface water
- Missouri American Water Company – Brunswick (0.084 MGD) – Groundwater
- Salisbury (0.175 MGD) – Groundwater

The remaining 13 water systems provide the remaining 9.186 MGD to the 10-county region and do not have a dependable water source that can be counted on to provide even the current water demand during the drought of record. These systems and their water sources are the following:

- Brookfield and Marceline (1.014 MGD) – Surface water
- Kirksville (3.432 MGD) – Surface water
- NCMRWC (1.572 MGD) – Surface water
- Unionville (0.330 MGD) – Surface water
- Trenton (1.718 MGD) – Surface water
- City of Keytesville (0.053 MGD) – Groundwater
- City of Meadville (0.034 MGD) – Groundwater
- City of Princeton (0.137 MGD) – Groundwater
- Linn CPWSD No. 1 (0.085 MGD) – Groundwater
- Linn-Livingston PWSD No. 3 (0.168 MGD) – Groundwater
- Livingston County PWSD No. 2 (0.087 MGD) – Groundwater
- RRWA (0.557 MGD) – Out-of-region

Figure 1.5.1.1-3 shows a breakdown in the 10-county region water suppliers according to adequacy.

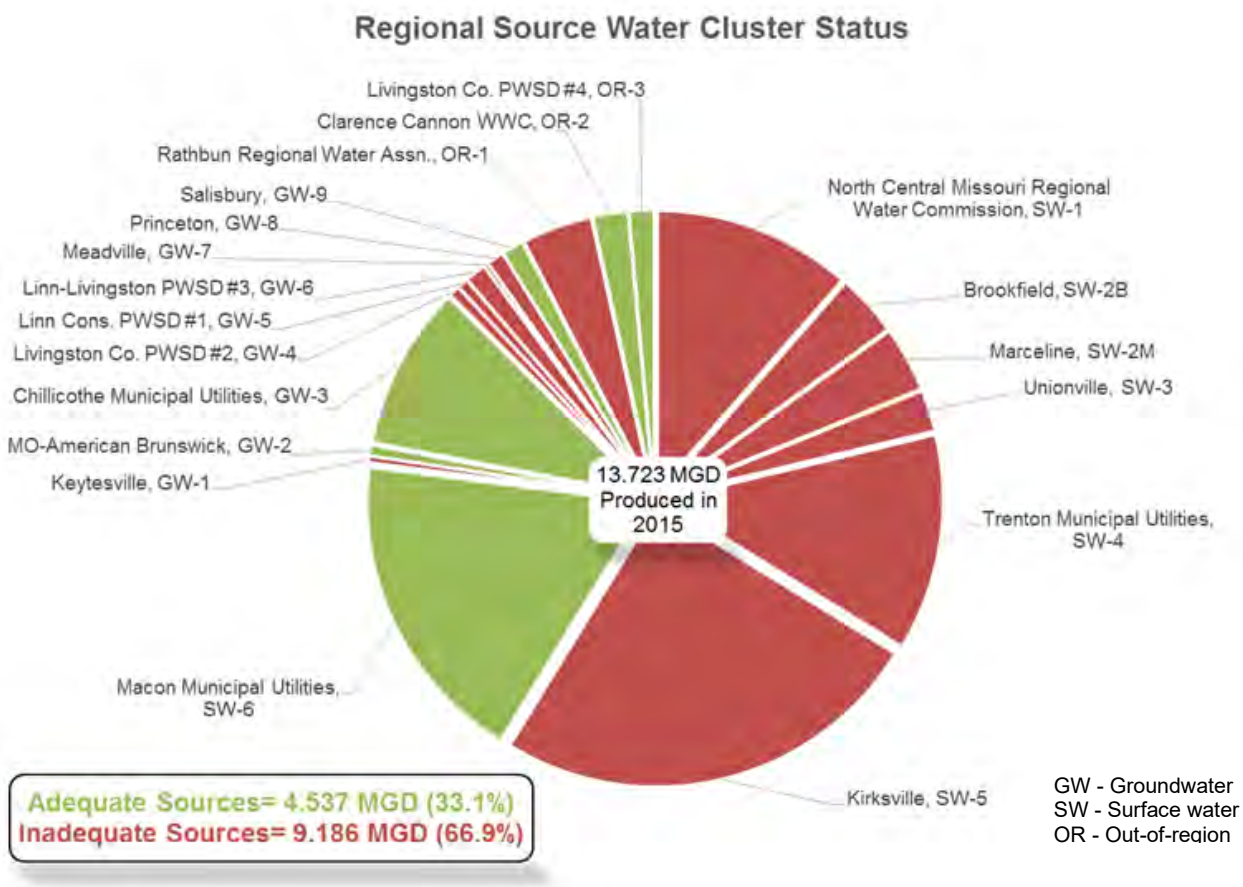


Figure 1.5.1.1-3. Adequacy of 10-county Region Water Systems.

1.5.1.2 Projected Water Supply Needs

The projected need is based on the 9.186 MGD inadequate supply demonstrated in the previous section, with additional contingencies built in to account for unforeseen demand and compliance

with MDNR drinking water design standards. The MDNR drinking water design standards account for water loss in treatment and distribution.

1.5.1.2.1 Planning Contingencies

Predicting future water demand includes accounting for potential demand increases that cannot reasonably be predicted. A 10 percent contingency or 0.92 MGD water demand increase for the inadequate water sources is added to the unfinished total projected demand to account for climate change and increased drought risk, population and water demand growth, increased agricultural demand, and increased business demand. While it is difficult to predict which contingency will occur over the next 100 years, any one of the contingencies or a combination of contingencies could require the supply of 0.92 MGD or more.

Extreme Weather Events and Increased Drought Risk

In August 2003 and 2012, the 10-county region was under a “category 3” drought as established by the MDNR. This level of drought requires water conservation practices and is one step below the emergency drought category (MDNR 2002). Future droughts in the central plains (including Missouri) are projected to be more severe with an increased risk that a drought could last for a decade or longer, according to a National Aeronautics and Space Administration (NASA) study (Cole and McCarthy 2015). The NASA study is based on the effects of climate change and carbon dioxide emissions related to the probability of future droughts. The most severe drought period in Missouri since record keeping began in the late 19th century was from 1951 to 1959 (MDNR 2011a).

In an October 30, 2000, letter to the NCMRWC from the University of Missouri-Columbia’s Missouri Climate Center, Dr. Adnan Akuyz stated, “Climatology of Missouri shows that the probability of severe summer drought in Missouri is 20 percent, or once every 5 years. Thus, Northern Missouri is more susceptible to drought than the rest of the state.” He concluded, “Because of the issues mentioned above, I endorse any action to construct a new water supply lake in Sullivan County to serve as a regional public water supply source” (A. Akyuz, personal communication, Oct. 30, 2000, Appendix B).

At the 2014 Governor’s Conference on Natural Resources, Dr. Pat Guinan of the Missouri Climate Center presented information that showed that the recent droughts of 2000, 2003, 2011, and 2012, have garnered the current level of overwhelming concern and support for more dependable water supplies, but these were all “short duration” droughts compared to the drought of record. As Mr. Guinan pointed out in his summary, “The 2012 drought resulted in numerous impacts, affecting many sectors in Missouri. However, it was a young drought when compared to other historic droughts, i.e., 1952-56” (Guinan 2014).

Paleoclimate reconstruction with subfossil oak wood collected in north-central Missouri streams showed drought duration and frequency in the U.S. Corn Belt during the period from 992 A.D. to 2004 A.D. (Stambaugh et al. 2011). This study identified three years since AD 992 that were drier than 1934, the driest year of the instrumental period. Thirteen droughts of 10 years or more in length occurred during the period. The longest drought of the period occurred during the late 12th century and lasted sixty-one years. This study documents that the 10-county region has experienced droughts with severity and duration that exceed those of modern record.

During recent short-duration droughts, it became necessary to implement emergency measures. In the 1990s, over $500,000 was invested in two failed instream intakes along Locust Creek prior to the current intake configuration. The current intake, which is 3.1 miles from its discharge in Elmwood Lake, was built in 2002 at a cost of $921,000 and is configured for low- and high-stream flow. Even with this creek intake, the reality of water shortages forced a 2008 project to pump treated water from Grundy County PWSD No. 1. Because of hydraulic limitations over the 35-mile pipeline, only 0.11 MGD can be supplied. This project had a final cost of nearly $2 million. The Regional Water Source Evaluation (Allstate 2016, Appendix C) shows in the drought of record analysis that neither the Locust Creek intake nor the Grundy County PWSD No. 1 treated waterline can supply sufficient water for the current demand.

In the time since the 2006 FEIS was completed, the United States has become increasingly aware of the impacts that extreme weather events may have on agriculture, industry, and our quality of life. May 6, 2014, the White House issued a comprehensive, authoritative scientific report on the impacts of current and future climate change on every region of the country (White House 2014). The state report for Missouri says the following:

> *"The Midwest's agricultural lands, forests, Great Lakes, industrial activities, and cities are all vulnerable to climate variability and climate change. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress,* ***flooding, drought,*** *and late spring freezes…. Climate change may intensify other stresses on urban dwellers and vegetation, including increased atmospheric pollution, heat island effects,* ***a highly variable water cycle,*** *and frequent exposure to new pests and diseases" (Emphasis added. Source: White House 2014).*

In March 2016, the White House issued a presidential memorandum for the heads of executive departments and agencies on building national capabilities for long-term drought resilience. The purpose stated, "Our Nation must sustain and expand efforts to reduce the vulnerability of communities to the impacts of drought." Drought planning and capacity building are policy goals listed in the memorandum, among others. (White House 2016)

A recent report (Moody's Investors Service 2017) highlights the growing awareness of the potential impacts of extreme weather events on local governments. Moody's Investors Service is the bond rating business of Moody's Corporation; it provides international financial research on bonds issued by commercial and government entities. Moody's Investors Service is considered one of the "Big Three" credit rating agencies, along with Standard & Poor's and Fitch Group. Moody's Investors Service issued a report November 28, 2017, titled, *Environmental Risks -- Evaluating the impact of climate change on U.S. state and local issuers* (Moody's Investors Service 2017). The report explains how the company incorporates extreme weather events into its credit ratings for state and local bonds. The increasing frequency and magnitude of "climate shocks" such as droughts, floods, and storms can significantly impact the ability of communities to service their debt if they have not taken steps to mitigate potential impacts. Moody's Investors Service will consider both exposure and what communities are doing to mitigate the potential impacts of climate shocks when issuing bond ratings. Communities that have not prepared for

extreme weather events are a greater credit risk and will pay higher interest rates than those that are prepared.

Extreme weather events are likely to produce more frequent and potentially more extended droughts. A project meeting the water supply needs of the 10-county region will protect the human health, safety, and welfare of communities and citizens from the increased risk of prolonged droughts, and thus, from a shortage of adequate water supply.

Conservation and Drought Mitigation

The NCMRWC and its members have exhaustively explored and implemented numerous alternative measures to supplement and augment both finished water supplies and raw surface water supplies and have also implemented water conservation measures because of a current drought and impending water shortage. Finished water supply alternatives have included interconnections with other existing rural water supply district systems; however, these interconnections cannot provide the minimum amount of water economically nor in an amount necessary to fully mitigate short-term drought conditions.

Numerous alternatives for raw water supply augmentations of Elmwood Lake have been evaluated, planned, and implemented. These alternatives include installing a raw surface water pump station in main stem Locust Creek; it has been in operation (though flows in Locust Creek necessary to operate the pump have been sporadic). In addition, temporary pumping of East Locust Creek and its tributaries delivers water into other local lakes that is then pumped to Elmwood and the NCMRWC drinking water treatment plant. None of the temporary or pilot measures attempted or implemented provide a solution to the regional water supply demands, nor are they sufficient to meet MDNR minimum capacity requirements.

A temporary, short-term water shortage mitigation measure has been proffered by Smithfield Foods Incorporated, which operates a packing plant in Milan, Missouri, very near Elmwood Lake. That proposal would deliver treated wastewater effluent into Elmwood Lake using the Locust Creek pump line. A rigorous testing protocol is proposed and is subject to approval by MDNR. Treated wastewater effluent delivery would only be allowed when a water shortage is imminent based on Elmwood Reservoir lake level. Treated wastewater effluent flows into Elmwood Creek (below the Elmwood Lake) would continue during normal lake conditions and demand.

Increased Domestic Water Demand

The population growth trend in the 10-county region does not correlate well to water demand, because other factors affect demand numbers. Water consumption data is available from 2006 to 2016 (MDNR 2016). Water demand over the 11-year period increased 6 percent, a trend opposite to the slight decline in population. The North Central Missouri Water Supply Reliability Study coordinated by USACE and MDNR comes to several conclusions regarding the impact of population change on water source dependability (HDR Inc. 2016), which are the following:

- Population declines only provide excess water capacity if water sources are well maintained and not affected by pollution or sedimentation.
- The decline in a reliable water source is a potential factor in the population decline.
- Population decline may reflect a decline in workforce, which limits the availability of registered operators for local water systems.

- Declining population may reduce funds for water systems.

The long-term population trend for the 10-county region shows a population decline starting in 1900. The population decline was steepest from 1900 to 1960 before moderating in the 1970s and 1980s. The population in the 10-county region was 107,130 according to 2010 census data, which was a decrease of 1,160 people, or 1.1 percent, from the 2000 census data (U.S. Census 2010). The current population trend shows a stabilization of the population decline.

An evaluation of births, deaths, and net migrations completed by the Missouri Office of Administration shows a projected 2030 population of 102,228 people for the 10-county region (Missouri Office of Administration 2008). This represents a decline of 2,848 people (2.8 percent) from the 2015 population. On a 10-year basis, this is a decline of 0.56 percent, which shows a decreasing rate of population decline. The decline in population of 2,848 people would account for 0.162 MGD based on the current 119 gallons per capita day (gpcd) water demand.

The long-term population decline does not necessarily indicate a decrease or increase in population projection over the next 100 years. The flattening of the decline curve over the last 25 years and in future projections to 2030 indicate the population is stabilizing and could increase in the future. Some counties, like Adair, Macon, and Sullivan have experienced a recent population increase (HDR Inc. 2016). Similarly, the increase in water consumption over the last 11 years indicates a short-term trend that may continue or may remain volatile into the future. Potential business growth and population dynamics will affect water consumption over the next 100 years. Given the uncertainties in water use and population trends, it is difficult to predict future water demand.

From a water planning perspective, a continued increase in water demand is likely. Short–term water usage shows an increase of 6 percent over the last 11 years. Accounting for the 0.92 MGD ten percent planning contingency described above, water demand increase would equate to a 0.018 MGD increase annually for 50 years. Beyond 50 years it is not possible to accurately project population or water use trends. Because an accurate water usage projection cannot be made past 50 years, it is assumed that the amount required at 100 years will be the same amount as required at 50 years. Based on the 2015 population and water consumption data, the per capita water consumption totals 119 gpcd. At this rate, a population increase of 7,731 people over 50 years (an average of 155 people per year in the 10-county region) would consume the 0.92 MGD 10 percent contingency.

Increased Agriculture Demand

Based on the latest USDA National Agriculture Statistics Service data, Missouri is ranked second in the nation in number of beef cattle; there are 170,400 head of beef cows, excluding calves, in the 10-county region (USDA 2014a). According to the *Missouri Livestock Watering Systems Handbook*, cattle watering should plan for a peak demand of 30 gallons per day for a 1,000-pound cow (NRCS 1998). This equates to 5.1 MGD within the 10-county region. MDNR calculated livestock water demand for the 10-county region at 4.9 MGD for beef cows. (MDNR 2014b).

Livestock producers can stockpile forages but running low on water creates an emergency. During the 2012 drought, public water supplies were used to help meet the needs of livestock producers. There were 201 approved projects that included connections to public water supplies

in 52 Missouri counties (Office of Governor Jay Nixon 2013). The drought of record would reasonably cause a similar or greater demand on drought-strained public water systems. The 0.92 MGD ten percent contingency would provide the 10-county region with only 18 percent of the estimated peak beef cattle water demand.

Increased Business Demand

Business expansion in the 10-county region is limited in part because of the lack of dependable water sources. Reliable groundwater supplies are not available in much of the region and have created a limiting factor for the location and establishment of rural business facilities (Burns & McDonnell 2003). Such facilities must be located near the source of raw materials, including water (Burns & McDonnell 2003).

Historically, two examples demonstrate the water demanded by businesses. The officials at the Smithfield Farmland facility in Milan have wanted to add a third shift for some years but have been restricted by a lack of water. They have approached the NCMRWC to purchase raw water from a new water supply reservoir, if and when one is constructed (MDNR 2004). The addition of a third shift would likely increase the facility's current water usage to 1.54 MGD. Smithfield Farmland has drilled test wells in the Milan area, but available yields are inadequate to supplement their water supply (Burns & McDonnell 2003). Water supply is Smithfield Farmland's primary factor in determining a future plant location (MDNR 2014b). In 2002, ConAgra closed a food processing facility in Milan. When operating, ConAgra had a daily average water demand comparable to that of Smithfield Farmland (Burns & McDonnell 2003). Development and expansion of facilities, such as Smithfield Farmland and ConAgra, are not possible without a dependable water supply.

Although these problems were documented more than a decade ago, they have not been remedied and continue to create barriers for businesses seeking to expand in or relocate to this area. Because of the proprietary nature of future business plans, information is not available regarding other businesses that may have considered this area for relocation or expansion but declined to do so for lack of water. The importance of water in a business's relocation and expansion decisions was detailed in a letter to the Green Hills Regional Planning Commission by an economic development marketing and site selection firm. The letter stated that "water is a strategic economic development asset," and that "Communities and regions with ample water and wastewater treatment capacities will have an advantage…" (J. Ady, personal communication, Dec. 16, 2015). Water source dependability is also important because companies "want to understand the source of the water (groundwater or surface), its chemical characteristics, and the community's ability to treat various levels of biochemical oxygen demands in the water" (J. Ady, personal communication, Dec. 16, 2015). Lastly, the letter states that companies are "actively looking for new locations with better long-term water supplies" (J. Ady, personal communication, Dec. 16, 2015).

More recently, Kraft-Heinz has completed a $250 million expansion of its Kirksville facility. The new facility is operational and created an additional 448 jobs. The 450,000-square-foot facility is more than double the size of the original 188,000-square-foot facility (Kirksville Daily Express 2018). Additional water usage is expected to total 0.375 MGD for the facility expansion (Ken Dunlap with City of Kirksville, personal email, August 31, 2016).

As the economic development firm recognized in its letter to the Green Hills Regional Planning Commission, a dependable water supply could help convince businesses to relocate or expand their businesses in the 10-county region (J. Ady, personal communication, Dec. 16, 2015). A few businesses like Smithfield Farmland (0.923 MGD) or a series of smaller businesses and business expansions could require the 10 percent contingency (0.92 MGD), or even more, over the 100-year time frame.

Summary of Planning Contingencies

The four planning contingencies in this section addressed unforeseen changes in climate and increased drought risk, increased domestic water demand, increased agriculture demand, and increased business demand. As described above, any one of these planning contingencies could require the planned 10 percent or 0.92 MGD water supply contingency. The more likely scenario would include a portion of the water supply from multiple planning contingencies or all of the planning contingencies to reach the 0.92 MGD water supply. In either scenario, a planning contingency is appropriate and necessary to address additional future water needs.

1.5.1.2.2 Water Loss in Treatment and Distribution

Water demand in the 10-county region is presented as finished water demands, except for water supplied to Smithfield Farmland. Smithfield Farmland is a hog slaughter facility that buys primarily raw water from the NCMRWC. Current MDNR design standards require raw water sizing for surface water supplies to account for water loss because of treatment and distribution, or approximately 20 percent of the raw water supply (MDNR 2013a). These losses are standard in finished water distribution and account for system losses.

Accounting for water loss in treatment and distribution is summarized below.

Total Finished Water Demand

Inadequate Water Sources plus Planning Contingencies minus Smithfield Farmland
(9.186 MGD) + (0.92 MGD) - (0.923 MGD)

= Total Finished Demand (9.183 MGD)

Water Loss in Treatment and Distribution

Total Finished Demand times Twenty Percent Typical Loss
(9.183 MGD) X (0.20)

= Total Estimated Water Loss in Treatment and Distribution (1.837 MGD)

1.5.1.3 Total North Central Missouri Regional Water Commission Raw Water Supply Need

The lack of dependability of surface, groundwater, and out-of-region water systems showed a total water supply need of 9.186 MGD as shown on Figure 1.5.1.1-3. Prudent planning methodology requires a contingency to account for possible increases in water demand that cannot be reasonably predicted. A 10 percent contingency was chosen to account for climate change or severe drought, population or water demand growth, increased agricultural demand,

or an increased business demand. Water treatment and distribution losses were calculated in Section 1.5.1.2.2.

The total calculated NCMRWC raw water supply needed was determined by adding the following water supply components:

Lack of Dependability of Existing Systems (9.186 MGD)
plus Ten Percent Planning Contingency (0.92 MGD)
plus Estimated Water Loss in Treatment and Distribution (1.837 MGD)
= Total NCMRWC Raw Water Supply Need (11.943 MGD)

Projecting future water demands over the 100-year project life is inherently uncertain because of unpredictable changes in climate, population, business development, natural disasters, and other factors. Increasing uncertainty in future water supply is evidenced by the large number of water supply systems that have ceased water supply operations in the past 35 years. Deterioration of current water source systems caused by siltation of lakes, groundwater level declines, and other factors will likely continue, with water source-challenged systems looking for a dependable, affordable water supply. Those systems that are currently susceptible to drought shortages will continue to have reduced source capacity and increasing water deficits resulting from source deterioration, cost of meeting water quality standards, and climatic uncertainties.

A new source that would eliminate shortfalls in current supplies does not necessarily provide for all contingencies such as potential growth in industry or population that must be served over the next 100 years. The total water needed for the 10-county region includes replacing or supplementing water systems that are not dependable during the drought of record, planning for contingencies, and accounting for water loss in treatment and distribution. Changes in population dispersion, population growth patterns, industry density, political environment, and other factors could affect which systems are a part of this project. Recognizing these uncertainties, and consistent with the 2006 FEIS, 7 MGD was selected as the absolute minimum amount of raw water that an alternative must be able to provide.

The project provides a regional water system that would supplement the existing water suppliers in the 10-county region. A regional water system came at the request of MDNR because it regulates drinking water in Missouri and was reaffirmed in an October 2018 letter from Governor Parsons who calls the project “a part of Missouri’s strategic regionalization strategy”. The proposed Project is not intended to replace all water suppliers. Based on the North Central Missouri Regional Water Source Evaluation (Allstate 2016), the list of water suppliers that have an unreliable water supply during the drought of record were included in the 10-county region demand. The North Central Missouri Regional Water Source Evaluation builds on the Everett Baker report (MDNR 2004) that supports the water supply need for the region. The proposed Project will take pressure off existing water systems that do not join the NCMRWC.

Letters of support (Appendix B) for a dependable water supply were obtained from 18 water supply systems including 9 of the 12 primary water supply systems that were deemed to have inadequate water systems in the 2016 North Central Missouri Regional Water Source Evaluation Study (Allstate 2016, Appendix C). Not all the letters of support indicated an immediate use of the regional water supply system, though they indicated a future use if the need arises. Currently, 13 associated members are interested in joining the NCMRWC. It is the nature of water districts

and communities to reject claims that their water supply is vulnerable. If a water supply is available, future planning will make use of the water supply. Based on the 2016 North Central Missouri Regional Water Source Evaluation Study (Allstate 2016, Appendix C), future planning for the region must have another water source to plan for the drought of record.

1.5.2 Need for Flood Damage Reduction

This project intends to provide flood damage reduction benefits along a 22.5-mile reach of East Locust Creek above the confluence with Locust Creek (Figure 1.5.2-1). This reach in Sullivan County includes the community of Milan but is primarily comprised of agricultural land. The 2006 FEIS includes flood damage estimates and flood damage reduction benefits along both East Locust Creek and Locust Creek, referred to as “on-site” and “off-site”, respectively. The current analysis determines the flood damage reduction need and updates the on-site information from the 2006 FEIS. Analysis of the Locust Creek floodplain is consistent with the 2006 FEIS and is not revised further in the current document.

The East Locust Creek 100-year floodplain includes approximately 5,041 acres in the reach downstream from the toe of the dam and extending to the confluence with Locust Creek (Figure 1.5.2-1). According to National Land Cover Database (NLCD) data, the area includes 10 acres of high-density developed (urban) land, 29 acres of medium-density developed (normally residential) land, 73 acres of low-density developed (rural agriculture and residential) land, and approximately 86 acres of developed open space, including parks, industrial ground, and infrastructure such as roads and utility rights-of-way. The remaining acreage (4,843 acres) includes agricultural cropland, pasture, deciduous forest, and wetlands.

Past Flood Events

Anecdotal evidence offers insight into the threat to life and property posed by flooding along East Locust Creek. According to Officer Terry Michaels, Milan Chief of Police, East Locust Creek almost always overtops its banks even during common, nonsevere rain events. Floods have damaged commercial properties in Milan, and the floodwater routinely overtops bridges, cutting off access between communities located east and west of East Locust Creek (T. Michaels, personal communication, Dec. 30, 2014).

A major disaster declaration was issued October 31, 2014, for eight counties in northern Missouri, including Sullivan County, for severe storm damage and flooding that occurred September 9 and 10, 2014 (FEMA 2014). Sullivan County incurred some of the greatest damages, with assessments of $50.04 per capita ($335,969; U.S. Census 2010) in the county to allay some of the damage costs (FEMA 2014). Similar storm and flood damage affected northern Missouri, including Sullivan County, in May and June, 2013, with severe storms and a subsequent disaster declaration, as well as a disaster declaration for storm and flood damage in August 2010 (MSEMA 2014). Figure 1.5.2-2 shows the impact of a 100-year flood event to the City of Milan.

Extreme Weather Events and Future Flood Events

In the time since the 2006 FEIS was completed, there has been an increased awareness and focus on extreme weather events. Just as water supply will be affected by predicted extremes in precipitation and the potential for more frequent or extreme droughts, so too will the risk of flooding.

Recent research indicates that Missouri may be at risk for more frequent severe storm events with the potential to increase flood damages. The 2017 Climate Science Special Report states, “Significant increases in flood frequency have been detected in about one-third of stream gauge stations examined for the central United States, with a much stronger signal of frequency change than is found for changes in flood magnitude in these gauges.” In the Central U.S., a future increase in flood frequency is more likely than an increase in flood magnitude. (U.S. Global Change Research Program 2017).

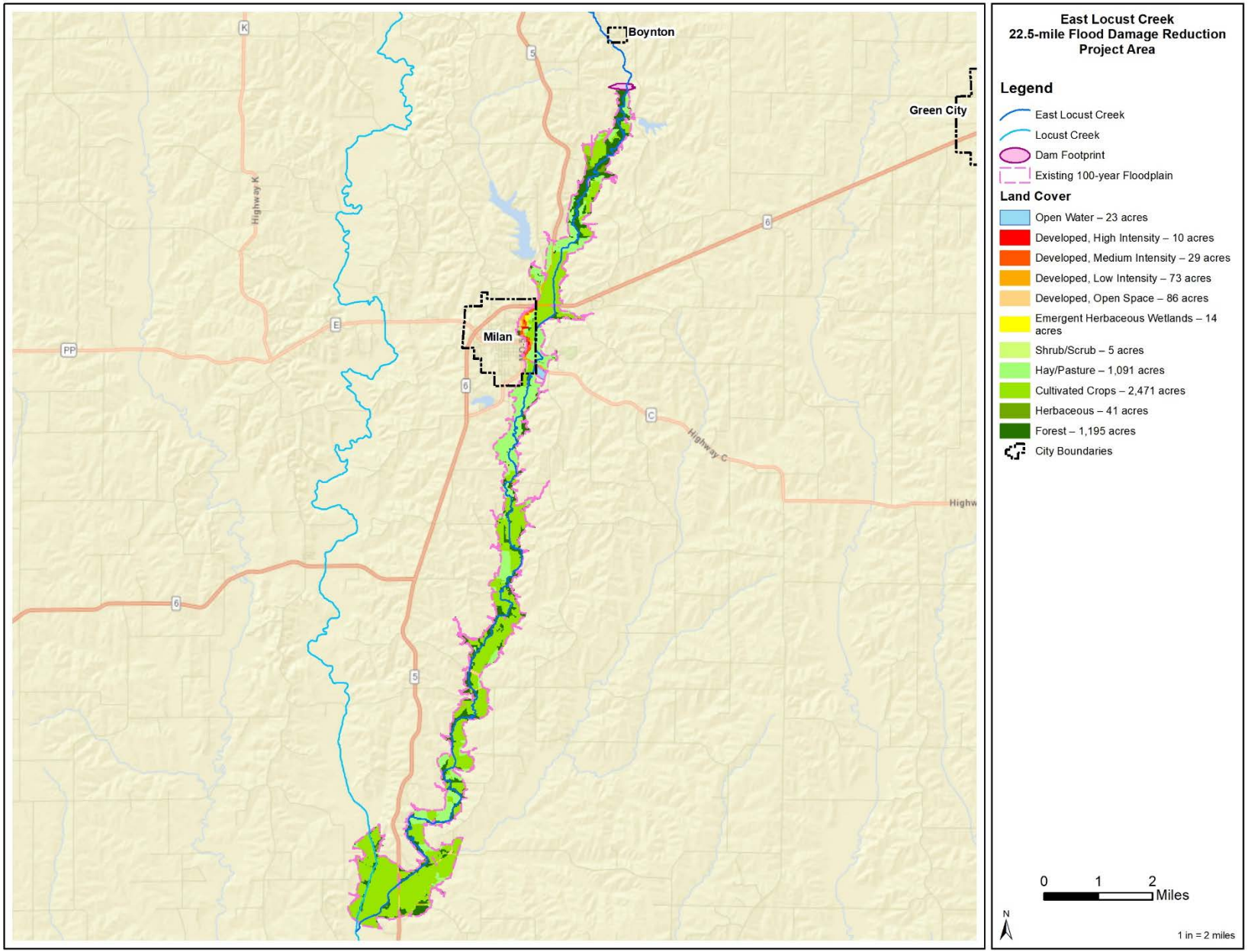


Figure 1.5.2-1. East Locust Creek 100-year Floodplain.

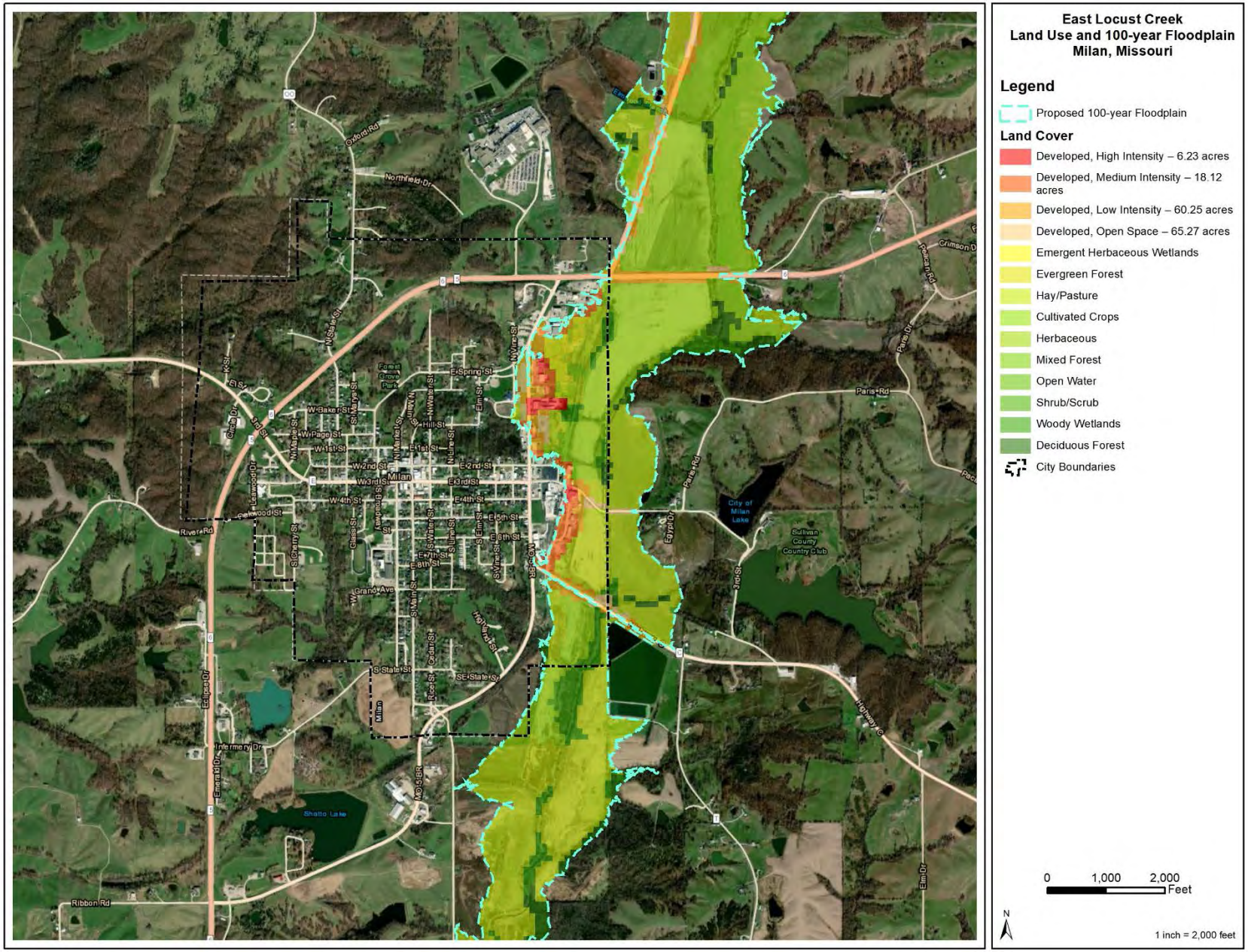


Figure 1.5.2-2. Milan 100-year Floodplain.

Floods occur primarily from March through June. The most damaging flood along East Locust Creek occurred in 1947 when 8,800 acres were flooded. This storm, estimated to be a 100-year event, dropped 7.1 inches of rain in 24 hours and caused an estimated $799,000 of crop and pasture damage, based on 2004 current normalized prices. Other off-site agricultural damages, such as fences and debris, were estimated to be $193,000 (NRCS 2006).

Flooding from heavy rains commonly occurs in most tributary streams in northern Missouri and may be expected once or twice in most years (Decker 2014). Flash flooding can be expected in minor streams following heavy thunderstorms, typically in the spring and early summer, but they may occur during any month. Since 2009, National Oceanic and Atmospheric Administration (NOAA) climatological data for Milan show at least two severe storms (defined as greater than 2 inches in 24 hours) per year, except for 2012, which was a period of exceptional drought. Five severe storms occurred in 2010 and three severe storms occurred in 2014, including a 6.9-inch downpour in September of that year.

The frequency of severe storms in Missouri – as predicted with modeled climate change – is expected to increase, with the potential of flash flooding also increasing because storms are likely to occur during anticipated wetter winters and springs (UCS 2009). Because more of the expected precipitation increases will fall as heavy downpours, infiltration amounts decrease and runoff volumes correspondingly increase, thereby increasing flood potential.

Annual Flood Damage Reduction

The July 1987 East Locust Creek Watershed Plan and Environmental Assessment proposed construction of 121 small floodwater retarding structures (FWRs) in the East Locust Creek Watershed. At the time that the 2006 East Locust Creek Watershed Revised Plan and Environmental Impact Statement were written, 72 small FWRs were constructed. Of these, 12 were in the Headwaters East Locust Creek HUC-12 above the proposed reservoir dam and 7 were in the Headwaters East Locust Creek HUC-12 and would be inundated either wholly or partially by the proposed reservoir dam. Twenty-two of the remaining structures were in the East Locust Creek HUC-12 floodplain below the proposed reservoir dam and 17 were in the Little East Locust Creek HUC-12, which is a tributary to East Locust Creek. The 2006 EIS proposed plan modified the earlier plan by recommending construction of the proposed East Locust Creek Reservoir in lieu of the remaining 21 unbuilt FWRs in the Headwaters East Locust Creek HUC-12 and the 6 remaining unbuilt FWRs in the East Locust Creek HUC-12. In addition, the 2006 plan proposed constructing 22 FWRs in the Little East Locust Creek HUC-12 in lieu of the 18 remaining unbuilt FWRs in the Little East Locust Creek HUC-12. Nine of the 22 FWRs were built before funding was pulled from the program. The remaining 13 are not expected to be re-funded."

The 72 FWRs constructed under the 1987 watershed plan reduced total average annual flood damages in the East Locust Creek and Locust Creek floodplains from $2,650,000 to $1,230,000, in 2005 dollars. The additional 9 FWRs constructed under the 2006 revised watershed plan resulted in a 7 percent reduction in estimated annual flood damages in the East Locust Creek and Locust Creek floodplains (from $1,230,000 to $1,140,000).

Average annual flood damages for the current analysis were calculated using the NRCS ECON2 model. ECON2 modeling determines damages between cross-sections from several known data points. It uses several types of information, including commodity prices, crop distributions, water surface elevations where damages begin, and elevation and areas affected for specific storm-

event flows based on the modeling of stream flood flows. Flood flows were computed using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) model. Flood flows estimated by the HEC-HMS model were entered into the River Analysis System (HEC-RAS) hydraulic model of East Locust Creek from the outlet of the proposed dam to the mouth at the confluence with the main stem of Locust Creek. HEC-RAS modeling estimates water surface elevations over the geographic area of interest for storm events of various frequencies.

ECON2 modeling calculates bridge damages using a damage curve for each bridge. The damage curve indicates how much damage occurs at certain water surface elevations. The ECON2 model then analyzes the flows for the different flooding frequencies to calculate the average annual damages (USDA 1990). The ECON2 model estimates that the cost of damages to infrastructure, such as roads, bridges, and utilities, is $73,600 per year.

ECON2 modeling was also used to estimate the annual damage to agricultural land, including cropland and pastureland. ECON2 modeling used hydraulic information from HEC-RAS and hydrologic information from HEC-HMS to determine the flooded area. The time of year that the flood event occurred was factored into the economic damages that occur from the flood event (USDA 1990). ECON2 modeling calculated that the average damages to crops and pasture are $674,000 per year.

Another way to calculate cropland flood damage is from crop insurance claims, which are tracked by the USDA Risk Management Agency and categorized by the natural disaster that caused the damage. While not all farmers have crop insurance, the 10-year average annual losses caused by flooding in Sullivan County are $71,153 (USDA 2014b). Crop insurance policies cover 50 to 80 percent of the yield and 55 to 100 percent of the price (USDA 2014b). The loss values are based on the crop price during the year in which the loss occurred. Crop losses are difficult to quantify because of replanting, partial loss, or loss of yield. Partial loss and loss of yield are losses in profit at harvest, while replanting losses could also include a reduction in yield and duplicated fuel, labor, and equipment costs, which are difficult to quantify.

The USDA Risk Management Agency's average annual value of $71,153 for Sullivan County (USDA 2014b) is likely below the actual agricultural loss value. However, the estimated crop and pasture losses identified from ECON2 modeling ($674,032) could be above the actual value. Neither estimate accounts for field damages. For the purposes of this DSEIS, a number between the two was chosen; the estimated crop losses caused by annual flooding are $100,000 for the flood damage within the 22.5-mile reach from the toe of the dam to the confluence of Locust Creek. The estimated value is in the middle of the range and accounts for additional flood damages to fields.

The total average annual flooding cost includes losses to crops and infrastructure. Based on an estimated average annual loss of $100,000 for crops and an average annual estimated $73,600 for infrastructure, the average annual flood damages total $173,600 along the main stem of East Locust Creek from the toe of the dam to the confluence with Locust Creek.

1.5.3 Need for Water-based Recreation

This project is intended to provide water-based recreation for the unmet demand in the 10-county region. The recreational need has been identified as water-based for fishing, nonrestricted boating activities (includes wake boating), and swimming. The recreational purpose for the East Locust Creek project is not and has not been to provide athletic recreational facilities such as golf, tennis,

basketball, soccer, or football. Key additional benefits associated with a lake for water-based recreation are camping, hiking, bird-watching/nature study, and picnicking within the area managed for wildlife habitat, among other potential uses. These additional benefits are secondary to the primary purpose of water-based recreation.

Quantifying the Regional Need for Water-based Recreation

The need for water-based recreation was derived from supply-and-demand data. The 2006 FEIS prepared a recreation evaluation for East Locust Creek that used the 1990 Missouri Statewide Comprehensive Outdoor Recreation Plan (SCORP) to develop demand estimates, and Uhlig (1980) to develop supply estimates. The 2006 FEIS analysis used a population within 25 miles of the proposed East Locust Creek Reservoir site, which included the entire population of Sullivan County and portions of populations from nine other counties. The results of the 2006 FEIS indicated a water-based recreation demand of 213,000 annual user-days after removing secondary recreational activities such as hiking and camping, and an estimated supply of 52,700 annual user-days from seven lakes within the 25-mile radius. The result of the recreational analysis determined an unmet demand of 160,000 annual user-days. The analysis concluded that the East Locust Creek project would support the unmet demand by supplying 72,000 annual user-days.

Since 2006, the 2013 – 2017 Missouri SCORP has been published by MDNR for the Missouri State Inter-agency Council for Outdoor Recreation, with updated demand estimates (NRCS 2006). This updated information quantifies rural and urban recreational uses and looks at trends to support future needs. The 2013 – 2017 Missouri SCORP indicates that fishing and hunting are two important activities for introducing youth to the outdoors and are much more popular in Missouri than in the U.S. as a whole, particularly among rural residents (MDNR 2013d). Furthermore, the 2013 – 2017 Missouri SCORP references the USFWS' 2006 National Survey of Fishing, Hunting, and Wildlife as indicating that two-thirds of rural Missourians go fishing each year, compared to 55 percent of urban residents.

Trends documented by the 2013 – 2017 Missouri SCORP for the next five years indicate fishing as the top activity expected to grow in Missouri (MDNR 2013d). According to the 2013 – 2017 Missouri SCORP, 20 percent of fishermen who fish at least once a year indicated their fishing will increase, while only five percent indicated their fishing will decrease. The 2013 – 2017 Missouri SCORP also indicates substantial resident participation for all types of boating, including motor boating, sailing, canoeing, and kayaking. The East Locust Creek purpose is consistent with the 2013 need for water-based recreation for fishing, swimming, and boating/sailing/ canoeing/kayaking, as determined by the 2013 – 2017 Missouri SCORP.

Use of the recreational site depends to an extent on the population living within a certain distance from it. A recreational market area (RMA) was developed based on the distance Missourians would travel to participate in outdoor recreation (MDNR 2013d). The 2013 – 2017 Missouri SCORP showed that 65 percent of rural Missourians would travel less than 50 miles for outdoor recreation on a weekend. For consistency with the other project purposes, the entire 10-county region is established as the RMA. The average distance from the center point of the 10-county region to its borders is approximately 47 miles. Using the 10-county region as the RMA, an estimated 65 percent of residents within the 10-county region would travel to a centrally located lake within the RMA and are included in the need analysis. The remaining 35 percent of residents are likely to travel outside the 10-county region for recreation and are not included in the need analysis. The population of the 10-county region is 107,130 people (U.S. Census 2010). Based

on an estimated 65 percent of residents who would travel 50 miles or less, the population of recreational users in the RMA totals 69,600 people.

Figures 1.5.3-1 and 1.5.3-2 show the RMA with existing lakes, stream access points, and county population based on the 2010 U.S. Census. For clarification, final recreation demand and supply numbers are rounded to four significant digits.

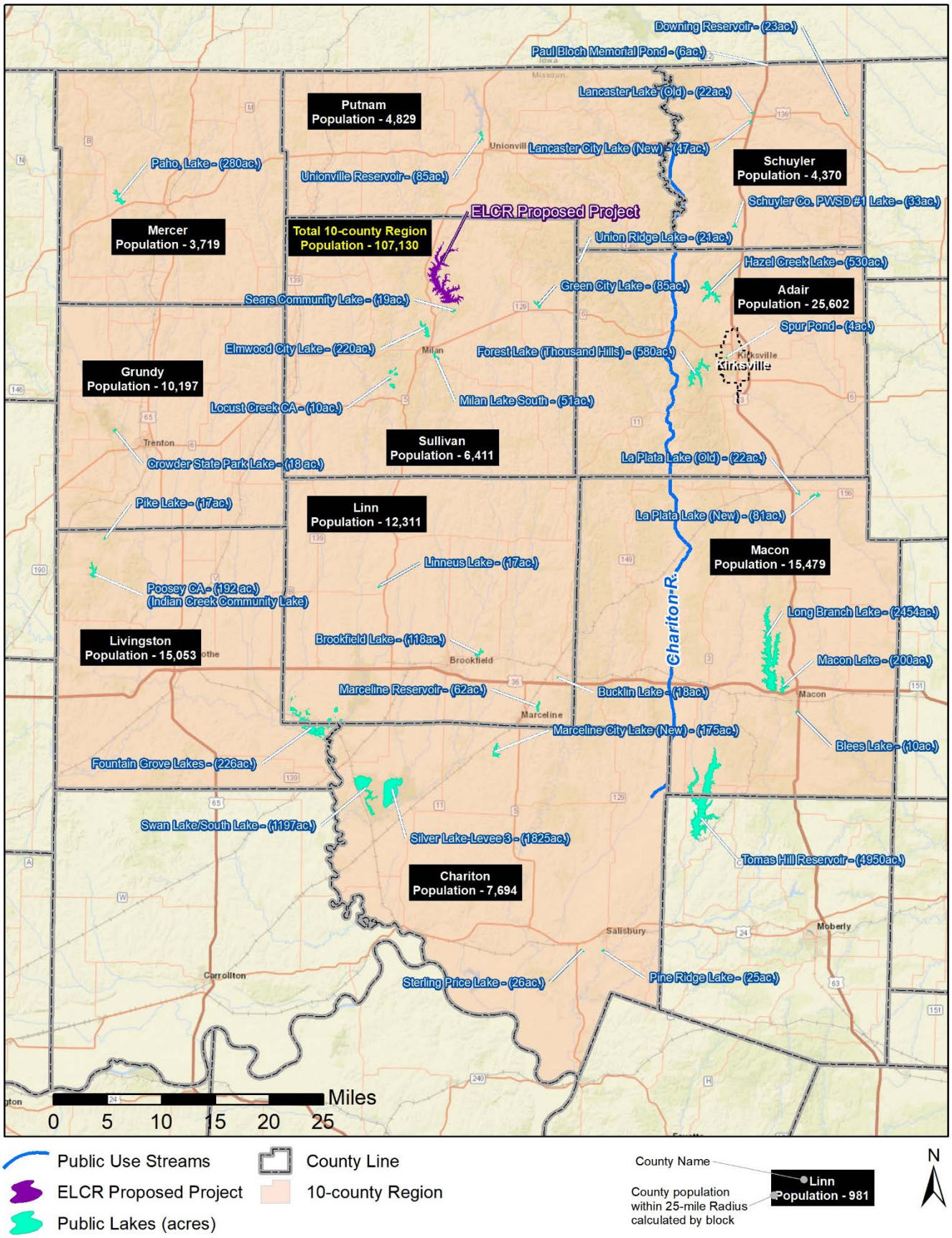


Figure 1.5.3-1. Lakes Within Recreation Market Area.

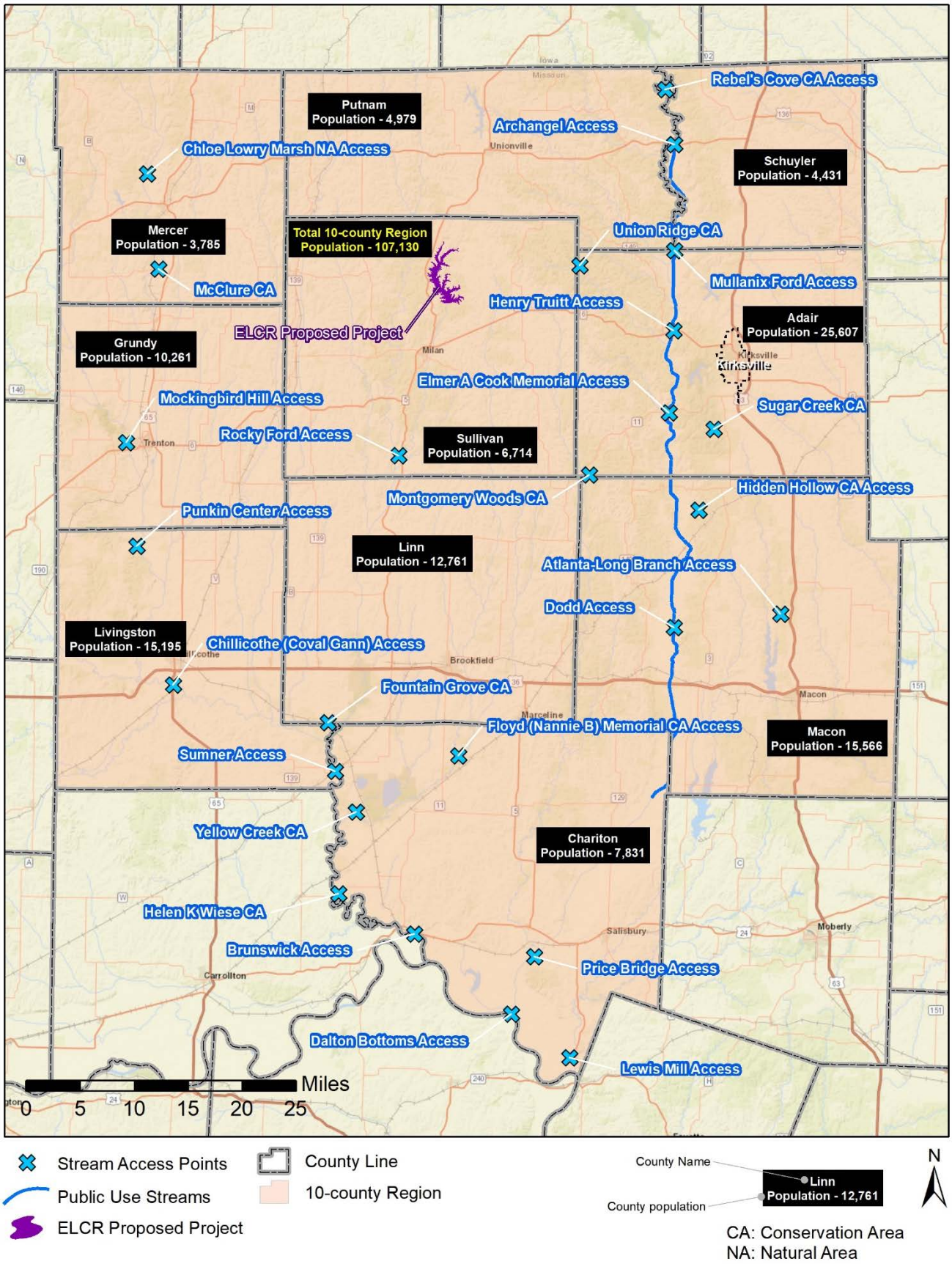


Figure 1.5.3-2. Stream Access Within Recreation Market Area.

Recreation Demand Calculations

Demand for recreation is based on how often people would use the recreation type in a year (annual user-days per person). The 2013 – 2017 Missouri SCORP includes participation data for the two categories of water-based activities – fishing and boating/sailing/canoeing/kayaking – that will be evaluated for East Locust Creek. Data from SCORP Table 9 (MDNR 2013d) was used to calculate the annual user-days per person for these two activities. Tables 1.5.3-1 and 1.5.3-2 summarize the methodology and resulting user-days for participants for each activity. Note that the total annual user-days per person is consistent with the USFWS 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, which stated the Missouri statewide average days fished per angler was 17 days (USFWS 2013).

Once user-days per person-demand was determined, the number of people who would fish or boat in the RMA was then estimated. The population within the 10-county region was modified by the percentage of people who indicated a willingness to travel to participate in outdoor recreation outside the 10-county RMA region. Sixty-five percent of the people who live in the 10-county region are willing to travel within the RMA for recreational opportunities. This assumes those willing to travel greater distances may go to facilities farther away from their residences. The calculations included a Travel Factor of 0.65 (65 percent).

Table 1.5.3-1. Calculation of Total Annual User-days for Fishing.

How Often do People Fish	Annual Visits (Days)	Percentage (%) of People Who Report Fishing this Often	Annual User-days per Person (Annual Visits x Percentage)
Once per year	1	15.5	0.2
Every 4 – 6 months	2	16.4	0.3
Every 2 – 3 months	5	8.2	0.4
Monthly	12	25.5	3.1
2 – 3x/month	30	10.0	3.0
Weekly	52	15.5	8.0
2 – 3x/week *	130	9.1	11.8
4 – 5x/week *	234	0	0
Daily *	365	0	0
Subtotal Annual User-days			26.8
Travel Factor			0.65
TOTAL ANNUAL USER-DAYS PER PERSON			**17.4**

* Because of seasonal restrictions, those surveyed who indicated daily or 4-5x/week were included as 2-3x/week or 130 annual visits.

Table 1.5.3-2. Calculation of Total Annual User-days for Boating/Sailing/Canoeing/Kayaking.

How Often do People Go Boating	Annual Visits (Days)	Percentage (%) of People Who Report Boating this Often	Annual User-days per Person (Annual Visits x Percentage)
Once per year	1	26.8	0.3
Every 4 – 6 months	2	19.1	0.4
Every 2 – 3 months	5	7.6	0.4
Monthly	12	21.0	2.5
2 – 3x/month	30	5.7	1.7
Weekly	52	12.0	6.2
2 – 3x/week *	130	7.6	9.9
4 – 5x/week *	234	0	0
Daily *	365	0	0
Subtotal Annual User-days			21.4
Travel Factor			0.65
TOTAL ANNUAL USER-DAYS PER PERSON			**13.9**

* Because of seasonal restrictions, those surveyed who indicated daily or 4-5x/week were included as 2-3x/week or 130 annual visits.

The Total Annual User-days per Person in the relevant population was calculated for each of the two recreational uses, and then multiplied by the relevant population to obtain the total annual demand, as summarized in Table 1.5.3-3.

Table 1.5.3-3. Annual User-days Demanded by the Relevant Population.

Activity	Percent (%) of Population Participating in this Activity*	Number of People Participating	Annual User-days per Person	Demand Annual User-days
Fishing	59	63,207	17.4	1,100,000
Boating/Sailing/ Canoeing/Kayaking	52	55,708	13.9	774,000
			TOTAL DAYS	**1,874,000**

*Source: MDNR 2013a

For outdoor fishing and boating/sailing/canoeing/kayaking, a demand exists for 1,874,000 user-days of recreation from residents within the 10-county RMA.

Supply Calculations

The methodology to calculate total recreation supply for fishing and boating within the RMA is consistent with the methodology used in the 2006 FEIS. One difference is that river access points were not included in the 2006 FEIS but are included in this DSEIS. Because estimates of supply can vary, three methodologies were compared, as described below.

Uhlig (1980) Methodology

The Uhlig method, used in the 2006 FEIS, bases supply on parking availability. The RMA includes the 10-county region and contains 13,700 acres of public lakes and 64 miles of stream access. Adequate parking is an essential component of supply. To determine supply, the 2006 FEIS used availability of parking; it estimated the number of parking spaces by multiplying the total waterbody

acreage by 0.1. For the DSEIS, existing parking spaces were estimated by using aerial imagery to measure the area of the parking lot at each waterbody. Parking spaces were then estimated from the average space needed for a car and truck with trailer. The areas required for a single car or truck with trailer parking space were calculated based on reviewing USACE lakes with distinguishable parking stalls and measuring the square footage required for a car parking space (355 square feet) or a truck with trailer space (587 square feet). Parking spaces created by a turn-in or circle drive were estimated based on a vehicle requiring 30 feet to park and were included as additional parking spaces. The average of these two numbers (471 square feet) was used to estimate the number of parking spaces at existing lakes and river accesses (Table 1.5.3-4). A total of 1,869 available vehicle spaces is estimated for the 10-county region.

Table 1.5.3-4. Lake and River Access Parking Spaces.

Missouri Department of Conservation and Public Lake and River Access	Stream Access (miles)	Lake or Pond Size (acres)	Parking Lot Area (square feet)	Additional Parking Spots	Total Parking Spots
Archangel Access	0.20	0	7,252	0	15
Brookfield City Lake	0.00	118	19,709	22	64
Brunswick Access	0.10	0	18,400	0	39
Bucklin Lake	0.00	18	0	5	5
Chillicothe (Coval Gann)	0.20	0	3,927	0	8
Dalton Bottoms Access	0.25	0	30,520	0	65
Dodd Access	0.25	0	6,226	0	13
Downing Reservoir	0.00	23	1,411	2	5
Elmer A. Cook Memorial	0.10	0	3,222	0	5
Floyd (Nannie B) Mem CA*	0.25	0	0	1	1
Forest Lake (Thousand Hills)	0.00	580	121,354	0	258
Fountain Grove CA	0.00	226	0	0	22
Fountain Grove CA	12.00	0	6,297	0	13
Green City Lake	0.00	85	2,830	0	6
Hazel Creek Lake	0.00	530	14,131	2	32
Henry Truitt Access	0.13	0	7,751	0	16
La Plata City Lake	0.00	81	3,982	0	8
Lake Paho CA	0.00	280	11,961	86	111
Lancaster	0.00	6	0	2	2
Lancaster City Lake	0.00	47	5,906	0	13
LaPlata Lake (Old)	0.00	22	0	5	5
Lewis Mill Access	0.20	0	7,069	0	15
Linneus Lake	0.00	17	0	3	3
Locust Creek CA	0.00	10	3,616	2	10
Long Branch Lake	0.00	2,454	52,562	305	417
Macon (Blees Lake)	0.00	10	3,221	0	7
Macon City Lake	0.00	200	7,743	17	33
Marceline Reservoir (old Marceline City)	0.00	62	17,059	0	36
Marceline City Lake	0.00	175	4,554	0	10
McClure CA	1.00	0	2,439	0	5
Milan (Elmwood Lake)	0.00	220	5,395	4	15
Milan Lake South	0.00	51	2,250	5	10
Mockingbird Hill Access	0.30	0	6,331	0	13
Mullanix Ford Access	0.17	0	6,282	0	13
Poosey CA (Indian Creek)	0.00	255	56,877	2	123

Missouri Department of Conservation and Public Lake and River Access	Stream Access (miles)	Lake or Pond Size (acres)	Parking Lot Area (square feet)	Additional Parking Spots	Total Parking Spots
Price Bridge Access	0.70	0	0	2	2
Punkin Center Access	0.30	0	1,303	0	3
Rebel's Cover CA	5.00	0	20,267	0	43
Rocky Ford Access	0.14	0	3,588	0	8
Salisbury (Pine Ridge Lake)	0.00	25	12,317	0	30
Schuyler County PWSD No.1	0.00	33	0	2	2
Sears CL**	0.00	19	6,800	0	14
Silver Lake	0.00	1,825	719	6	8
Spur Pond	0.00	4	4,053	0	9
Sterling Price CL	0.00	26	0	7	7
Sumner Access	0.10	0	14,796	0	31
Swan Lake	0.00	1,197	3,197	0	7
Thomas Hill Reservoir CA	0.00	4,950	95,693	0	253
Union Ridge	0.00	21	9,223	0	20
Unionville (Lake Mahoney)	0.00	85	5,439	2	14
Yellow Creek CA	4.00	0	1,120	0	2
TOTAL	**25.4**	**13,655**	**618,792**	**482**	**1,869**

Source: MDC 2017a
Note: Lakes are indicated by the grey rows and streams are indicated by the white rows.
* CA = Conservation Area; **CL = Conservation Lake

The supply calculations do not account for the quality of the public lake or stream access or the life expectancy of the public lake or stream access. Many of the lakes are already over 50 years old and may not be functioning over the desired 100-year life expectancy of the project. Older lakes have increased potential for fish kills and sedimentation, and high nutrient inputs can increase eutrophication and affect the quality of the fishery and potentially impact the safety of human water contact. For the purposes of this DSEIS, to be conservative, a high-level analysis was completed that assumes the existing recreational lakes and stream accesses are available long-term.

The 2006 FEIS used the methodology of Uhlig (1980) to determine the number of user-days supplied by these lakes for all recreational types each year. For this DSEIS, the calculations are as follows:

- 1,869 spaces * 4 people per car * 2 times per day (Uhlig 1980) = 14,952 people per day
- 14,952 people per day / 0.0231 (Sunday-use factor; Uhlig 1980) = 647,273 annual user-days of recreation supplied

Based on the Uhlig 1980 methodology, the existing lakes and stream accesses in the 10-county region provide 647,000 annual recreation user-days for lake and stream access. This totals 107,000 stream user-days for stream access (310 parking spaces) and 540,000 lake user-days for lake access (1,559 parking spaces). The lake access equates to 39.5 user-days per acre of lake.

U.S. Army Corps of Engineers Recreation Use Data

The annual recreation use of USACE lakes in northern Missouri was evaluated as an alternative method of calculating the annual recreation user-days supplied by lakes in the 10-county region.

The USACE has recreation use data on three USACE lakes in northern Missouri: Smithville Lake, Long Branch Lake, and Mark Twain Lake (USACE 2013a).

The USACE data duplicates similar recreational uses that could occur during a single use. For example, the water skiers would also be counted as boaters. To account for the duplicate uses, a correction factor was subtracted to make the total uses consistent with the total person trips. As shown in Table 1.5.3-5, the USACE lakes provide approximately 73 annual recreation user-days per acre.

Table 1.5.3-5. Average Annual Recreation Use – U.S. Army Corps of Engineers Lakes.

Skiers, Boaters, and Fishermen Person-Trips			
USACE Lake	Person Trips	Lake Acres	Trips per Acre
Long Branch	162,389	2,430	66.8
Mark Twain	1,085,361	18,600	58.4
Smithville	672,786	7,190	93.6
Average	**n/a**	**n/a**	**72.9**
Calculation of Supply of Lake User-days			
Lake Acres in the 10-county Region			13,655
USACE Average Trips per Acre			72.92
Total Annual User-days			**996,000**

Source: USACE 2013a

Based on 13,655 lake acres in the 10-county region, this would total 996,000 annual lake user-days. Because the lake acres do not account for stream access, 107,000 annual stream user-days from stream access are added to the USACE recreation use data. This totals 1,103,045 annual recreation user-days of water-based recreation for the 10-county region using USACE data.

Missouri Department of Conservation Recreation Use Data

The annual recreation use of Missouri Department of Conservation (MDC) lakes in the 10-county region also was evaluated as an alternative method of calculating the annual recreation user-days supplied by lakes in the 10-county region (MDC 2016). The MDC recreation use data is available for 18 lakes in the 10-county region; other lakes in the 10-county region did not have MDC data available. The lakes include municipal lakes, USFWS lakes, and USACE lakes. One of the lakes, the USFWS Swan Lake, was removed because the lake uses do not include boating or fishing, as indicated by the low number of recreational uses.

The MDC report based the recreational uses (angler days) on surveys of fishing permit holders. The fishing permit holder numbers do not include people 65 years and older, or ages 3 to 15 years, because these groups are not required to have permits. In order to include these groups, the data in the MDC report was “corrected” based on the percentage of people who fish in Missouri and the population in the 65 years and older category and the 3 years to 15 years category. Tables 1.5.3-6 and 1.5.3-7 show the recreation use calculations.

Table 1.5.3-6. Missouri Department of Conservation Data Correction.

Correction Factor Calculations	
Missouri Population (2010)[1]	5,988,927
Number of People holding Missouri Fishing Permits[2]	747,436
Missouri Population 65 years and older or 3 to 15 years of age[1]	1,867,880
Estimated number of People age 65 and older or 3 to 15 years of age that fish	233,117
Correction Factor (percent of population that do not need permits)	0.31
% of Missouri population that fishes	**16.4**

[1] Source: U.S. Census 2010
[2] Source: MDC 2016

Table 1.5.3-7. Missouri Department of Conservation Data Annual Lake Use.

Lake Name	Lake Acres	Lake Uses (User-days per Acre)	Recreation Uses Correction Factor (User-days per Acre)	Average Annual (User-days per Acre)
Brookfield City Lake	118	807	1,059	9
Forest Lake (Thousand Hills)	580	23,293	30,558	53
Fountain Grove CA	226	32,598	42,765	189
Green City Lake	85	4,741	6,220	73
Hazel Creek Lake	530	4,005	5,254	10
La Plata City Lake	81	8,056	10,569	130
Lake Paho CA	280	10,624	13,938	50
Lancaster City Lake	47	1,030	1,351	29
Locust Creek CA	10	3,062	4,017	408
Long Branch Lake	2,454	42,397	55,620	23
Macon City Lake	200	3,121	4,094	20
Marceline City Lake	175	22,551	29,584	169
Milan (Elmwood Lake)	220	206	270	1
Poosey CA (Indian Creek Community Lake)	255	12,803	16,796	66
Sterling Price CL	26	2,316	3,038	117
Thomas Hill Reservoir CA	4,950	118,227	155,101	31
Union Ridge	21	4,309	5,653	269
TOTALS	**10,258**	**294,146**	**385,887**	**38**

Source: MDC 2016

Based on the 13,700 lake acres in the 10-county region, the MDC method would total 519,000 annual lake user-days. Because the lake acres do not account for stream access, the 107,000 annual stream user-days from stream access are added to the MDC recreation use data. This totals a supply of 626,000 annual user-days of water-based recreation for the 10-county region.

Comparison of Methodologies

The Uhlig 1980 methodology is the only methodology that accounts for peak use days. Use of actual or survey data that provides average annual recreation use does not account for peak days but assumes peak use if factored in on an annual basis. The USACE lake data is based on lakes that are all larger than the Proposed Action and in the case of Mark Twain Lake, substantially larger. The quality of amenities may also differ between USACE lakes and other lakes in the 10-county region.

The same number of annual user-days for stream access were included for all three methodologies and were based on Uhlig 1980. Comparison of the lake analysis shows a supply range of 519,000 (38 user-days per acre) to 996,000 annual lake user-days (72 user-days per lake acre) with an average of 685,000 annual lake user-days. Because the Uhlig 1980 methodology is the only methodology of the three that accounts for peak use days, the 540,000 annual lake user-days (39.5 user-days per lake acre) is used for calculating the lake supply. This value is consistent with and within the range of other methodologies for calculating recreation use in the 10-county region. The 540,000 annual lake user-days is added to the 107,000 annual stream user-days to result in a supply total of 647,000 annual recreation user-days.

Data Limitations

Determining recreation supply by parking spaces does not determine who will use the parking spaces. Waterbodies within the RMA have numerous uses in addition to water-based recreation. For example, Thousand Hills Lake has many nonwater-based recreational uses that include camping (primitive and cabins), hiking, dining, picnicking, and wildlife viewing. These additional uses would reduce the total supply of parking spaces for water-based recreational uses.

In addition, many of the lakes in the 10-county region have boating restrictions that do not allow boat wakes, require 10 horsepower or less motors, or only allow electric motors. MDC policy states that lakes smaller than 70 acres can only support electric motors. Of the remaining lakes in the 10-county region, only Long Branch, Thomas Hill, and Thousand Hills lakes do not have motor restrictions or allow up to 90 horsepower motors. Other lakes larger than 70 acres have restrictions that include electric only or no-wake boating (MDC 2017a). Lakes with motorized restrictions are not able to provide the full range of boating opportunities as described in the Missouri SCORP and result in additional limitations on the supply calculated using the method of Uhlig 1980.

Recreational fishing in the 10-county area is tied to older lakes, many of which were built prior to 1970. Several of these lakes are experiencing water quality issues and declining sportfish populations. A person's desire to fish is determined not only by the lake size or proximity, but also, at least in part, by the quality of fisheries available. The Uhlig methodology (1980) does not account for the quality of a fishery in determining the recreational opportunities it can provide.

The data limitations result in a calculation of annual recreation user-days that overestimate the supply in the 10-county region. Because the annual recreation user-days calculated by Uhlig cannot be split into specific uses, the overestimation was not adjusted.

Unmet Demand Results

The recreation supplied by waterbodies in the 10-county region includes activities other than water-based recreation (boating and fishing), and the demand does not account for lake-based swimming. With the data limitations, the Unmet Demand for boating and fishing is determined by subtracting supply from demand as follows:

Demand (1,874,000 annual recreation user-days*)*
– Supply (647,000 annual recreation user-days)
= Unmet Demand (1,227,000 annual recreation user-days)

The unmet demand for the 10-county region, as calculated based on public surveys from the 2013 – 2017 Missouri SCORP, and water-based recreational opportunities as determined by Uhlig (1980), is 1,227,000 annual user-days.

Demand calculations were consistent between the current methodology and 2006 FEIS. The source of data for the demand calculations changed from the 1990 Missouri SCORP to the 2013 – 2017 Missouri SCORP.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

2.0 Alternatives Analysis

This alternatives analysis is intended to meet the requirements of both NEPA and Clean Water Act Section 404(b)(1) guidelines. Both require that a reasonable range of alternatives be considered. The NEPA alternatives analysis focuses on screening alternatives that are reasonable and feasible and meet the purpose and need for the project. The Clean Water Act Section 404(b)(1) process focuses on determining a practicable alternative that is the least damaging to aquatic resources while considering other significant adverse environmental consequences. Practicable means "available and capable of being done after taking into consideration cost, technology, and logistics" (40 CFR 230.3(g)). In terms of the LEDPA analysis, the least environmentally damaging alternative focuses primarily on aquatic resources and secondarily on a public interest review of other environmental resources. The alternatives discussed were developed jointly with the regulatory agencies to satisfy both NEPA and Clean Water Act Section 404(b)(1) requirements.

Multipurpose Project

The project proponent, in coordination with NRCS and MDNR, has developed a project with three purposes: water supply, recreation, and flood damage reduction. The project alternatives must meet each of the three purposes. Each project purpose is equally weighted and is a requirement during the analysis of alternatives. This DSEIS document presents each project purpose individually with the goal of screening alternatives that do not meet the individual purpose. Alternatives that pass the screening criteria are combined and considered for the multipurpose Preferred Alternative.

In discussion with regulatory agencies and with a goal of identifying alternatives that would satisfy both the NEPA and the Clean Water Act Section 404(b)(1) requirements, a list of alternatives was developed by the project proponent and NRCS. The alternatives presented in the individual purpose sections do not necessarily meet all three project purposes and may require a combination with other alternatives to meet the multiple purposes required for this project. Because the project alternatives may provide one, two, or three of the project purposes, alternatives that meet two or three of the project purposes will be presented in each individual purpose section as a multipurpose project.

The intent of each individual purpose section is to screen alternatives to see if they meet that specific project purpose; not to compare their impacts. Screening of alternatives with regard to preliminary impact analysis occurs in the multipurpose alternatives analysis section where the alternatives that meet all three project purposes are compared for impacts. The multipurpose alternative analysis section will select the Preferred Alternative.

Screening Criteria

Each of the three project purposes includes the development of alternatives and screening criteria that allow the project proponent to meet the purpose and need for each individual project purpose. An alternative is eliminated from consideration if it does not meet an individual project purpose or cannot be combined with another alternative to meet an individual project purpose as determined by the screening criteria. Thresholds within the screening criteria are intended to eliminate alternatives but allow for analysis of a reasonable range of alternatives. Screening for a

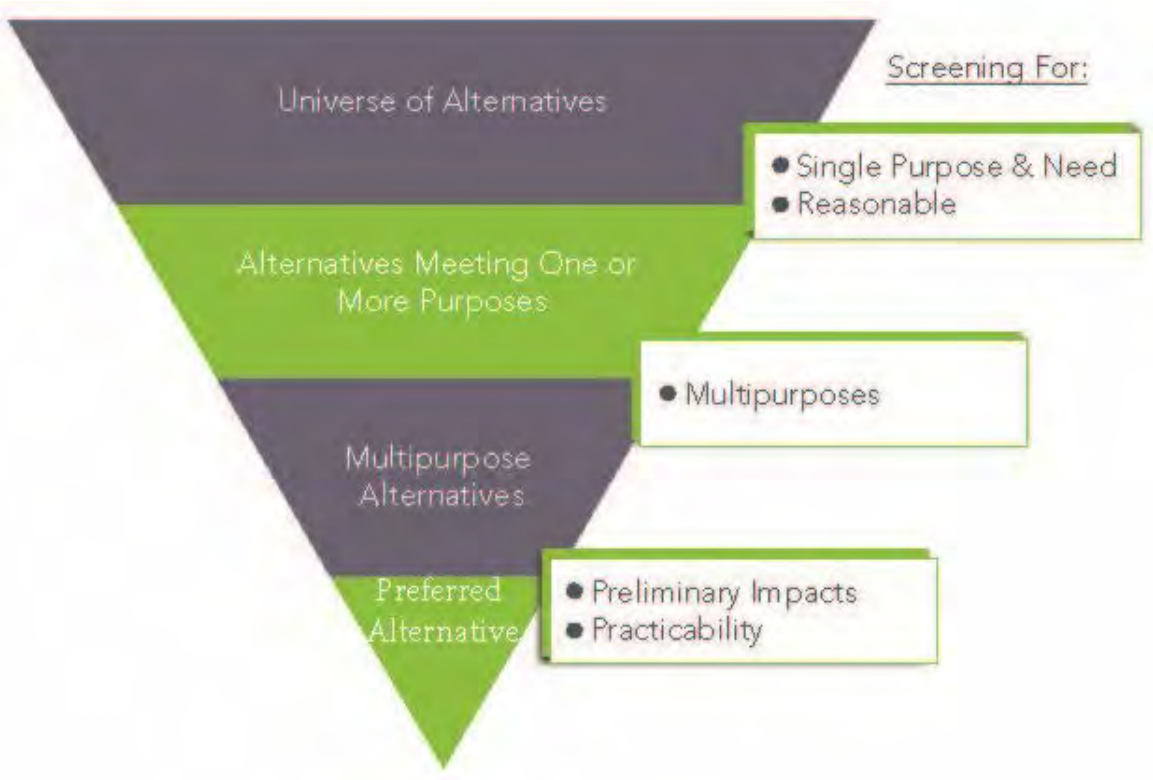
reasonable range of alternatives allows a more detailed evaluation of a smaller number of alternatives that meet all of the project purposes and needs.

Combination of Alternatives

Alternatives are combined in the individual purposes sections and in the multipurpose section. In the individual purposes section, an alternative may be combined with another alternative if both do not individually meet the screening criteria. Alternatives that individually meet the screening criteria and also meet the project purpose are considered in the multipurpose analysis section.

In the multipurpose analysis section, alternatives that have met screening criteria for at least one individual purpose but do not meet all three project purposes are combined with other alternatives to create a combination that meets all three purposes. Combined alternatives for both the individual purposes and for the multipurpose analysis that have either the lowest life cycle cost or the fewest wetland, stream, or forest impacts are carried forward for further analysis.

The alternatives screening process can be complicated and lengthy, so this "directory" will appear in various places throughout this chapter to help the reader follow along in the screening process.



Evaluation of Alternatives

Alternatives which were carried forward from the initial screenings were analyzed to meet the requirements of the Clean Water Act Section 404(b)(1) guidelines and the Endangered Species Act. For consistency in comparing all alternatives in this chapter, existing databases were used to analyze wetland, stream, and forest impacts. Detailed studies and analyses of impacts have been completed for the Proposed Action and are presented in the 2006 FEIS and sections 3, 4, and 5 of the DSEIS.

Impacts to wetlands for all alternatives are based on the National Wetlands Inventory (NWI). Impacts to streams for all alternatives are based on Missouri stream classification, which ensures consistency in comparing alternatives. MDNR stream surveys are completed once every three years as part of a recreational use attainability analysis (MDNR n.d.) and are used to determine the stream classification that is published in the code of state regulations. Detailed information on the Proposed Action impacts to wetlands and streams, as well as other resources that are being evaluated in this DSEIS, is presented in sections 3, 4, and 5.

For consistency in comparing all alternatives, forest impacts were calculated using the NLCD and were included in the evaluation criteria as a possible indication of impacts to the habitat of threatened or endangered bats. A detailed bat study has been completed for the Proposed Action and a summary of the study results is included in Section 3.

Water treatment facilities and water transmission lines are connected actions to the Proposed Action. The same connected actions would be needed for all multipurpose alternatives to meet the project purpose and need for water supply. Because the connected actions are a constant for each alternative and do not increase or decrease based on the alternative, they are not described for each alternative. The proposed water treatment plant is anticipated to be built either at the existing NCMRWC water treatment site or at a new site that does not have impacts to streams, wetlands, or forest. The water transmission lines have not been designed and the routes provided in Figure 2.0-1 are conceptual only. The exact location of the transmission lines would be designed as the distribution system is built out over time. Construction of the distribution system would have temporary impacts to streams and wetlands. Permanent impacts are considered for forested areas and for palustrine forest (PFO) wetlands. Based on the conceptual diagram, the forest impacts total 466 acres and the PFO wetlands impacts total 30 acres.

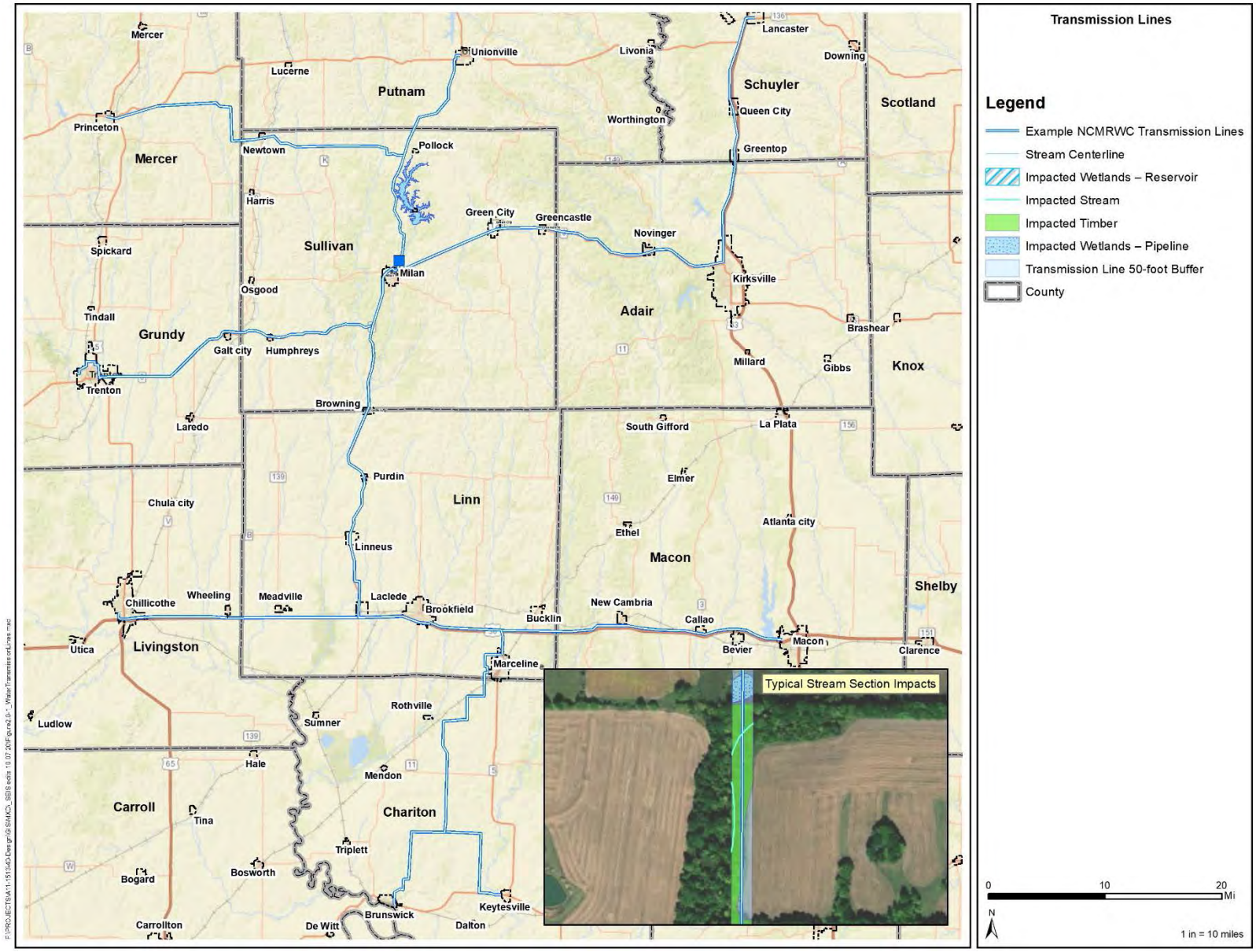


Figure 2.0-1. Water Transmission Lines.

Alternative Life Cycle Cost Development

Life cycle cost is used to determine if alternatives are practicable in the multipurpose alternatives analysis section. The life cycle costs are based on USDA bulletin 1780-2 and include costs associated with construction, nonconstruction, and operation and maintenance costs over the life of a project (USDA 2013). The life cycle cost description is included in Appendix A.

Alternative Naming Convention

Some of the alternatives are described in only one project purpose section, whereas others are found in more than one section. To be consistent in naming the alternatives that appear in different sections, alternatives were named based on the number of project purposes the alternative could provide and the individual purpose the alternative could provide.

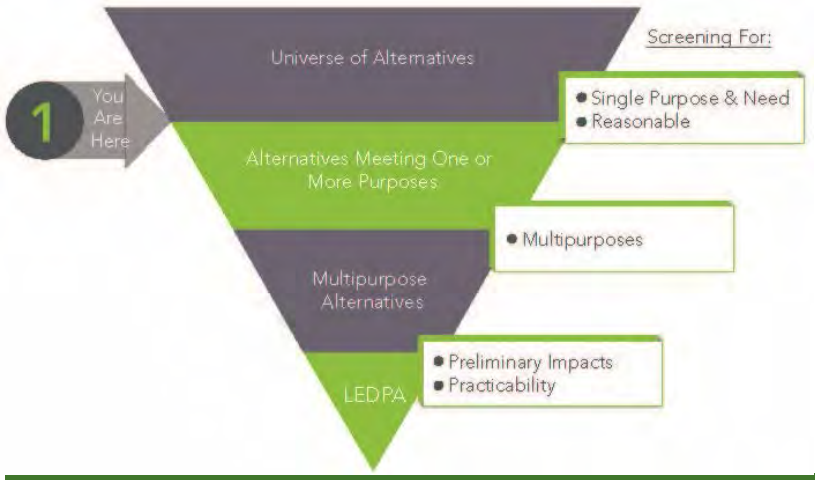
The list below describes how different alternatives are named and how they are evaluated in the alternatives analysis.

- **Alternatives providing all three purposes are named MA followed by the number to indicate a multipurpose alternative.** These alternatives provide all three of the project purposes of water supply, flood damage reduction, and water-based recreation opportunities. Multipurpose alternatives do not need to be combined with other alternatives.
- **Alternatives providing two project purposes are named DPA followed by the number to indicate a dual purpose alternative.** An alternative that provides two of the project purposes would need to be combined with an alternative providing the third purpose to create a multipurpose alternative; it would not be combined with an alternative for the two purposes already met.
- **Alternatives providing one project purpose are named WA followed by the number to indicate a water supply, RA followed by the number to indicate a water-based recreation, or FA followed by the number to indicate a flood damage reduction alternative.** Alternatives that could provide one of the project purposes would need to be combined with one or more alternatives providing the remaining two purposes to create a multipurpose alternative; they would not be combined with an alternative for the purpose already met.
- **No Action Alternative.** Although this alternative does not meet any of the project purposes, it is carried forward as a baseline comparison, as is required by NEPA.

2.1 Water Supply Alternatives Development

The water supply project purpose is:

"Provide a dependable, affordable long-term water supply to meet the water demand for the 10-county region of north-central Missouri including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties."



This section screens the universe of alternatives for water supply.

A list of alternatives was developed that was analyzed to determine whether the alternatives could meet the purpose and need for water supply.

The MDNR has identified the need for an adequate, dependable, and high-quality regional water supply system for the rural areas and municipalities of north-central Missouri and is working with the NCMRWC to develop it (2017 MDNR Letter – Appendix B). As demonstrated in the Burns & McDonnell feasibility study (Burns & McDonnell 2003) and Chapter 1 of this DSEIS, an additional drinking water source in north-central Missouri is needed to meet the existing and future needs of water suppliers and water users in the region during the drought of record, as well as to provide resiliency against uncertainty in future water demands and climate change.

This analysis assumes that the current water treatment plant at Milan will be expanded to provide the 7 MGD water supply. The current water treatment plan was designed to allow for a future expansion. The expanded facility is anticipated to have minimal environmental impacts and is not included in the alternative's environmental impacts. The Milan water treatment plant is centrally located in the 10-county region and provides an optimal location to serve the 10-county region. The expansion of the Milan water treatment plant is included in the 2006 EIS.

To compare likely environmental impacts, all alternatives include a conceptual alignment of transmission lines from the water supply source to the existing NCMRWC water treatment facility in Milan. The alignment for the transmission lines was chosen based on following the most direct route along existing highways. However, the actual path for the selected alternative can be expected to change somewhat during the final design phase of the project, with the intent of finding the most cost-effective route and further minimizing environmental impacts.

To compare life cycle costs, cost estimates for alternatives that met the screening criteria included an expanded water treatment facility cost that covers the life cycle cost for the infrastructure and equipment required to produce finished water, or the life cycle cost of "purchasing" capacity from existing facilities. Alternatives that do not meet the screening criteria do not include cost estimates.

For consistency in comparing all alternatives on an equal basis, environmental impacts to streams, wetlands, and forest areas were calculated from publicly available Missouri stream classification, NWI, and NLCD data.

Water Supply Alternatives Considered

The following list includes all the water supply alternatives that are analyzed in this section:

No Action Alternative

Groundwater Sources

- Water Supply Alternative 1 (WA1) – Drill wells into glacial aquifers
- Water Supply Alternative 2 (WA2) – Drill wells into bedrock aquifers
- Water Supply Alternative 3 (WA3) – Drill wells into Missouri River alluvium
- Water Supply Alternative 4 (WA4) – Drill wells into Mississippi River alluvium
- Water Supply Alternative 5 (WA5) – Drill wells into Grand River alluvium

Connection to Existing Systems

- Water Supply Alternative 6 (WA6) – Livingston County PWSD No. 4
- Water Supply Alternative 7 (WA7) – RRWA
- Water Supply Alternative 8 (WA8) – MMU
- Water Supply Alternative 9 (WA9) – Missouri American Water Company – Brunswick
- Water Supply Alternative 10 (WA10) – Salisbury
- Water Supply Alternative 11 (WA11) – Chillicothe Municipal Utilities

Streams and Rivers

- Water Supply Alternative 12 (WA12) – Thompson River
- Water Supply Alternative 13 (WA13) – Locust Creek

Existing Lakes

- Water Supply Alternative 14 (WA14) – Forest Lake (Thousand Hills)
- Water Supply Alternative 15 (WA15) – Green City Lake
- Water Supply Alternative 16 (WA16) – Elmwood Lake
- Water Supply Alternative 17 (WA17) – Unionville Lake
- Water Supply Alternative 18 (WA18) – Hazel Creek
- Water Supply Alternative 19 (WA19) – Mark Twain Lake

Creation of a New Reservoir

- Dual Purpose Alternative 1 (DPA1) – Create an offline reservoir
- Dual Purpose Alternative 2 (DPA2) – Big Locust Creek
- Dual Purpose Alternative 3 (DPA3) – Little East Locust Creek
- Dual Purpose Alternative 4 (DPA4) – West Fork Locust Creek
- Dual Purpose Alternative 5 (DPA5) – Yellow Creek
- Multipurpose Alternative 1 (RW1) – East Locust Creek - Proposed Action

Combination of Alternatives

- Water Supply Alternative 20 (WA20) – Forest Lake, Green City Lake, Livingston County PWSD No. 4, MMU, Missouri American Water Company – Brunswick, Salisbury, and Chillicothe Municipal Utilities

2.1.1 Water Supply Screening Criteria

The following steps were used to screen water supply alternatives:

1. Each alternative was first screened for its ability to meet the water supply purpose and need by the criteria in the following list.
2. Alternatives that met these criteria either alone or in combination with other alternatives were then evaluated to estimate the environmental impacts of each.
3. The alternatives that met the water supply screening criteria and had fewer environmental impacts were carried forward to determine the project multipurpose Preferred Alternative.

The water supply screening criteria are the following:

A. Alternatives must reliably provide at least 7 MGD average daily demand during a drought equivalent to the drought of record.
B. Alternatives must be available and capable of being accomplished.
C. Alternatives must provide a water supply through willing participation of stakeholders.
D. Alternatives must meet current MDNR Minimum Design Standards for Missouri Community Water Systems (MDNR 2013c) that include the following requirements.
   - For Reservoirs – Minimum 120-day surplus storage during droughts
     - Chapter 3 of the Minimum Design Standards for Missouri Community Water Systems (MDNR 2013c) states that, "Reservoir storage volume shall provide a reasonable surplus for reserve storage. A reasonable amount of surplus reserve storage should be considered in order to maintain public confidence in the reliability of supply at predicted depletion levels during a prolonged severe drought. A minimum of 120 days surplus reserve storage should be considered."
   - For Rivers or Streams – Minimum 7Q10 flow rate
     - Chapter 3 of the Minimum Design Standards for Missouri Community Water Systems (MDNR 2013c) states that, "When a river or stream is to be used as the sole source of water, the flow in the river or stream shall exceed the current registered and future downstream uses, instream flow recommendations, usually the 7Q10 flow rate, and the design year future water system demand. Historical data must be used to determine that stream flows are adequate."

2.1.2 Water Supply Alternatives Considered

2.1.2.1 Water Supply Avoidance Alternative

No Action Alternative

Under this alternative, a water supply reservoir would not be constructed. Existing water suppliers would be required to find alternative water sources to meet the projected future water needs, and the additional water sources would be developed on an individual, nonregional basis. Consequently, many water utilities would do nothing because implementation of nonregional solutions would be cost prohibitive. Water shortages during drought conditions would continue.

The drought of record would cause water shortages for the majority of water systems in the 10-county area. Critical water shortages would occur for multiple years consistent with the drought of record and would affect the quality of life, health, and welfare of residents and businesses. The

water uncertainty and shortage would reduce the standard of living for residents and threaten the ongoing viability of business operations in the 10-county region.

The No Action alternative does not provide any additional drinking water supply to help the region survive such droughts and therefore, does not meet the screening criteria for the project. It fails to satisfy screening criteria A, B, C, or D. This alternative is carried forward as a baseline for comparison.

2.1.2.2 Water Supply – Groundwater Sources

These alternatives consider potential groundwater sources in the region. The 10-country region has three different types of groundwater sources: glacial drift, bedrock, and Missouri River alluvium aquifers. Glacial drift is material that was transported and deposited by glacial action. Alluvium is material that has been transported and deposited by flowing water. Groundwater sources available in the 10-county region have distinct limitations.

A description of each groundwater alternative is described in detail in this section along with the potential yields and number of wells required.

Glacial Drift Aquifer Wells (WA1)

The most widespread groundwater resources in northwestern Missouri occur in glacial materials. Depending on thickness, composition, and other factors, the glacial drift aquifer can yield from less than a gallon of water per minute (gpm) to as much as 500 gpm. Average yield of the glacial drift throughout northwestern Missouri is less than 5 gpm. The areas with the highest potential yields are drift-filled valleys formed prior to the glaciers, where there are earlier alluvial deposits. In some places, the alluvial deposits found in these preglacial valleys yield from 100 to 500 gpm. However, these alluvial deposits are very limited in area and are found in rather narrow linear trends, much the same as modern alluvial valleys (MDNR 1997).

The Missouri Geological Survey and Water Resources completed a study in 1957 that detailed water possibilities from glacial drift in Sullivan County (Missouri Geological Survey and Water Resources 1957). Similar studies were completed for the counties that surround Sullivan County and produced comparable results. In this study, Missouri Geological Survey (MGS) referenced a test-drilling program that was used to locate new reserves of groundwater in northern Missouri. The study concluded that only a very small portion of Sullivan County could produce a substantial amount of water. In one small, glacial valley that is approximately 4,000 acres in size (one percent of Sullivan County), located in the northwestern portion of the county, well yields of 200 to 1,000 gpm may be obtained (MGS 1957). However, the effects of drawdown and the lack of recharge to this aquifer would not allow the pumping rate to be maintained for any substantial length of time. Figure 2.1.3-1 shows the area explored in the 1950s by the MGS.

Multiple small glacial valley beds that contain water are within the region, but the recharge rates and the amount of water available is minimal. For planning purposes, glacial drift aquifer wells in the area can be assumed to each generate an average of 5,000 gallons per day (gpd). This is a conservative estimate for planning purposes and is slightly lower than the 6,900 gpd average for glacial drift throughout northwestern Missouri (MDNR 1997). Based on 5,000 gpd, a total of 2,450 wells would be needed to meet the peak day demand of 12.25 MGD. The peak demand is calculated by multiplying the average daily demand (7 MGD) by a factor of 1.75. The peak demand

is used for water sources that do not have a reservoir that can balance daily variations in water usage. Each of these wells would require multiple test holes to locate an adequate well location.

Factoring in the small predicted yield, especially given the effects of drought and over-pumping on aquifer storage, this alternative does not warrant further consideration. The ability to create 2,450 wells in unique locations that would provide a consistent yield is not capable of being accomplished. Because the yield is not reliable, a water supply of 7 MGD that is dependable during a drought is not available. This alternative fails to meet water supply screening criteria A and B and is therefore not carried forward for combination with other alternatives. Because the alternative is not being carried forward, a figure and description of environmental impacts for this alternative are not included in this section.

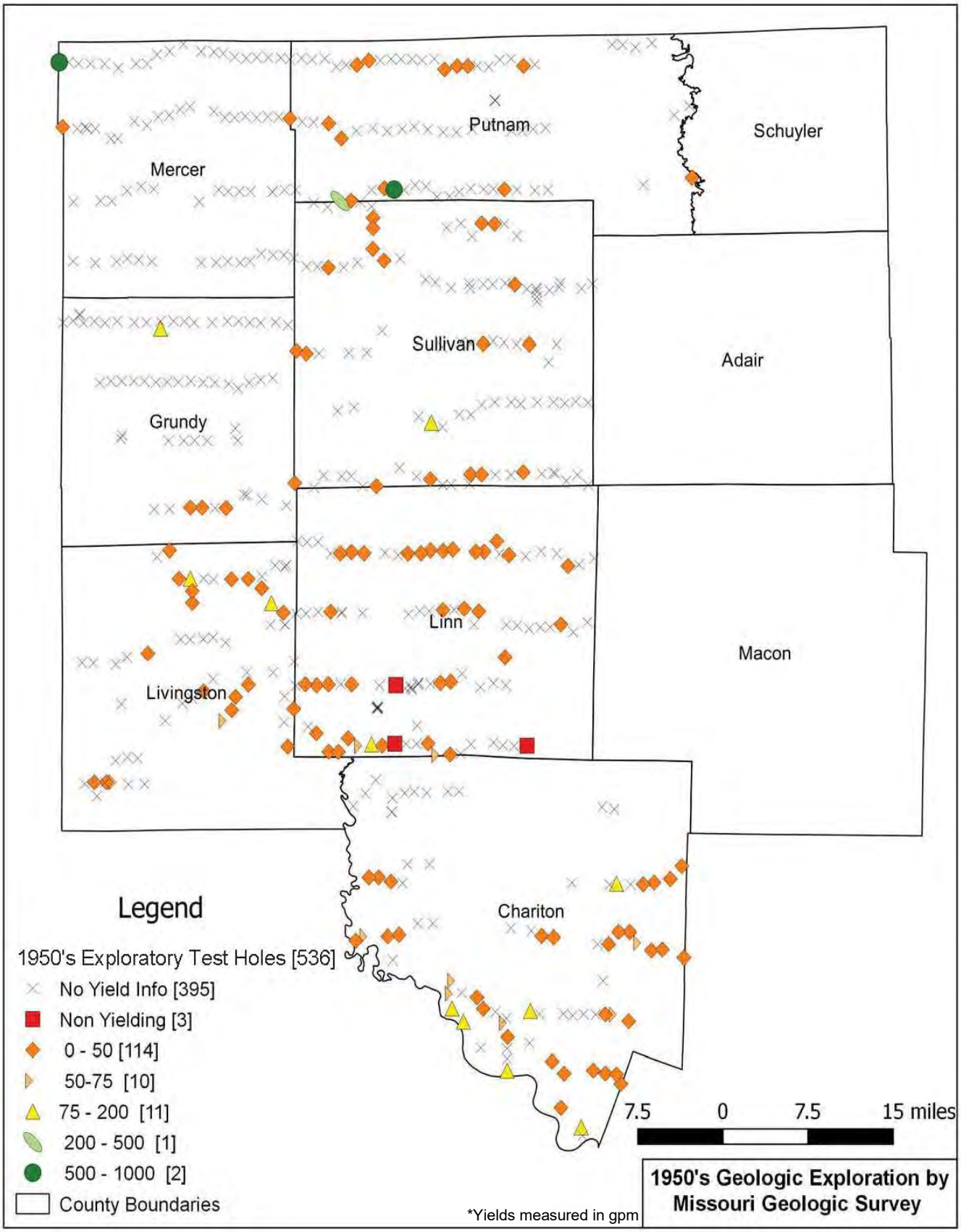


Figure 2.1.3-1. 1950s Geologic Exploration by Missouri Geologic Survey.

Bedrock Aquifer Wells (WA2)

The Pennsylvanian age bedrock formations in northern Missouri contain small amounts of marginal quality groundwater, but only at shallow depths. All the Pennsylvanian age rock units have very poor vertical and horizontal permeabilities, meaning water does not flow readily through them. Despite the great thickness of Pennsylvanian-age rock in northwestern Missouri, only the upper 100 to 150 feet potentially can yield potable water. Because of this narrow layer, yields of wells in Pennsylvanian rock are generally very low, ranging from nearly zero to as much as 10 gpm, but averaging less than 3 gpm (MDNR 1997). Recharge of the Pennsylvanian rock from overlying glacial drift, as well as direct recharge from precipitation in areas where there is no drift, is also very poor.

The quality of water from the Pennsylvanian rock is, at best, marginal. It generally contains excess sulfate, iron, and total dissolved solids. The dissolved solids content of bedrock wells deeper than 200 to 300 feet range from 2,000 milligrams per liter (mg/L) to more than 20,000 mg/L (Gann 1973).

EPA has established National Primary Drinking Water Regulations (NPDWRs) that set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant levels" (MCLs), which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water that is delivered to the consumer.

In addition, EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set nonmandatory water quality standards for 15 contaminants. EPA does not enforce these secondary maximum contaminant levels (SMCLs). They are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

Dissolved solids concentrations of 2000 to 20,000 mg/L are well above what is normally used for public drinking water. The SMCL for dissolved solids is 500 mg/L (Bronz 2017). High concentrations of dissolved solids cause drinking water to taste and smell bad, can discolor consumers' teeth, and cause damage to plumbing.

For the purposes of this analysis, we assume that wells in the Pennsylvanian bedrock aquifer produce an average of 3 gpm, or 4,320 gpd (MDNR 1997). This would require a total of 2,836 wells to meet the average flow design demand of 12.25 MGD. Within the Pennsylvanian bedrock formation, there are not enough suitable sites that do not overlap for this large number of wells.

Because of the poor quality of water that would be produced, the sporadic yields, and the large number of wells to be created at unique sites, this alternative does not meet water supply screening criterion A or B and is therefore not considered for combination with other alternatives. Because of this, a figure and description of environmental impacts for this alternative are not included in this section.

Drill Wells into Missouri River Alluvium (WA3)

The Missouri River forms the western border of Missouri as far south as Kansas City and bisects the state between Kansas City and St. Louis where it enters the Mississippi River. The Missouri River alluvium is a valley of permeable alluvial sediments that lie beneath the Missouri River floodplain. The floodplain ranges up to 12 miles wide. The alluvial aquifer is an abundant source of water. There are 25 counties in Missouri that border the Missouri River, and most of them make use of water available from the alluvium. The alluvium receives recharge from four sources: from infiltration from the Missouri River, from bedrock adjacent to and underlying the alluvium, from precipitation falling on the floodplain, and from downward leakage of water from streams flowing across the alluvium (MDNR 1997).

According to the Groundwater Resources of Missouri Report (MDNR 1997), wells located in this reach of the Missouri River are capable of pumping from 725 gpm to 1,400 gpm. Planning conservatively, the low value was used to determine the number of wells required to meet the demand. The “firm capacity” of the system, which is defined as the available capacity at any time assuming any one well is out of service, must meet the 7 MGD average daily demand. An assumed runtime of 1,000 minutes per day accounts for variability in a well and its operational parameters, maintenance downtime, and demand requirements. If each well pumps 725 gpm with a runtime of 1,000 minutes per day, the daily amount pumped is 0.725 MGD per well. A total of 18 wells would be required to meet the peak day demand of 12.25 MGD. It is important to note that wells in the region have a reduced serviceable production life and declining yield because of mineralization. The solution to this shortened serviceability and decline of yield is to chemically treat the well or to abandon and develop a new well (Allstate 2016, Appendix C). Consequently, one to five wells will be needed at each of the 18 withdraw points over the 100-year project period. This could increase the total number of wells needed from 18 to 90 wells.

This alternative assumes that a 67-mile transmission pipeline would be installed to pump water from new wells in the Missouri River alluvium south of Brunswick, Missouri, to the existing water treatment plant in Milan, Missouri. Figure 2.1.3-2 shows the route of the transmission line. The transmission line is expected to require nine pump stations, 77 road crossings, and 94 stream crossings (including the Grand River). The pump station would require construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from the Missouri Department of Transportation (MoDOT). The creek crossings would require encasement of the line.

This alternative meets the screening criteria to provide a potential source of the needed water and therefore is carried forward for multipurpose analysis.

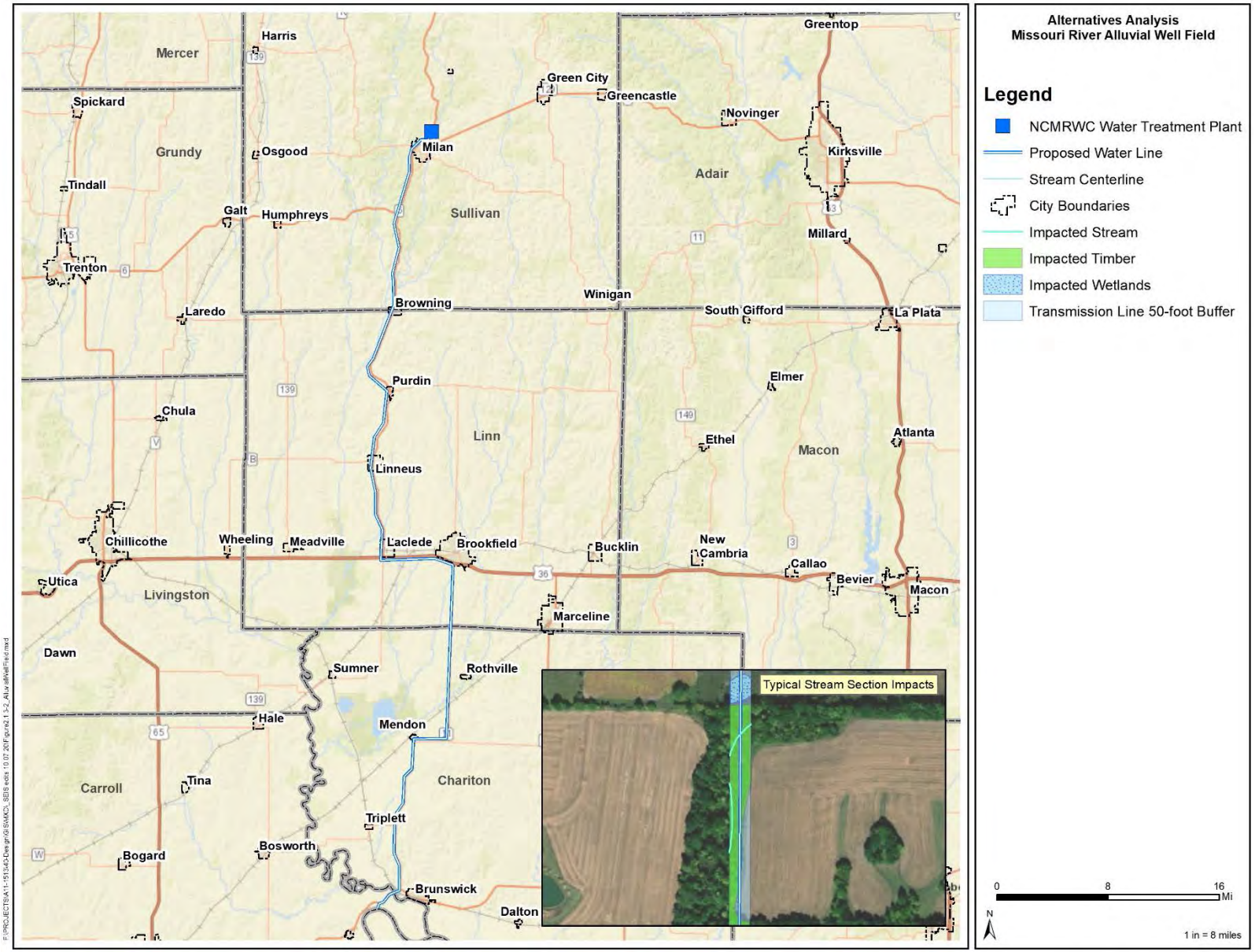


Figure 2.1.3-2. Missouri River Alluvial Well Field.

Drill Wells into Mississippi River Alluvium (WA4)

The Mississippi River is the largest drainage system in North America. It begins in Minnesota and flows through 10 states before discharging into the Gulf of Mexico 100 miles downstream of New Orleans. The total drainage basin covers more than 1,245,000 square miles. The Mississippi River upstream from the Missouri River drains a much smaller area than the Missouri River but has a much higher runoff rate and annual discharge.

Approximately 77 square miles of Mississippi River alluvium occurs in Clark County and extreme northeastern Lewis County. The estimated storage from this area is approximately 88 billion gallons of water or 270,300 acre-feet (AF) (MDNR 1997). The groundwater quality from the alluvium is good except for high concentrations of iron and manganese (MDNR 1997). If each well pumps 500 gpm, with a runtime of 1,000 minutes per day, the daily total amount pumped is 0.500 MGD per well. A total of 25 wells would be required to meet the peak day demand of 12.25 MGD. It is important to note that wells in the region have a reduced serviceable production life and declining yield because of mineralization. The solution to this shortened serviceability and decline of yield is to chemically treat the well or to abandon and develop a new well (Allstate 2016, Appendix C). Consequently, one to five wells will be needed at each of the 25 withdraw points over the 100-year project period. This could increase the total number of wells needed from 25 to 125 wells.

This alternative assumes that a transmission pipeline would be installed to pump water from wells in the Mississippi River alluvium north of Canton, Missouri, to the NCMRWC water treatment plant at Milan. Figure 2.1.3-3 shows the route of the transmission line. The 98-mile-long transmission line would follow Missouri state highways to the proposed water treatment system location.

The transmission line is expected to require 12 pump stations, 121 road crossings, and 114 stream crossings (including the Wyaconda and Chariton rivers). The pump station would require construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require encasement of the line.

This alternative meets water supply screening criteria A through D and will be considered a viable alternative that will be carried forward for multipurpose analysis.

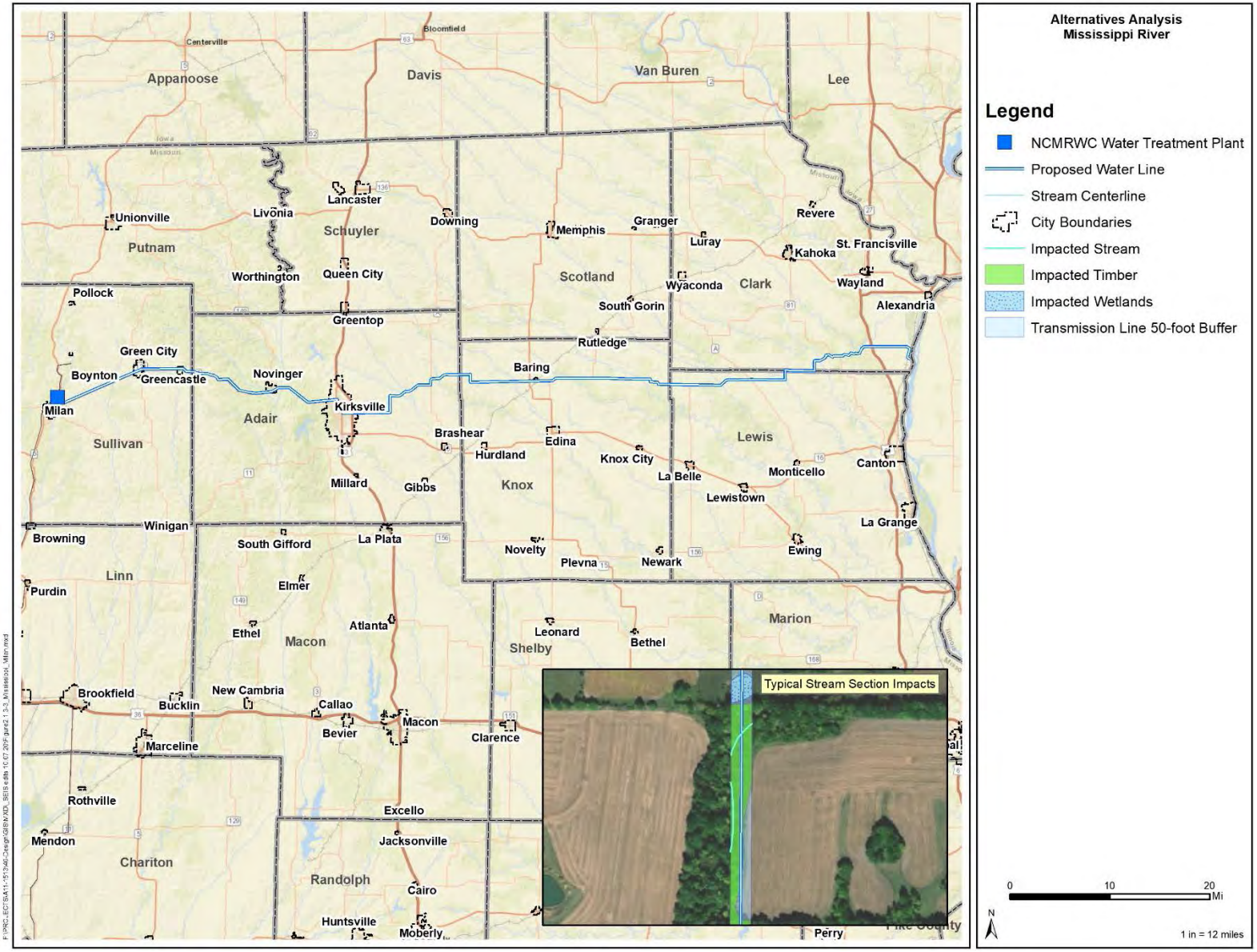


Figure 2.1.3-3. Mississippi River Alluvium Water Supply Alternative.

Drill Wells into the Grand River Alluvium (WA5)

The Grand River is the largest northern Missouri tributary. The basin is about 150 miles long and 90 miles wide and contains some 7,900 square miles of drainage, about 80 percent of which (6,320 square miles) is located in Missouri. Many reaches of the channels of the Grand River and its major tributaries have been straightened in the past to decrease flooding. The Grand River has several major tributaries, including the Thompson River, Shoal Creek, Medicine Creek, Locust Creek, and Yellow Creek, all with more than 500 square miles of drainage.

Near the town of Sumner, Missouri, the Grand River drains 6,880 square miles and has an average discharge of 4,112 cubic feet per second (cfs), based on data collected between 1923 and 1993. Average annual runoff near Sumner is 8.12 inches. The lowest flow water year on record was 1934, when discharge averaged 367 cfs; minimum recorded flow was 10 cfs August 12, 1934 (Vandike 1995). With proper development (irrigation or high-yield wells), yields of 200 – 1000 gpm may be obtained (MGS 1957). This range of quantity of groundwater does not guarantee water quality. “In general, the water from the glacial drift is high in total iron, total dissolved solids, and sulfates (MGS 1957). The “firm capacity” of the system must meet the 7 MGD average daily demand. If each well pumps 200 gpm, with a runtime of 1,000 minutes per day the output would total 0.200 MGD per well. The lower end of the range was used to conservatively estimate the number of wells needed and to reflect the uncertain water quality and potential for declining yield over the life of the project. A total of 62 wells would be required to meet the peak day demand of 12.25 MGD. It is important to note that wells in the region have a reduced serviceable production life and declining yield because of mineralization. The solution to this shortened serviceability and decline of yield is to chemically treat the well or to abandon and develop a new well. Consequently, this solution could correspond to increased cost of production or one to five wells needed at each of the 25 withdraw points over the 100-year project period. Developing replacement wells could increase the total number of wells needed from 62 to 310 wells. The wells would need to be sufficiently spaced to avoid water drawdown impacts between wells.

The City of Sumner previously had wells near the Grand River that had declining yield. Because of the declining yield, Sumner sold its entire water system to Chariton-Linn PWSD No. 3 in 2008. The last recorded MDNR average daily production rate was 0.014 MGD (Allstate 2016, Appendix C).

A 57-mile water transmission line is needed to pump water from the Grand River at Sumner to Milan. The transmission line is expected to require eight pump stations, 64 road crossings, and 79 stream crossings. The pump station would require construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require encasement of the line.

This alternative meets water supply screening criteria A through D and will therefore be considered a viable alternative that will be carried forward for multipurpose analysis.

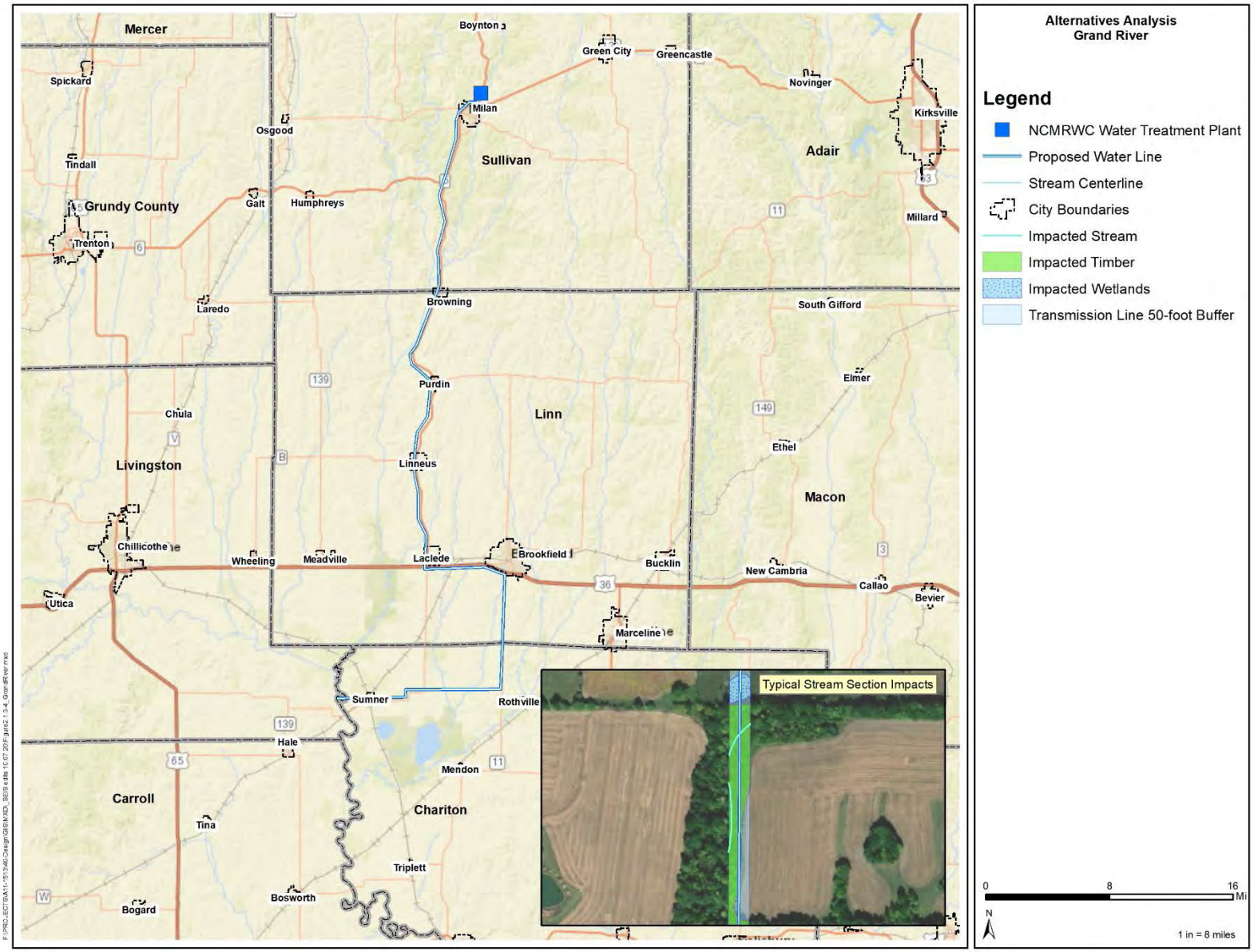


Figure 2.1.3-4. Grand River Alluvium Water Supply Alternative.

2.1.2.3 Water Supply – Connection to Existing Systems

Livingston County Public Water Supply District No. 4 (WA6)

Livingston County PWSD No. 4 is located in Daviess County, Missouri, which is not within the 10-county study region and therefore is considered out of region. The water district serves customers in both Livingston and Daviess counties and provides wholesale water to customers in Caldwell County. The main sources of water for Livingston County PWSD No. 4 are 3 wells located in Daviess County, Missouri.

According to MDNR well data, the three alluvial wells, two drilled in the 1970s and one drilled in 2010, provide 0.340 MGD of treated water. The alluvial wells are from the Grand River alluvium. According to the North Central Missouri Regional Water Source Evaluation, 0.200 MGD of the produced water is consumed by the district customers. The remaining produced water is sold to communities outside the region. The excess capacity of the Livingston County PWSD No. 4 is limited to 0.140 MGD, far below the required flow of 7 MGD. The capacity of these shallow alluvial wells during the design drought is unknown.

This alternative fails to meet water supply screening criterion A (providing at least 7 MGD water supply) and is therefore not carried forward as a standalone alternative for multipurpose analysis. Because a water supply is available, Livingston County PWSD No. 4 will be considered in the water supply combination of alternatives.

Rathbun Regional Water Association (WA7)

RRWA is supplied by Rathbun Lake, which is located approximately 7 miles north of Centerville, Iowa, in Appanoose County. The lake was completed in 1969 to control flooding, reduce stream pollution, and provide a water source to the residents in the region. The major source of water flowing into Rathbun Lake is the Chariton River. RRWA currently provides 0.557 MGD to the 10-county region.

RRWA is allocated 6,680 AF of storage; an additional 8,320 AF of storage is available at Rathbun Lake. The U.S. Congress has provided RRWA the right of first refusal on the additional allocation, and RRWA is in the process of acquiring the additional 8,320 AF of storage (Glenn 2019). RRWA has indicated that it does “not believe that the available water supply storage allocation in Rathbun Lake will allow us to provide potable water to customers outside of our association’s current service territory” (Glenn 2019).

RRWA is in Iowa and water conveyance across state lines is regulated under the 2017 Iowa Code (455B.266(2)). Water conveyed across state lines is the first to be cut off when there is a shortage:

> “2. Notwithstanding a person’s possession of a permit or the person’s use of water being a nonregulated use, the department may suspend or restrict usage of water by category of use on a local or statewide basis in the following order:
>
> **a. Water conveyed across state boundaries.**
> b. Water used primarily for recreational or aesthetic purposes.
> c. Uses of water for the irrigation of any general crop.
> d. Uses of water for the irrigation of any specialty crop.
> e. Uses of water for manufacturing or other industrial processes… ” (emphasis added)

This alternative is an inadequate source because of the restriction of water conveyance over a state boundary as the first legal priority in allocation.

The alternative fails to meet water supply screening criteria A, B, and C and is therefore not carried forward as a standalone alternative for the multipurpose analysis or combination of alternatives. Because this alternative is not carried forward, a detailed cost estimate, figure, and description of environmental impacts for this alternative are not included in this section.

Macon Municipal Utilities (WA8)

MMU, located in Macon County, Missouri, is fed primarily by Long Branch Reservoir. The primary purpose of Long Branch Lake is flood control with secondary purposes of water supply and recreation. MMU has purchased rights to 4,400 AF of water supply storage in the reservoir (Allstate 2016, Appendix C). This volume means that the yield capacity is 3.40 MGD and the current demand is 2.75 MGD (Allstate 2016, Appendix C). The excess capacity from this purchased water supply is 0.65 MGD.

Long Branch Reservoir has 20,000 AF or 7.6 MGD of remaining multipurpose volume to be allocated by the USACE (USACE 2013a). The 2011 MDNR Water Study, revised 2013, states that the drought plan is to release water to the East Fork of the Chariton River to supplement Moberly, Missouri (MDNR 2011a). This release would deplete Long Branch Reservoir's excess capacity held by the USACE (Allstate 2016, Appendix C).

This alternative fails to meet water supply screening criterion A (providing at least 7 MGD water supply) and is therefore not carried forward as a standalone alternative for multipurpose analysis. Because a water supply is available, MMU will be considered in the water supply combination of alternatives.

Missouri American Water Company – Brunswick (WA9)

The Missouri American Water Company – Brunswick treatment facility is located in Brunswick, Missouri, in Chariton County. The groundwater that is fed to Missouri American Water Company – Brunswick is drawn from three wells.

The three wells have raw water yields of 0.028 MGD, 0.075 MGD, and 1.030 MGD; the last amount is produced by a well located near the Grand River and Missouri River channels and is an uncharacteristically high flow when compared to other groundwater sources in the 10-county region. The total yield is 1.133 MGD and the region has a demand of 0.0841 MGD, resulting in an excess capacity of 1.049 MGD. The capacity of these shallow alluvial wells during the drought of record is unknown.

This alternative fails to meet water supply screening criterion A (providing at least 7 MGD water supply) and is therefore not carried forward as a standalone alternative for the multipurpose analysis. Because a water supply is available, Missouri American Water Company – Brunswick will be considered in the water supply combination of alternatives.

Salisbury (WA10)

The City of Salisbury, Missouri, is supplied by two wells. An additional well in the area is not currently being operated because of high ammonia content and associated increased operation and maintenance costs.

The two wells are in the alluvium of the Chariton River with a total yield of 0.432 MGD. The average demand was 0.175 MGD, which results in an excess yield of 0.257 MGD. The capacity of these shallow alluvial wells during the design drought is unknown.

This alternative fails to meet water supply screening criterion A (providing at least 7 MGD water supply) and is therefore not carried forward as a standalone alternative for analysis. Because a water supply is available, Salisbury will be considered in the water supply combination of alternatives.

Chillicothe Municipal Utilities (WA11)

The City of Chillicothe, located in Livingston County, Missouri, is another potential option for a connection to an existing system. The water system for Chillicothe is currently supplied by four alluvial wells. These wells have high iron content and the groundwater extracted from them must be treated to remove this iron. According to the 2016 North Central Missouri Regional Water Source Evaluation (Allstate 2016, Appendix C), the Chillicothe treatment plant has a capacity of 2.64 MGD and the average usage for the Chillicothe system is 0.89 MGD.

The City of Chillicothe also supplies water to Livingston County PWSDs 1, 2, and 3 East, Chula, and Hale. These PWSDs have an average daily flow of 0.08 MGD, 0.07 MGD, 0.20 MGD, 0.02 MGD, and 0.04 MGD respectively, or 0.41 MGD combined (Allstate 2016, Appendix C). Based on this data, the excess capacity for the Chillicothe treatment system is 1.34 MGD. The capacity of these shallow alluvial wells during the design drought is unknown.

This alternative fails to meet water supply screening criterion A (providing at least 7 MGD water supply) and is therefore not carried forward as a standalone alternative for multipurpose analysis. Because a water supply is available, Chillicothe Municipal Utilities will be considered in the water supply combination of alternatives.

2.1.2.4 Water Supply – Streams and Rivers

The Missouri River, Mississippi River, and Grand River each would provide a dependable water supply that meets the purpose and need. There are two methods to attain this water supply: surface water pumps and alluvial wells. Because of higher costs and higher risk associated with river intakes, only alluvium will be evaluated. Both sources of water would require approximately the same distance to pump water to Milan.

The variability in water quality parameters, such as turbidity and organic content, make river water more difficult and costly to treat. MDNR guidance recognizes that treating river water requires sedimentation pretreatment and the ability to not operate for a period of time if a pollution event were to occur (MDNR 2013c). Pretreatment would need to be done near the source to reduce pumping solids and organics a substantial distance to a water treatment facility. This would require additional land to site the facility and provision for staffing.

The alluvial wells considered previously provide a more efficient; cost-effective approach to supplying water from the rivers. The Missouri River, Mississippi River, and Grand River are not considered in this section. Intakes are already present for the Thompson River and Locust Creek, and they are discussed below.

Thompson River (WA12)

The Thompson River is the water supply source for the City of Trenton water system. This alternative assumes that a new transmission pipeline would be installed to pump water from a new intake structure downstream of the Thompson River and upstream of Trenton, Missouri.

For the Thompson River, the nearest gauging station downstream of the proposed intake structure would be U.S. Geological Survey (USGS) 06899500 Trenton, Missouri. The following excerpt is from the North Central Missouri Regional Water Source Evaluation (Allstate 2016, Appendix C):

> "The daily flow recordings by the USGS are at the Thompson River observation station at Trenton, MO. The data shows a 4-consecutive month period (November 1955 to February 1956) when average monthly (from daily flow calculations) flows in the Thompson River were below the base flow of 9 cfs, therefore no pumping could be allowed during this time."

This means that there would be no excess capacity available for the 10-county region during the drought of record.

This alternative fails to meet water supply screening criteria A and B and will not be considered a viable alternative moving forward. Because this alternative is not carried forward, a figure, description of environmental impacts, and cost estimate are not included for this alternative.

Locust Creek (WA13)

Locust Creek is a tributary to the Grand River. The south-trending basin drains a portion of the area between the Thompson basin and the Chariton River basin north of the Grand River. The Locust Creek drainage area totals 631 square miles. The Locust Creek watershed begins west of Seymour, Iowa, and flows south until it enters the Grand River near Sumner, Missouri.

This alternative assumes that a transmission pipeline would be installed to convey water from a new intake structure in Locust Creek west of Linneus, Missouri, to the proposed water treatment system location. For Locust Creek, the nearest gauging station downstream of this alternative's intake structure is USGS 06901500 Linneus, Missouri. The 7Q10 value for a stream is based on an annual series of the smallest values of mean discharge computed over any seven consecutive days during the annual period. The 7Q10 flow rate calculated at this gauging station is 0.97 cfs (0.63 MGD). The average demand of 10.85 cfs (7 MGD) to meet the project need would cause Locust Creek to run dry in a low-flow situation. For this reason, there would be no available yield for this alternative.

This alternative fails to meet water supply screening criterion A and is not a viable alternative; therefore, it will not be carried forward for the multipurpose analysis or water supply combination of alternatives. Because this alternative is not carried forward, a figure, description of environmental impacts, and cost estimate are not included for this alternative.

2.1.2.5 Water Supply Existing Lakes

The current and potential storage volumes for six existing lakes were evaluated to see whether one lake or a combination of lakes were capable of providing 7 MGD average demand for water

supply. The six lakes included Forest Lake, Green City Lake, Elmwood Lake, Unionville Lake, Hazel Creek Lake, and Mark Twain Lake.

Existing storage volumes at normal pool elevations for five of the six lakes (Forest Lake, Green City Lake, Elmwood Lake, Hazel Creek Lake, Unionville Lake) were obtained from area/volume tables provided on USGS bathymetric maps. The sixth lake, Mark Twain, has storage allocated by the USACE.

The potential storage volume was calculated by comparing each lake's normal pool elevation surface with a lake surface raised an additional 10 or 20 feet to simulate replacing the existing dam with a new dam constructed at an elevation 10 or 20 feet higher. Because of the age and uncertainty of existing dam construction, each dam would need to be decommissioned, removed and replaced. The storage analysis was completed to calculate the difference in volume between the two surfaces. The overall potential storage volume for each lake was determined by combining the normal pool storage volume and the storage volume resulting from replacing the dam. The available yield for each existing lake was determined using RESOP models as described in the North Central Missouri Regional Source Evaluation (Allstate 2016, Appendix C). The watershed was analyzed to determine if the watershed could support the increased lake size and potential water supply. The new water yield was estimated based on the watershed and additional water volume.

Forest Lake (Thousand Hills) Expansion (WA14)

Forest Lake (Thousand Hills) is in Adair County, Missouri, approximately 1.5 miles west of Kirksville. The Forest Lake dam has a height of 66 feet and was constructed in 1951. The lake is currently used for recreation and is surrounded by Thousand Hills State Park. The normal pool elevation is 796.5 feet, and the lake has a surface area of 580 acres. The storage volume of Forest Lake at normal pool elevation is 10,450 AF.

Forest Lake was evaluated for the feasibility of raising the dam 10 feet or 20 feet to provide additional water supply capacity from this source. Based on an evaluation of the tributary watershed, lake area, and available volume for storage, Forest Lake dam could be decommissioned and rebuilt with a crest elevation 20 feet higher, corresponding to a normal pool 20 feet higher in elevation. Raising the existing dam by 20 feet would provide an additional storage volume of 14,205 AF, resulting in an overall lake storage volume of 24,655 AF, which equals an estimated yield of 5.42 MGD. The current demand on Forest Lake is 2.51 MGD, resulting in 2.91 MGD of additional available yield. The Forest Lake expansion also provides water-based recreation, which will be described in section 2.3.

This alternative does not meet water supply screening criterion A and therefore will not be carried forward as a standalone alternative for multipurpose analysis. Because a water supply is available, Forest Lake expansion will be considered in the water supply combination of alternatives.

Green City Lake Expansion (WA15)

Green City Lake is in Sullivan County, approximately 1.25 miles east of Green City, Missouri. The Green City dam, at a height of 20 feet and constructed in 1974, controls the lake which is currently

used for recreation. The normal pool elevation is 999 feet and the lake has a surface area of 58.5 acres. The storage volume of Green City Lake at normal pool elevation is 386 AF.

Green City Lake was evaluated for the feasibility of raising the dam 10 feet or 20 feet to provide additional water supply capacity from this source. Based on an evaluation of the tributary watershed, lake area, and available volume for storage, Green City Lake dam could not provide additional water supply even if decommissioned and rebuilt to a higher elevation. The watershed does not support additional water supply withdrawal for even a 10-foot higher dam. However, raising the dam would provide additional recreational benefits. The water level and recreational area would fluctuate considerably but would provide additional recreational surface acres. For recreation, the existing dam would be raised by 20 feet and would provide an additional storage volume of 2,276 AF, resulting in an overall lake storage volume of 2,662 AF.

The optimal yield for the existing dam height is 0.15 MGD, which does not increase with a higher dam elevation because of limitations imposed by the small watershed. The current demand on Green City Lake is 0 MGD, resulting in an available yield of 0.15 MGD. The Green City Lake expansion provides water supply and water-based recreation. The water-based recreation description is included in section 2.3.

Green City Lake has an existing water treatment facility that was closed in 2004 because of source degradation. The closure was mandated by the MDNR and made the lake an inactive and inadequate location. The city now purchases all water from outside sources. The source degradation is assumed to be associated with the water quality of the existing lake and not the incoming stream. Thus, decommissioning and rebuilding the dam may improve the water source and provide a quality water supply.

This alternative does not meet water supply screening criterion A; therefore, it will not be carried forward for multipurpose analysis. Because water would become available as a result of rebuilding and raising the dam, this alternative will be considered for the water supply combination alternative.

Elmwood Lake Expansion (WA16)

Elmwood Lake is in Sullivan County, approximately 0.75 mile north of Milan, Missouri. The Elmwood City Lake dam has a height of 47 feet and was constructed in 1972. The lake is currently used for recreation and water supply. The normal pool elevation is 872 feet, and the lake has a surface area of 221.5 acres. The storage volume of Elmwood Lake at normal pool elevation is 2,503 AF.

Currently, Elmwood Lake is running out of water even in nondrought conditions. Its permit specifies that when the lake level drops 48 inches, the providers are required to begin purchasing and pumping water from emergency waterlines in Trenton. In October 2017, the lake was 42 inches below normal levels and losing about 2 inches per week because of the lack of rain. The Trenton line could only provide about 15 percent of the system need and would necessitate buying water at higher costs.

Elmwood Lake was evaluated for the feasibility of raising the dam 10 feet or 20 feet to provide additional water supply capacity from this source. Based on an evaluation of the tributary watershed, lake area, and available volume for storage, Elmwood Lake dam could be

decommissioned and rebuilt to a 10-foot higher elevation. Raising the existing dam by 10 feet would provide an additional storage volume of 2,859 AF, resulting in an overall lake storage volume of 5,362 AF. This total volume results in an estimated yield of 1.18 MGD. The current demand on Elmwood Lake is 1.52 MGD, resulting in no additional available yield.

For recreational benefits, an evaluation of a 20-foot increase was completed. The water level and surface area would fluctuate considerably but would provide additional recreational surface acres. Raising the existing dam by 20 feet for recreational benefits would provide an additional storage volume of 7,158 AF, resulting in an overall lake storage volume of 9,661 AF. Raising the reservoir 20 feet would provide no additional water supply capacity over the 10-foot raised dam described above. The Elmwood Lake expansion alternative is included in the water-based recreation, which is described in section 2.3.

This alternative does not meet water supply screening criterion A and therefore will not be carried forward for multipurpose analysis. Because a water supply is available, Elmwood Lake Expansion will be considered in the water supply combination of alternatives.

Unionville Lake Expansion (WA17)

Unionville Lake, also known as Lake Mahoney, is in Putnam County, approximately 1.7 miles northwest of Unionville, Missouri. The dam has a height of 30 feet and was constructed in 1941. This lake is currently used for recreation and water supply and is owned by the City of Unionville. The city also draws water from Lake Thunderhead, which is a private recreational lake that covers 1,140 acres. The agreement between the Lake Thunderhead Homeowners Association and the City of Unionville is not in writing (Allstate 2016, Appendix C). For this reason, the capacity of Lake Thunderhead will not be considered in this alternative.

The existing Unionville Lake dam cannot be raised because of its proximity to Thunderhead Lake. If the Unionville Lake dam were raised, Thunderhead Lake would receive less water and the water recharge would be reduced. Thunderhead is a private lake with docks that would be affected by the change in water recharge.

The normal pool elevation for Lake Mahoney is 975 feet, and the lake has a surface area of 75 acres. The storage volume of Unionville Lake at normal pool elevation is estimated to be 408 AF. Raising the existing dam by 10 feet would provide an additional storage volume of 960 AF, resulting in an overall lake storage volume of 1,368 AF. This total volume results in an optimal yield of 0.30 MGD; the current demand on Unionville Lake is 0.36 MGD, resulting in no excess supply.

This alternative does not meet water supply screening criterion A and therefore will not be carried forward for multipurpose analysis. Because raising the dam will impact Lake Thunderhead and provide no excess water supply, the alternative will not be carried forward for the water supply combination of alternatives.

Hazel Creek Expansion (WA18)

Hazel Creek Lake is in Adair County, approximately 3 miles north of Kirksville, Missouri. The Hazel Lake dam is 65 feet in height and was constructed in 1982. This lake is currently used for recreation and water supply. The normal pool elevation is 845 feet, and the lake has a surface area of 530 acres. The storage volume of Hazel Lake at normal pool elevation is estimated to be 7,390 AF.

Hazel Creek Lake was evaluated for the feasibility of raising the dam 10 feet or 20 feet to provide additional water supply capacity from this source. Based on an evaluation of the tributary watershed, lake area, and available volume for storage, Hazel Creek Lake dam could not provide additional water supply if decommissioned and rebuilt to a higher elevation. The watershed does not support additional water supply withdrawal for even a 10-foot higher dam. However, raising the dam would provide additional recreational benefits. The water level and surface area would fluctuate considerably but would provide additional recreational surface acres. For recreation, the existing dam would be raised by 20 feet and would provide an additional storage volume of 13,859 AF, resulting in an overall lake storage volume of 21,249 AF. The Hazel Creek Lake expansion is included in the water-based recreation alternatives, which is described in Section 2.3.

The existing watershed can support the current demand on Hazel Creek Lake of 1.27 MGD (Allstate 2016, Appendix C). However, raising the dam does not provide additional water supply because of the limited watershed. This alternative does not meet water supply screening criterion A and therefore will not be carried forward as a standalone alternative. Because no additional water supply is available, Hazel Creek Expansion will not be considered in the water supply combination of alternatives.

Mark Twain Lake Pipeline (WA19)

The Clarence Cannon dam, which forms Mark Twain Lake, was constructed in 1983. The drainage area for the lake is 2,318 square miles, making it the largest lake in northeastern Missouri (Figure 2.1.6-1). The lake is used for flood control, recreation, and water supply and has 457,000 AF of water storage to support multiple uses (USACE 2015).

Clarence Cannon Wholesale Water Commission (CCWWC), located in Ralls County, is the water system that currently is supplied by the Mark Twain Reservoir. The CCWWC intake structure and treatment plant are located on the southwestern side of the lake. The treatment plant was constructed in 1991 and had a design capacity of 5 MGD. The CCWWC has since added a second treatment plant and now has a treatment capacity of 10 MGD. There are currently 23 purchasing water systems which include Bowling Green, Cannon PWSD 1, Clarence, Curryville, Edina, Farber, Huntsville, Knox County PWSD 1, La Belle, Lewis County PWSD 1, Lewistown, Macon County PWSD 1, Madison, Marion County PWSD 1, Monroe County PWSD 2, New London, Paris, Perry, Pike County PWSD 1, Shelby County PWSD 1, Shelbyville, Thomas Hill PWSD 1, and Wellsville. Based on the 2016 Water Census, the average demand on the CCWWC system was 4.29 MGD (MDNR 2016).

The following excerpt is from the Mark Twain Lake Master Plan (USACE 2015):

"The CCWWC entered into a three-party contract with the USACE and the State of Missouri to purchase water storage space in Mark Twain Lake. The contract allows for removal of a maximum of 16 million gallons of raw water per day with an allowance for a failure rate of 2 years out of every 100 years for not being able to supply the full 16 MGD. The CCWWC owns the rights to 5.0 million gallons of storage space, while the remaining 11.0 million gallons of water per day are available to them through contract with the State of Missouri."

Because the CCWWC is allotted 16 MGD, the additional available capacity from Mark Twain Reservoir is 32 MGD (USACE 2015). In this alternative, a 30-inch water transmission pipeline would be constructed from Mark Twain Lake to the water treatment plant at Milan. The pipeline is estimated to be 126 miles long, would cross 170 streams and 194 road crossings, and require 12 pump stations. The Milan water treatment plant would need to be upgraded over the 100-year project life to provide the 7 MGD water supply for the 10-county region. This alternative meets the screening criteria and therefore will be carried forward as a standalone alternative for multipurpose analysis.

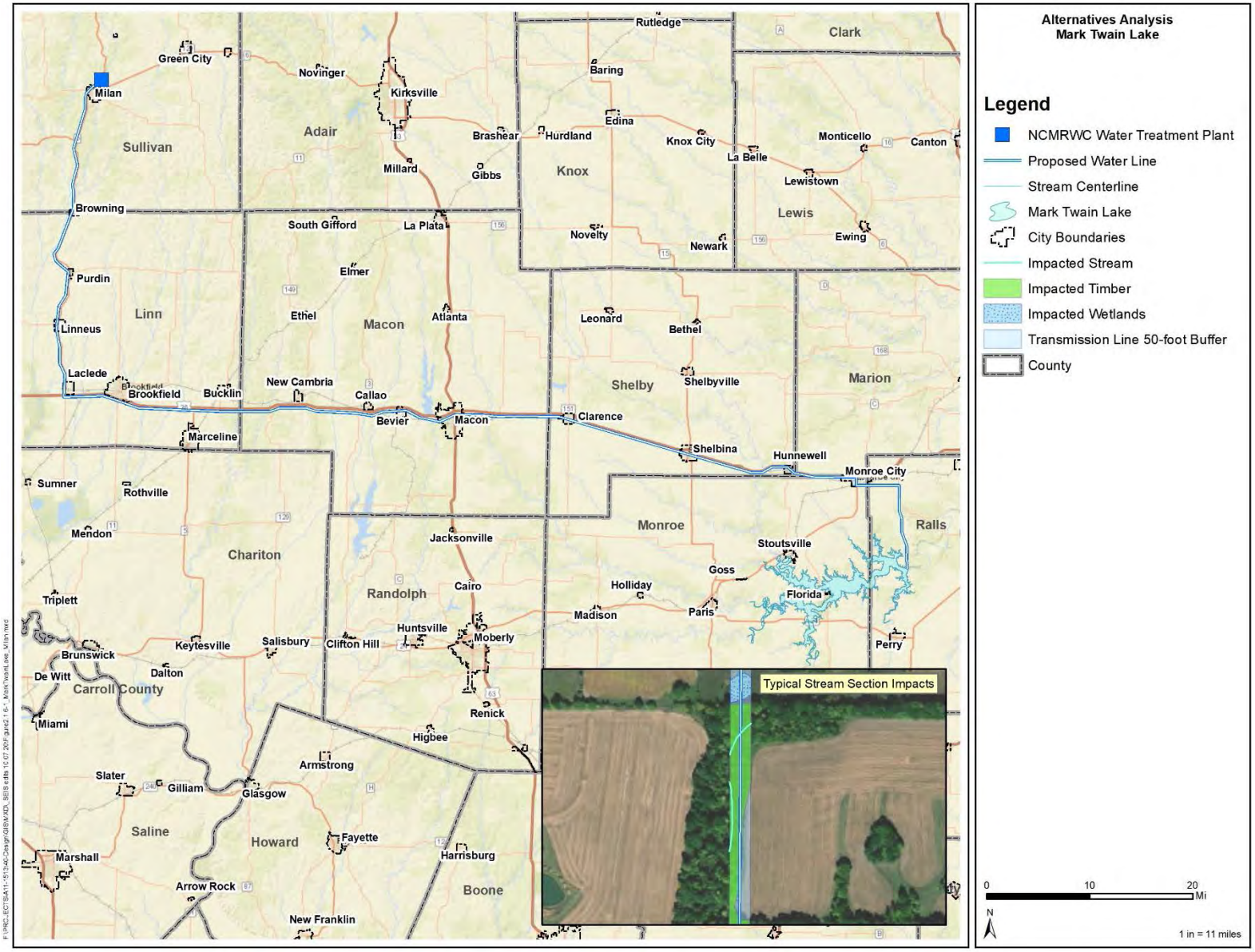


Figure 2.1.6-1 Mark Twain Lake Pipeline.

2.1.2.6 Water Supply – Creation of a New Reservoir

Create an Offline Reservoir (DPA1)

This alternative explored creating an offline reservoir for water supply and water-based recreation that would use either the Thompson River or Locust Creek as a source. Direct pumping from the Thompson River and Locust Creek were explored as potential water supplies in the Water Supply Rivers and Streams section of this report (Section 2.1.2.4). Pumping water from the Thompson River or the Locust River was ruled out because the rivers could not provide enough water to keep stream flow above the 7Q10 value required by MDNR regulations. An offline reservoir that could store water during high flows was evaluated as a potential alternative that would supply water using the two rivers and still meet MDNR regulations.

An offline reservoir is built away from a stream rather than damming the stream, as is the case for an online reservoir. An offline reservoir does not rely on direct inflow, does not require damming a stream, and is sized based on the water demand of the distribution system it serves or the recreational opportunities to be provided. Water is pumped from its source (stream flow) to the basin and then to the proposed treatment plant for the distribution system it serves.

For the alternatives considered here, a water transmission line would be constructed from the offline reservoir to the NCMRWC water treatment plant at Milan. Recreational facilities including a boat ramp, docks, road access lanes, and parking spaces would be constructed for the 10-county region. The offline reservoir would provide fishing opportunities, but a sustainable fishery that provides high-quality fishing opportunities with minimal management is difficult to achieve with an offline impoundment (MDC 2015a).

Flow records for Thompson River and Locust Creek were researched to determine whether, at any time during the available USGS stream gauge monitoring period, flow at the possible intake locations met the MDNR water system design standards. Two minimum design standards would need to be considered as outline below:

- If stream flow is below the 7Q10 value, water cannot be pumped from the stream for water storage.
- At least 120 days of water must always be stored, which would need to be accounted for in the sizing of the storage basin.

Flow records of the Thompson River (06899500) and Locust Creek (6901500) made available through the USGS website showed that flow in each stream never fell below 7Q10 flow rate for more than 120 days (USGS 2017a). However, as stated in the excerpt in the North Central Missouri Regional Source Evaluation (Allstate 2016, Appendix C), flow data “shows a 4-consecutive month period (November 1955 to February 1956) when average monthly (from daily flow calculations) flows in the Thompson River were below the base flow of 9 cfs, therefore no pumping could be allowed during this time.” Looking into this further, the Thompson River fell below 9 cfs for 79 consecutive days. Flow data at Locust Creek (6901500) was not available during the drought of record (1951 – 1959; USGS 2017a).

For water supply, the size of the reservoir was based on the system water demand of 7.0 MGD (10.85 cfs), the time of detention (120 days surplus plus the 79 days of no pumping during the drought of record), evaporation losses, and seepage losses. For time of detention, it was assumed

pumping operations would cease in Locust Creek for 79 consecutive days (same as Thompson River) during the drought of record. As stated in the minimum design standards, 120 days minimum of storage volume is needed. At the end of the 79 days of no pumping, there still must be 120 days of supply, which equates to 199 days of total required storage volume for an offline reservoir. Evaporation losses were assumed to be 0.10 inch per day (NOAA 1982), and seepage losses were assumed to be 0.003 inch per day (NRCS 2008). Added to the system demand, this totals a maximum demand of 10.7 cfs. The reservoir capacity for this demand and 199 days of storage is 1,379 million gallons, or 4,232 AF.

Assuming a 15-foot normal pool depth and a square basin with 3:1 side slopes, the side length required would be 3,556 feet and the total area would be 290 acres to create the 4,232 AF basin. Using aerial photographs and topographic maps, possible locations for an offline reservoir were identified for a 290-acre site along the Thompson River or Locust Creek that had a slope of less than 3 percent. A slope of less than 3 percent is necessary to maintain reasonable construction costs.

Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. Thus, a 290-acre lake would provide 11,500 user-days of recreation. A drawback to a 290-acre reservoir is that an impoundment of this size provides marginal waterskiing and motorized boating opportunities. For that reason, a 1,505-acre reservoir size that provides the recreation user-days required by the recreation purpose and need was also considered. See Section 2.3.1 for the water-based recreation screening criteria. A 1,505-acre lake would provide 59,500 user-days of recreation.

An evaluation of the Thompson River and Locust Creek watersheds did not result in identifying a location to site the 1,505-acre offline reservoir. Topography constraints (3 percent slope) limited the offline reservoir size. Also, the offline reservoir size is limited by the earthwork balance of cut and fill and the availability of clay soils to act as a liner. The larger an offline reservoir size, the higher potential for failure, higher cost of construction, and lower likelihood that a potential site would be adequate. Therefore, a 290-acre offline impoundment site located near Purdin, Missouri, will be analyzed for the offline reservoir.

Figure 2.1.7-1 shows the offline reservoir and route of the transmission line. The 21-mile-long transmission line would follow Missouri state highways from the offline reservoir to the water treatment plant. The transmission line is expected to require three pump stations, 29 road crossings, and 24 stream crossings (including the Grand River). The pump station would require construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require encasement of the line.

This alternative meets the screening criteria for water supply and therefore will be carried forward for multipurpose analysis. This alternative does not meet the recreation screening criteria but will be further evaluated in the recreation combination of alternatives.

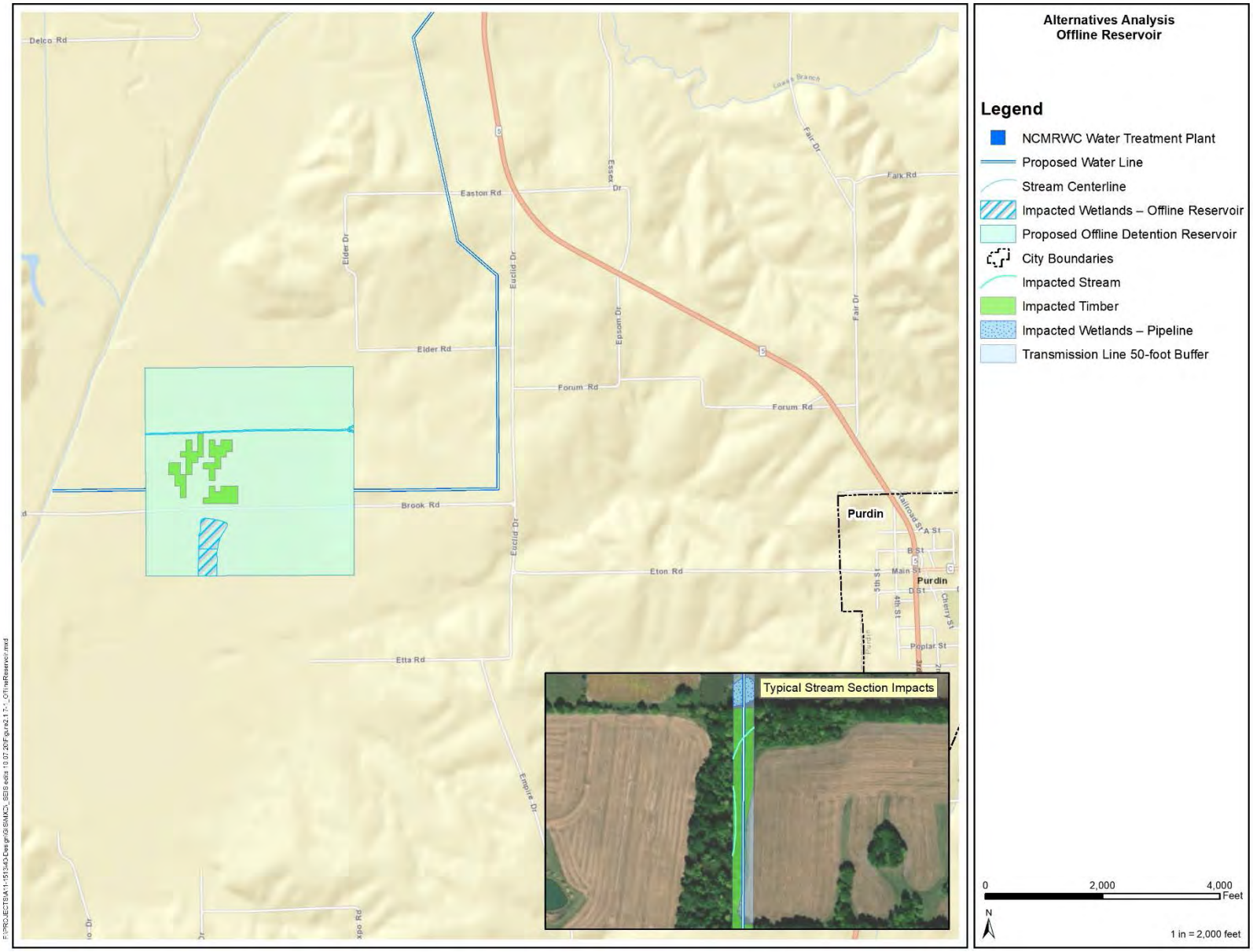


Figure 2.1.7-1. Offline Reservoir Water Supply Alternative.

Create an Online Channel Reservoir – Alternate Reservoir Locations

A feasibility study for the NCMRWC was done in 2003 to study a regional water supply source to serve the future needs of the Green Hills area (Burns & McDonnell 2003). The Green Hills area includes the same area covered in this DSEIS. As part of that feasibility study, five potential reservoir locations were evaluated, including the proposed East Locust Creek Reservoir (Multipurpose Alternative 1). The 2003 Burns & McDonnell feasibility study was the basis of the 2006 FEIS and is the basis of the online channel reservoirs for this DSEIS. The other four reservoir locations evaluated included sites at the following:

- Big Locust Creek
- Little East Locust Creek
- West Fork Locust Creek
- Yellow Creek

Because all reservoir alternatives are in the same general area, all have similar climate, land use, and hydrologic characteristics. The study concluded that the reservoir must have a drainage area of at least 30 square miles or greater to supply the design average daily demand of 7 MGD; the alternative locations all meet this criterion.

Big Locust Creek Reservoir (DPA2)

The Big Locust Creek Reservoir would provide water supply and water-based recreation opportunities. This alternate reservoir site would be developed by creating an earthen dam on Big Locust Creek, approximately 2.5 miles west of Milan. A water transmission line would be constructed from the dam to the NCMRWC water treatment plant at Milan. Recreational facilities including a boat ramp, docks, access lane, and parking spaces would be constructed to support recreational opportunities to the 10-county region.

The maximum normal pool depth would be approximately 50 feet with a water surface elevation of approximately 850 feet above mean sea level (MSL). The earthen dam would cross Big Locust Creek in an east-west direction and would be approximately 0.75 mile long. At normal pool, the reservoir would create a water supply of approximately 106,000 AF and would contain a water surface area of approximately 5,850 acres. This reservoir site would be the shallowest and widest, and the water level would remain relatively stable because it is undersized for the watershed. This dam site has a drainage area of approximately 222 square miles, which is over 7 times the needed watershed size and extends into Iowa.

Currently, much of the Big Locust Creek valley is cropland. Some of the flatter land out of the Big Locust Creek floodplain is also currently farmed. The use of pesticides and herbicides on agricultural land within a water supply watershed is a concern regarding water quality at this site. Two existing state-maintained blacktop roads, Missouri Route OO and Missouri Route BB, would be flooded with the construction of this reservoir. Portions of five county gravel roads would also be inundated with the impounded water.

Figure 2.1.7-2 shows the location of this alternative and the conceptual route of the transmission line from the alternate reservoir location to the proposed water treatment plant and distribution center at Milan. The 4.7-mile-long transmission line would follow Missouri state highways to the plant. The transmission line is expected to require one pump station, 16 road crossings, and four

stream crossings. The pump station would require the construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require concrete encasement or casing of the line.

The 5,850-acre reservoir would provide recreational opportunities to the 10-county region. Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. Thus, a 5,850-acre lake would provide 231,000 user-days of recreation.

This alternative meets the water supply and water-based recreation screening criteria and will be considered a viable alternative; it will be carried forward for the multipurpose analysis. For a description of the water-based recreation screening criteria, see Section 2.3.1.

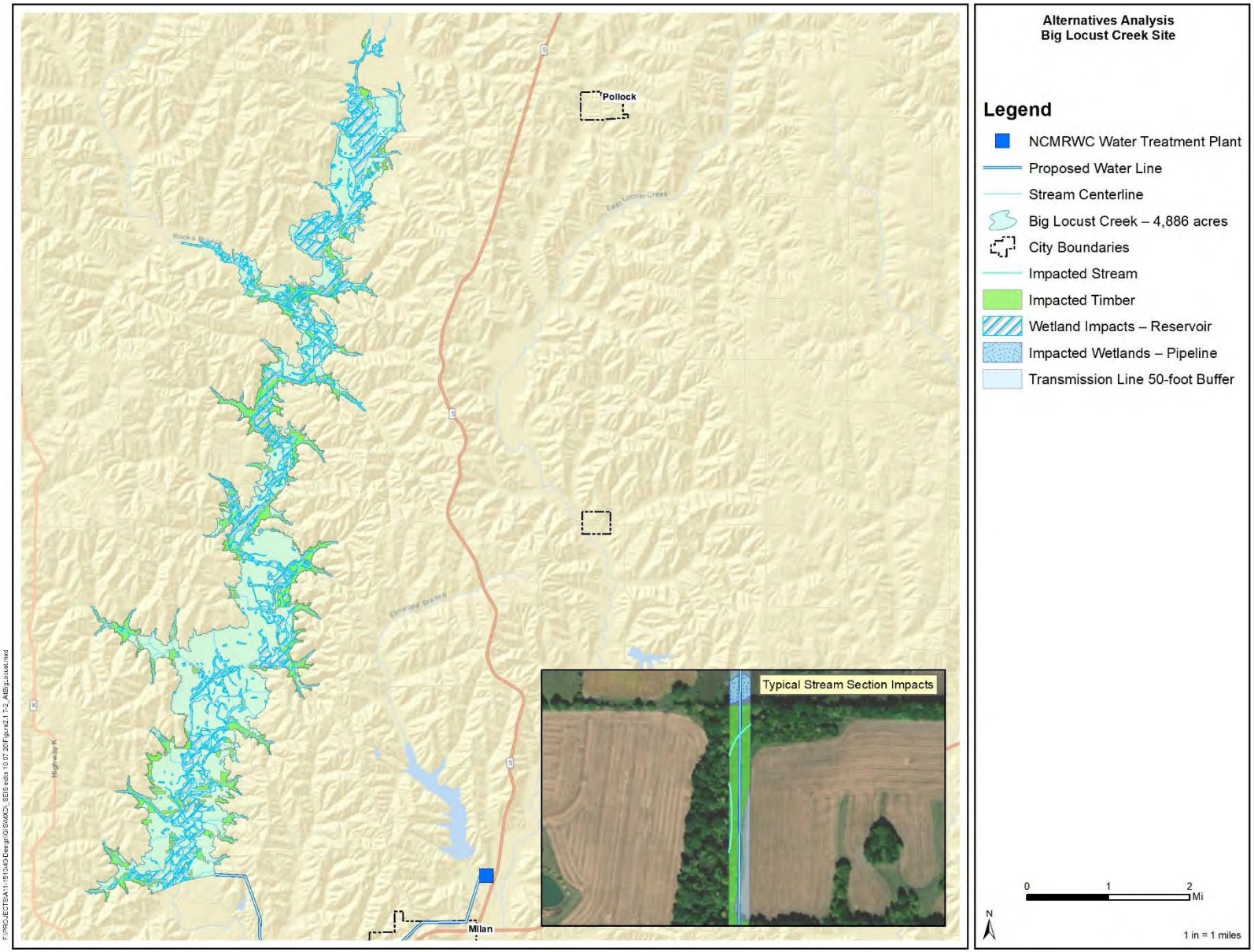


Figure 2.1.7-2 Alternative Lake Location Water Supply Alternative – Big Locust Creek Site.

Little East Locust Creek Reservoir (DPA3)

The Little East Locust Creek Reservoir would provide water supply and water-based recreation. This reservoir site would have an earthen dam across Little East Locust Creek, located 2 miles north and 1 mile east of the City of Browning, Missouri. A water transmission line would be constructed from the dam to the NCMRWC water treatment plant at Milan. Recreational facilities including a boat ramp, docks, access lane, and parking spaces would be constructed to support recreational opportunities to the 10-county region.

The dam would be approximately 0.70 mile in length with a permanent pool maximum depth of 70 feet. The elevation of the normal pool would be 820 feet above MSL. This structure would create an impoundment with 3,650 acres of surface area at the permanent pool and volume of approximately 64,000 AF of water. The drainage area of the reservoir is approximately 39 square miles.

Most of the drainage area for this lake site is in pasture, which is good from a water quality perspective because smaller amounts of pesticides or herbicides should be present in the runoff water from pasture. Initial observations indicate the construction of this reservoir site would not inundate any permanent residences and would have limited impacts to infrastructure. Impounded water would cross over five county gravel roads and Missouri Route UU in one spot. The water would cross over Missouri Route UU near the location where state maintenance ends and township maintenance begins. If this potential lake site is constructed, at least one section of petroleum pipeline would have to be relocated from the bottom of the reservoir. The pipeline is currently located approximately 2 miles north and 2 miles east of Browning.

The 3,650-acre Little East Locust Creek Reservoir would provide water-based recreation opportunities. Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. A 3,650-acre lake would provide 144,000 user-days of recreation.

Figure 2.1.7-3 shows the location of this alternative and the conceptual route of the transmission line from the alternate reservoir location to the proposed water treatment plant and distribution center at Milan. The 17.8-mile-long transmission line would follow Missouri state highways to the plant. The transmission line is expected to require two pump stations, 17 road crossings, and 17 stream crossings. The pump station would require the construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require concrete encasement or casing of the line.

This alternative meets the water supply and water-based recreation screening criteria and is considered a viable alternative; it is carried forward for the multipurpose analysis. For a description of the water-based recreation screening criteria, see Section 2.3.1.

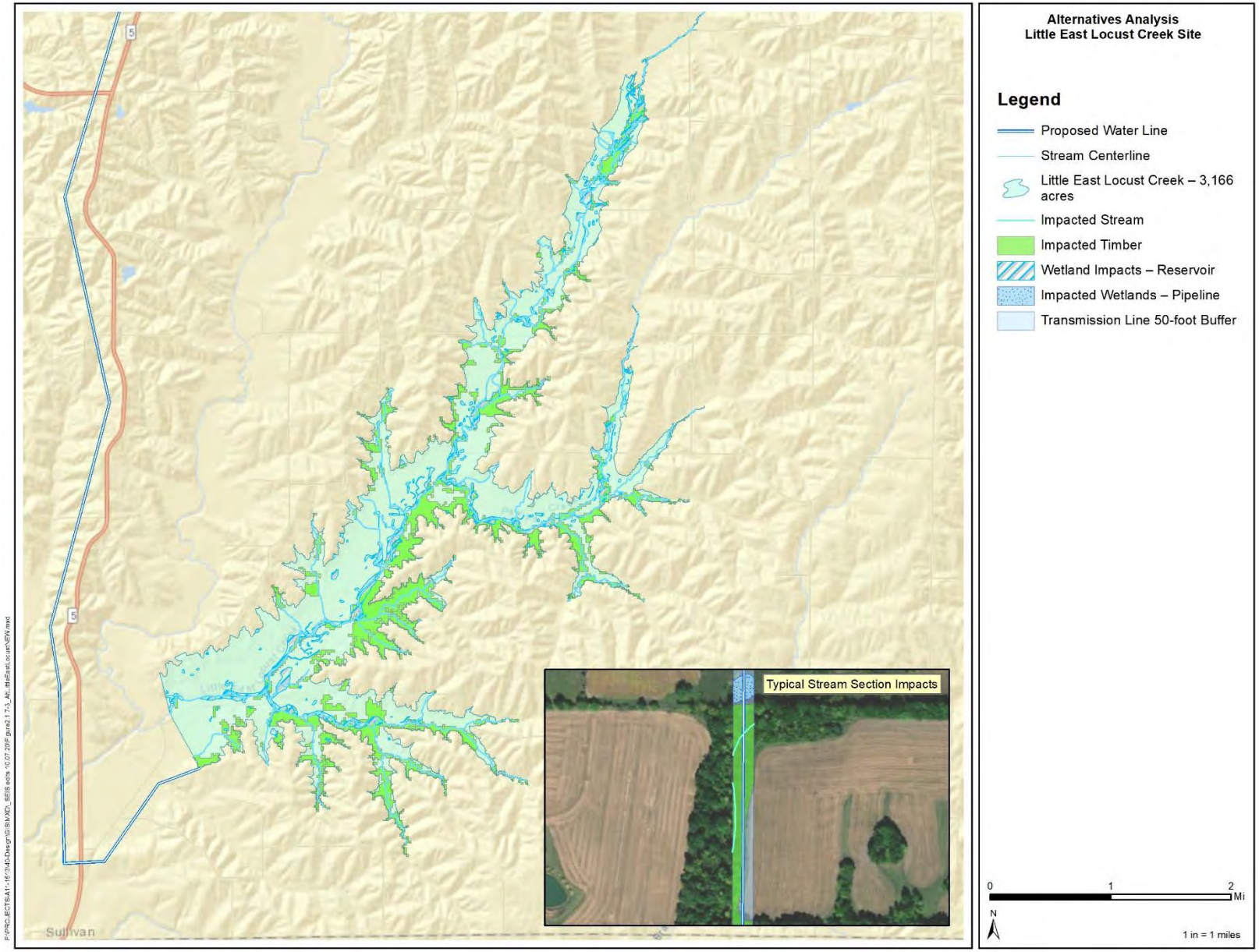


Figure 2.1.7-3. Alternative Lake Location Water Supply Alternative – Little East Locust Creek Site.

West Fork Locust Creek Reservoir (DPA4)

The West Fork Locust Creek Reservoir would provide water supply and water-based recreation. This alternate reservoir site would include an earthen dam across West Fork Locust Creek, located approximately 4 miles west and 1 mile south of Milan.

This alternative's earthen dam would be 0.45 mile long with a permanent pool maximum depth of 50 feet. The 3,860-acre reservoir would contain approximately 80,900 AF of water at normal pool elevation of 860 feet above MSL. The drainage area contributing to the reservoir is approximately 78 square miles. A water transmission line would be constructed from the dam to the water treatment plant at Milan.

Most of the reservoir's drainage area is pasture; however, approximately eight confinement hog operations are sited directly upstream of this alternative's location. Land application of animal waste poses a potential water quality risk. Impounded water would cross over five county gravel roads and Missouri Route PP in one spot.

The 3,860-acre reservoir would provide recreational opportunities to the 10-county region. Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. Thus, a 3,860-acre lake would provide 152,000 user-days of recreation.

Figure 2.1.7-4 shows the location of this alternative and the conceptual route of the transmission line from the alternate reservoir location to the proposed water treatment plant and distribution center. The 28-mile-long transmission line would follow Missouri state highways to the plant. The transmission line is expected to require one pump station, 28 road crossings, and 10 stream crossings. The pump station would require the construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require concrete encasement or casing of the line.

This alternative meets the water supply and water-based recreation screening criteria and is carried forward for the multipurpose analysis. For a description of the water-based recreation screening criteria, see Section 2.3.1.

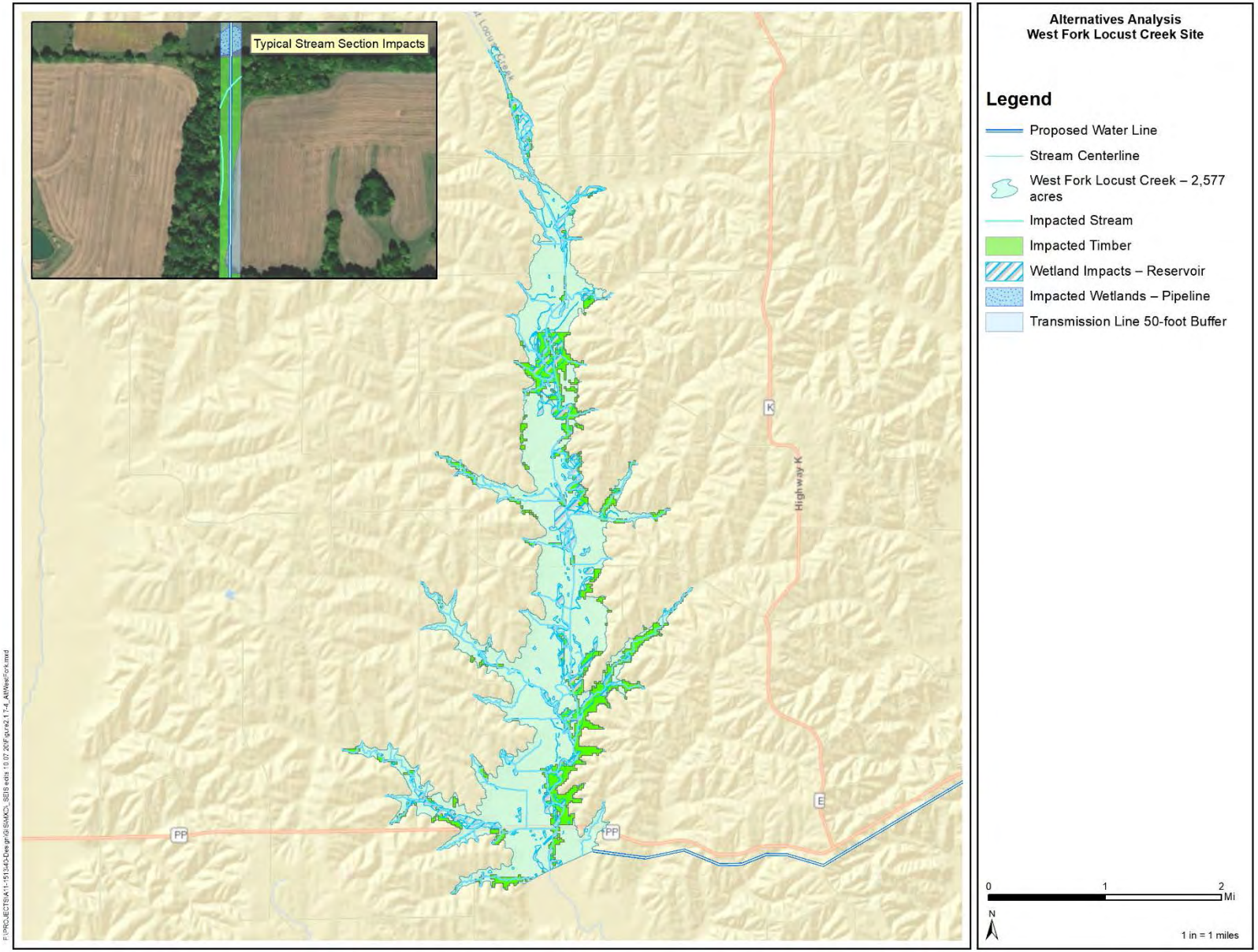


Figure 2.1.7-4. Alternative Lake Location Water Supply Alternative – West Fork Locust Creek Site.

Yellow Creek Reservoir (DPA5)

The Yellow Creek Reservoir would provide water supply and water-based recreation. This reservoir site would include an earthen dam across Yellow Creek, located approximately 2 miles west and 1 mile south of the unincorporated community of Winigan, Missouri. A water transmission line would be constructed from the dam to the water treatment plant at Milan. The 3,210-acre lake would contain approximately 82,700 AF of water at a normal pool elevation of 910 feet above MSL. The contributory drainage area is approximately 34 square miles.

This reservoir would inundate six county- and township-maintained roads, and water would be backed up against Missouri Route V in several locations.

The 3,210-acre lake would provide recreational opportunities to the 10-county region. Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. Thus, a 3,210-acre lake would provide 127,000 user-days of recreation.

Figure 2.1.7-5 shows the location of this alternative and the conceptual route of the transmission line from the alternate reservoir location to the proposed water treatment plant and distribution center at Milan. The 31-mile-long transmission line would follow Missouri state highways to the plant. The transmission line is expected to require three pump stations, 51 road crossings, and 29 stream crossings. The pump station would require the construction of additional access roads and supporting infrastructure. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The creek crossings would require concrete encasement or casing of the line.

This alternative meets the water supply and water-based recreation screening criteria and is considered a viable alternative; it is carried forward for the multipurpose analysis. For a description of the water-based recreation screening criteria, see Section 2.3.1.

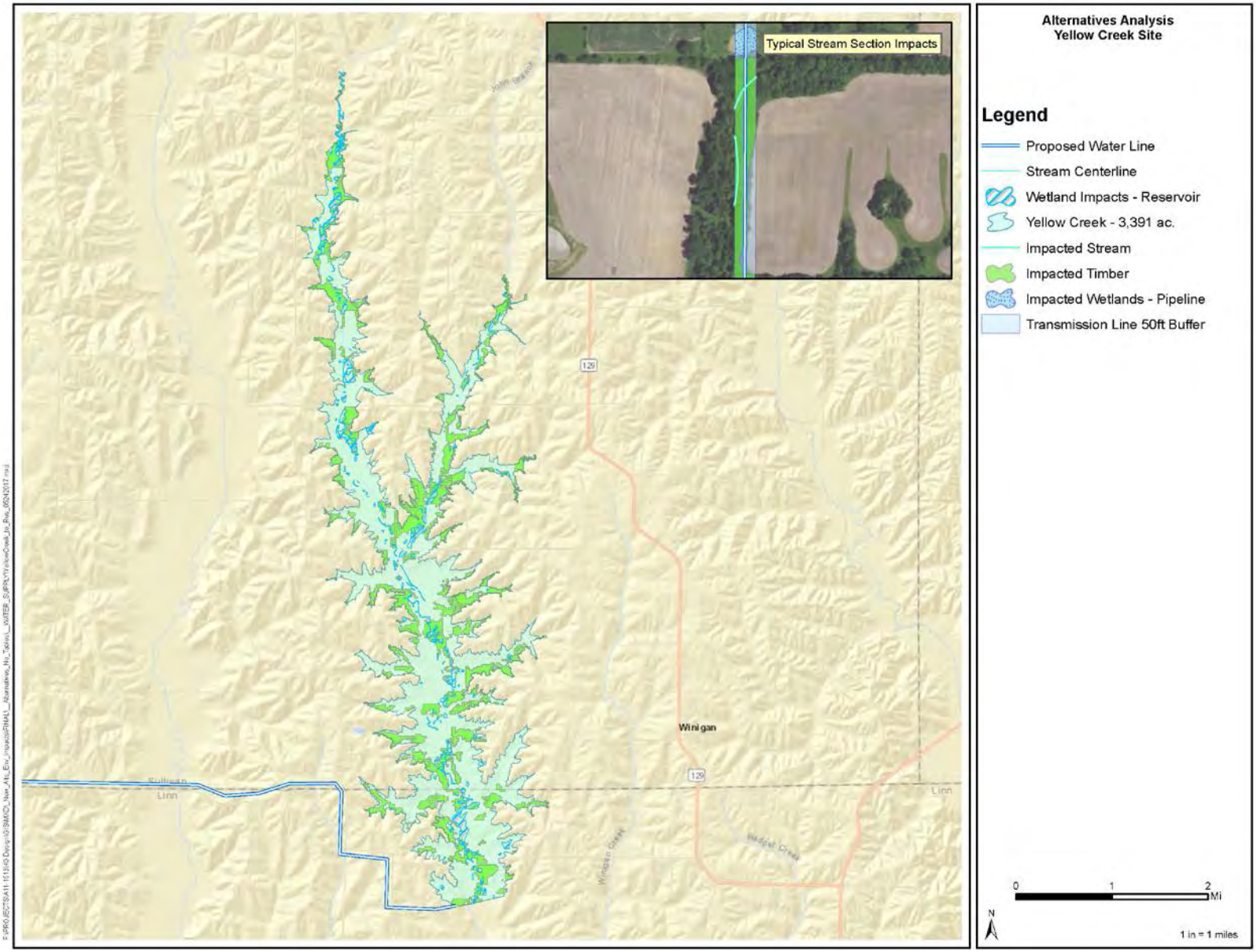


Figure 2.1.7-5. Alternative Lake Location Water Supply Alternative – Yellow Creek Reservoir.

Create a New Online Channel Reservoir – East Locust Creek (RW1)

The Proposed Action, East Locust Creek Reservoir, would be located in Sullivan County, approximately 6 miles north-northeast of Milan, Missouri. An earthen dam would be constructed on East Locust Creek south of Boynton and a water transmission line would be constructed from the dam to the water treatment plant at Milan. The reservoir would have a contributing drainage area of 32.7 square miles, and the 0.5-mile-long dam would impound water to a normal pool maximum depth of 56 feet. At this depth, the proposed lake would have a normal pool surface area of 2,328 acres and a storage volume of 54,000 AF.

This storage volume is the baseline volume established in the 2006 FEIS that would provide 7 MGD average daily demand needed for water supply. For the 2006 EIS, a water balance model was created using NRCS software TR-19 and RESOP. The RESOP model considered seepage, evaporation, rainfall, runoff, 0.5 cfs in-stream flow, and 7 MGD water use. The 7 MGD water use was supported by the RESOP model. A new water budget model was created to evaluate the RESOP model, which is based on monthly data. The new water budget model created a daily water budget to get a better idea of the reservoir level fluctuations. The new water budget model used the unit runoff method to measure runoff per unit area based on existing stream gages for each day during the period of record (1950 – 2017). The new water budget model supported the RESOP model and can be found in Appendix D.

The lake size was adjusted from 2,235 acres, stated in the 2006 FEIS, to 2,328 acres in this DSEIS. The change in normal pool size is based on the base data that was used to measure the normal pool elevation. The 2006 FEIS used photogrammetry measurements and the DSEIS was based on higher resolution 2009 lidar measurements. The Proposed Action would provide water supply, flood damage reduction, and water-based recreation.

The current 2.2 MGD NCMRWC water treatment plant at Milan would need to be upgraded over the 100-year project life to provide the 7 MGD water supply for the 10-county region. The water treatment plant upgrade will occur onsite and will not impact streams or wetlands. Wholesale water will be sold to water systems within the region without water production capabilities.

The Proposed Action would affect utilities, county roads, and Missouri Highway N at Boynton. Funding has been identified through the Better Utilizing Investments to Leverage Development (BUILD) grant program. This program provides federal funding through the project sponsor (MoDOT) to invest in road, rail, and transit projects. Relocations or improvements to county roads and Missouri Highway N have been identified as uses for the BUILD grant. Additional detail on road improvements and relocations related to the BUILD funding can be found in Appendix E.

The 2,328-acre reservoir would provide recreational opportunities to the 10-county region. Recreational facilities including a boat ramp, docks, access lane, and parking spaces would be constructed to support recreational opportunities. Based on the recreation calculations in the purpose and need, reservoirs provide 39.5 user-days of recreation per acre. Thus, a 2,328-acre lake would provide 92,000 user-days of recreation.

The Proposed Action would provide a 50 percent reduction to damages incurred by flooding along the lower 22.5 miles of East Locust Creek. The Proposed Action would result in a flood damage

reduction benefit of $86,800 annually and would not increase peak flow. Approximately 273 acres of current and former croplands would be inundated by the Proposed Action.

Figure 2.1.7-6 shows the proposed project location, utility relocation, road improvements, and the route of the transmission line from the proposed reservoir location to the proposed water treatment plant and distribution center at Milan. The 4-mile-long transmission line would follow Missouri state highways to the plant. The transmission line is expected to require no pump stations, four road crossings, and one stream crossing. Crossing Missouri state highways would require boring and an approved permit from MoDOT. The stream crossing would require concrete encasement or casing of the line.

This alternative meets the screening criteria for water supply, flood damage reduction, and water-based recreation and is carried forward for the multipurpose analysis. For a description of the water-based recreation screening criteria, see Section 2.3.1 and for a description of the flood damage reduction screening criteria, see Section 2.2.1.

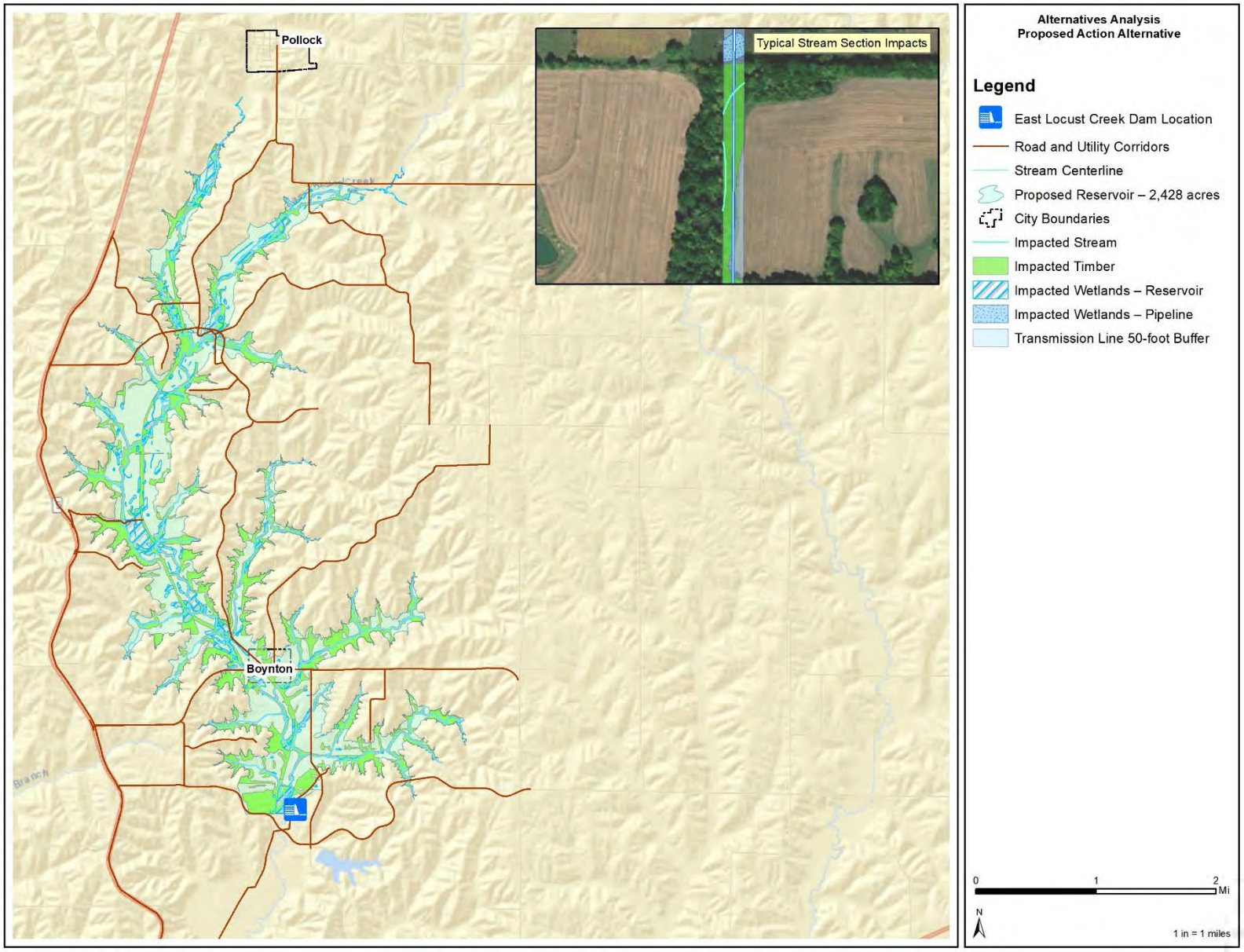


Figure 2.1.7-6. Water Supply Alternative – East Locust Creek Reservoir.

2.1.3. Summary of Individual Water Supply Alternatives

Table 2.1.3-1 summarizes all the individual water supply alternatives, how much volume of water they could produce, and whether they met all the screening criteria.

Table 2.1.3-1. Summary of Water Supply Alternatives Screening Criteria Results.

Alternatives	Meets Criteria	Screening Criteria			
		A Volume of Water Supply and Dependability in Drought	B Capable of being Accomplished/ Attained	C Willing Particip ation	D Meets MDNR Design Standards
No Action Alternative	N	N (0 MGD)	N	N	N
WA1. Drill wells into glacial aquifers	N	N (0 MGD)	N	Y	Y
WA2. Drill wells into bedrock aquifers	N	N (0 MGD)	N	Y	Y
WA3. Drill wells into the Missouri River alluvium	Y	Y	Y	Y	Y
WA4. Drill wells into the Mississippi River alluvium	Y	Y	Y	Y	Y
WA5. Drill wells into Grand River alluvium	Y	Y	Y	Y	Y
WA6. Livingston County PWSD No.4	N	N (0.140 MGD)	Y	Y	Y
WA7. RRWA	N	N (0 MGD)	N	N	Y
WA8. MMU	N	N (0.650 MGD)	Y	Y	Y
WA9. MO American Brunswick	N	N (1.049 MGD)	Y	Y	Y
WA10. Salisbury	N	N (0.257 MGD)	Y	Y	Y
WA11. Chillicothe municipal utilities	N	N (1.34 MGD)	Y	Y	Y
WA12. Thompson River	N	N (0 MGD)	N	Y	Y
WA13. Locust Creek	N	N (0 MGD)	Y	Y	Y
WA14. Forest Lake (Thousand Hills)	N	N (2.91 MGD)	Y	Y	Y
WA15. Green City Lake	N	N (0.15 MGD)	Y	Y	Y
WA16. Elmwood Lake	N	N (0 MGD)	Y	Y	Y
WA17. Unionville Lake	N	N (0 MGD)	Y	Y	Y
WA18. Hazel Creek	N	N (0 MGD)	Y	Y	Y
WA19. Mark Twain Lake	Y	Y	Y	Y	Y
DPA1. Create an offline reservoir	Y	Y	Y	Y	Y
DPA2. Create an online channel reservoir – Big Locust Creek	Y	Y	Y	Y	Y
DPA3. Create an online channel reservoir – Little East Locust Creek	Y	Y	Y	Y	Y
DPA4. Create an online channel reservoir – West Fork Locust Creek	Y	Y	Y	Y	Y
DPA5. Create an online channel reservoir – Yellow Creek	Y	Y	Y	Y	Y
RW1. Create an online channel reservoir – East Locust Creek (Proposed Action)	Y	Y	Y	Y	Y

2.1.4 Combination of Water Supply Alternatives

This section includes analysis of alternatives that offer some volume of water during drought conditions, but which do not individually supply enough water to meet the water supply purpose and need as determined through the screening criteria.

Table 2.1.3-1 shows all the water supply alternatives and their ability to meet the screening criteria. Water supply alternatives that did not meet screening criterion A but could supply some volume of water were considered for combining with another alternative. Water supply alternatives that did not meet screening criteria B, C, or D were not considered for the combination of alternatives because combining them with another alternative would not meet the screening criteria and water supply purpose and need.

The list of alternatives that could be considered for a combination alternative include the following:

- Livingston County PWSD No. 4 (WA6)
- MMU (WA8)
- Missouri American Water Company – Brunswick (WA9)
- Salisbury (WA10)
- Chillicothe Municipal Utilities (WA11)
- Forest Lake (Thousand Hills) (WA14)
- Green City Lake (WA15)

Water Supply Combination Alternative (WA20)

Combining all the bulleted water supply alternatives above creates the combination water supply alternative (WA20). As calculated from Table 2.1.3-1, the alternatives considered for the water supply combination of alternatives total 6.5 MGD of water supply. Thus, combining all possible combination alternatives does not provide the 7 MGD needed to meet criterion A. Even though the water supply combination alternative does not meet the screening criteria, it will be moved forward for a multipurpose alternative consideration for comparison purposes and Preferred Alternative consideration. The combination water supply alternative (WA20) also provides recreation to the 10-county region and will be considered for a recreation alternative. For a description of the water-based recreation screening criteria, see Section 2.3.1.

2.1.5 Water Supply – Summary of Alternatives Screening

Alternatives were screened based on their ability to meet the water supply purpose and need. The following alternatives were eliminated from consideration because they did not meet the water supply purpose and need.

No Action Alternative (carried forward for baseline comparison)

Groundwater Sources

- WA1 **–** Drill wells into glacial aquifers
- WA2 **–** Drill wells into bedrock aquifers

Connection to Existing Systems

- WA6 **–** Livingston County PWSD No. 4
- WA7 **–** RRWA
- WA8 **–** MMU
- WA9 **–** Missouri American Water Company – Brunswick
- WA10 **–** Salisbury
- WA11 **–** Chillicothe Municipal Utilities

Streams and Rivers

- WA12 **–** Thompson River
- WA13 **–** Locust Creek

Existing Lakes

- WA14 **–** Forest Lake (Thousand Hills)
- WA15 **–** Green City Lake
- WA16 **–** Elmwood Lake
- WA17 **–** Unionville Lake
- WA18 **–** Hazel Creek

Combination Alternative

- WA20 – Water Supply Combination Alternative (carried forward for comparison)

Alternatives that met the water supply purpose and need will be further described in the multipurpose analysis and are included below.

Groundwater Sources

- WA3 **–** Drill wells into Missouri River alluvium
- WA4 **–** Drill wells into Mississippi River alluvium
- WA5 **–** Drill wells into Grand River alluvium

Streams and Rivers

- None

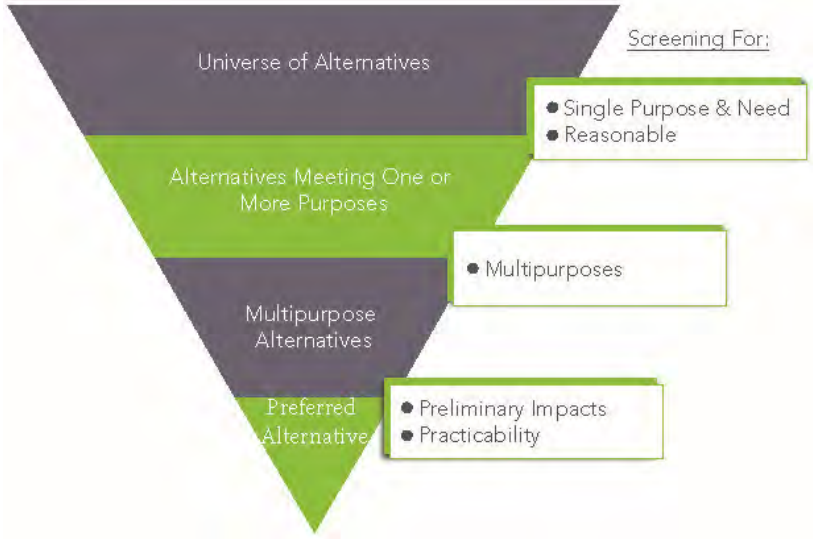
Existing Lakes

- WA19 **–** Mark Twain Lake

Creation of a New Reservoir

- DPA1 **–** Create an offline reservoir
- DPA2 **–** Big Locust Creek
- DPA3 **–** Little East Locust Creek
- DPA4 **–** West Fork Locust Creek
- DPA5 **–** Yellow Creek
- RW1 **–** East Locust Creek – Proposed Action

2.2 Flood Damage Reduction Alternatives Analysis



This section screens the universe of flood damage reduction alternatives.

One of the project purposes and needs is to reduce flood damages along East Locust Creek. The geographic area where flood damage reduction is desired includes the lower 22.5 miles of East Locust Creek above the confluence with Locust Creek near the city of Browning.

Without flood damage reduction, substantial threat of flooding from major storms would continue. Any flood damage alternative considered must reduce flood damages in the target stream reach on East Locust Creek and also must not increase peak flows and thus create flood problems further downstream.

The list of alternatives was developed after determining the flood damage reduction purpose, which is stated as, "reduce flooding damages by at least 50 percent on the lower 22.5 miles of East Locust Creek above the confluence with Locust Creek." A goal of 50 percent reduction in flood damage was selected, which allows for development and analysis of a reasonable range of alternatives.

Flood Damage Reduction Alternatives Considered

- No Action Alternative
- Flood Damage Reduction Alternative 1 (FA1) – Zoning
- Flood Damage Reduction Alternative 2 (FA2) – Floodplain Acquisition
- Flood Damage Reduction Alternative 3 (FA3) – Conservation Measures

Stream Flow Adjustment Alternatives

- Flood Damage Reduction Alternative 4 (FA4) – Conveyance
- Flood Damage Reduction Alternative 5 (FA5) – Levees and Raise Bridges

Dams and Storage Areas Alternatives

- Flood Damage Reduction Alternative 6 (FA6) – Wetland Storage Areas
- Flood Damage Reduction Alternative 7 (FA7) – Large Dry Dam 100-Year Storage
- Flood Damage Reduction Alternative 8 (FA8) – Small Detention Dams
- Multipurpose Alternative 1 (RW1) – Proposed Action – East Locust Creek Reservoir

Combination of Alternatives

- None

Alternative Screening Process

The alternatives were screened by comparing reasonable efforts necessary for the applicant to implement the project while still meeting the purpose and need. All the alternatives are directly focused on the lower 22.5 miles of East Locust Creek above the confluence with Locust Creek. See Figure 2.2-1 for a map of the flood damage reduction area. Efforts to reduce flood damages in the affected stream reach considered all areas in the watershed where peak-flow reduction or other measures resulted in reduced flood damages in the study area.

A hydrologic model was developed using the HEC-HMS software to simulate frequent storm and flow events for the East Locust Creek watershed. The HEC-RAS modeling software was then used to model peak flow water surface elevations along East Locust Creek for frequent or infrequent storms.

Average annual flood damages were calculated using the NRCS ECON2 model. ECON2 determines damages between floodplain cross-sections from several known data points. It uses commodity prices, crop distributions, water elevations where damages begin, ground and structure elevations, and areas affected by specific flows based on HEC-RAS. It then examines flows for various return periods. This analysis used a total of nine flooding frequencies, ranging from a storm occurring on average once every 500 years (0.2 percent probability) to a storm occurring on average twice a year (0.5-year return period). Also, seven different floodplain cross-sections were used. ECON2 weights each storm frequency to develop the average annual damages. A 500-year flow carries less weight than a 0.5-year flow even though it produces more damages, because a 500-year flow is very rare (USDA 1990).

The USDA Economic Research Service data is the standard data NRCS uses for crop price evaluation. The $5.43 per bushel value was determined based on a normalized price, which averages the previous five years' actual market prices. The normalized price for soybeans is $12.29 per bushel, for wheat it is $6.12 per bushel, and for hay it is $100.98 per ton (USDA 2016).

ECON2 calculates bridge damages in a similar fashion but with some differences. The main difference is that it uses a damage curve for each bridge to calculate damages. The damage curve tells ECON2 how much damage occurs at certain water surface elevations. It then analyzes the flows for the nine flooding frequencies to calculate the average annual damages. Average annual damages to roads and bridges are estimated to be approximately $73,600 (Figure 2.2-2).

For the purposes of this analysis, the estimated average annual crop losses described in the purpose and need caused by flooding is approximately $100,000. The ECON2 model was used to determine the reduced flooding impacts to crop and pasture acres for each alternative.

The total current annual flood damage cost is estimated to be approximately $173,600 (2016 dollars), which includes impacts to roads and bridges, crops, and agricultural land. With climate change and increases in winter and spring flooding potential, continued flooding of East Locust Creek and the corresponding crop losses would be expected to continue and potentially increase in the coming years.

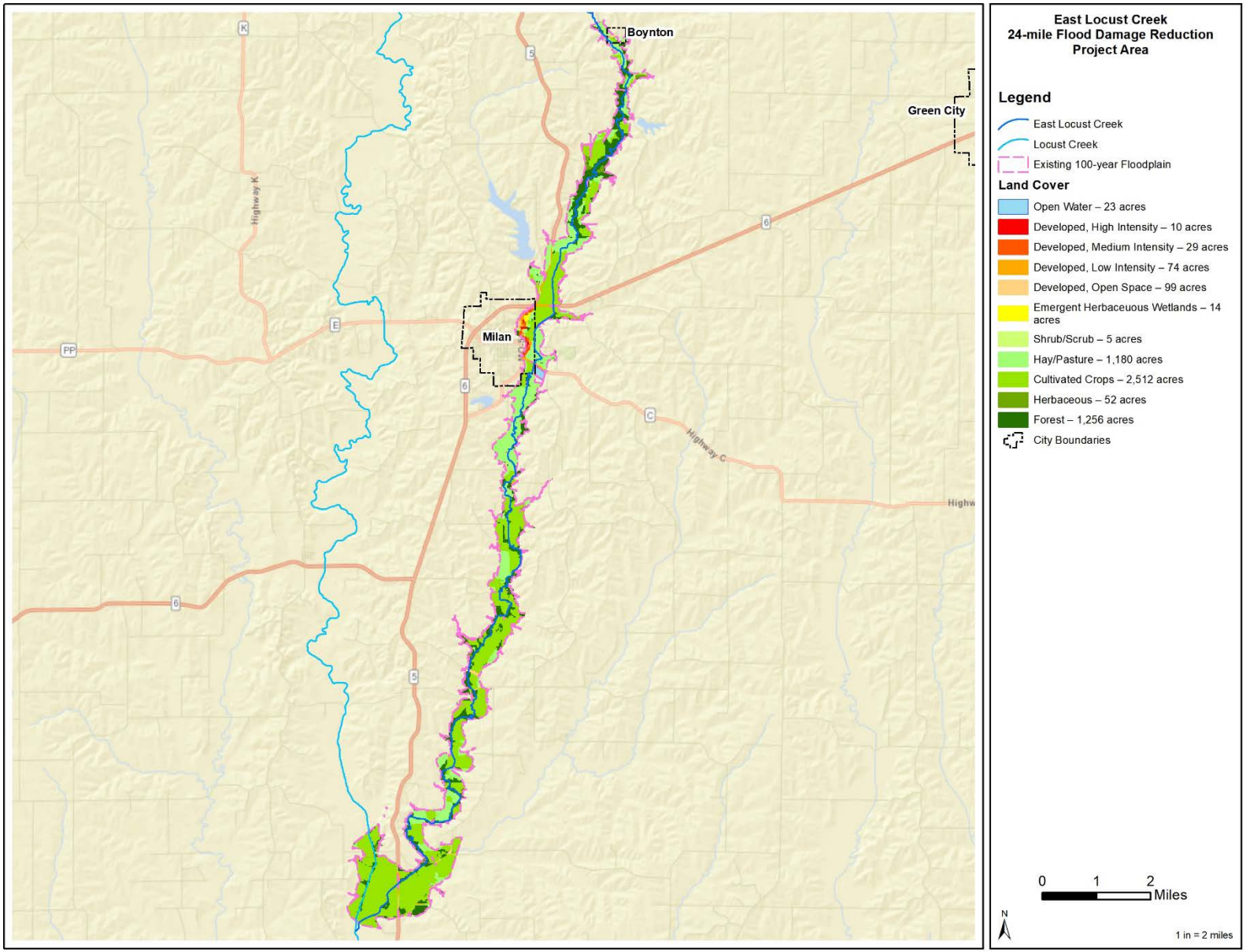


Figure 2.2-1. Flood Damage Reduction Area (URS Corporation 2014).

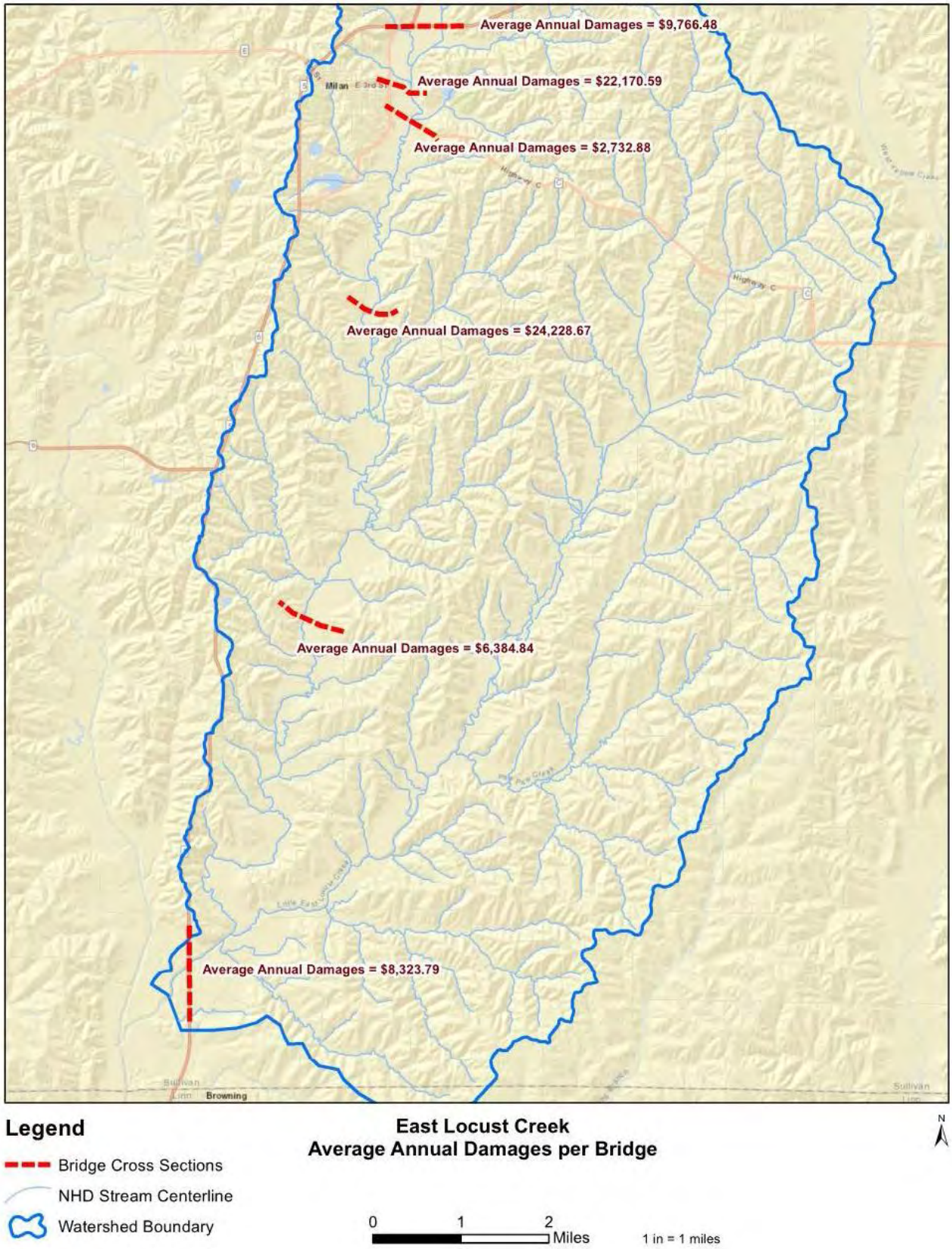


Figure 2.2-2. Location of and Average Annual Damage to Bridges within Flood Damage Reduction Area.

2.2.1 Flood Damage Reduction Screening Criteria

Screening criteria for the flood damage reduction alternatives evaluated the ability to substantially reduce annual flood damages consistent with the purpose and need. Substantial annual flood damage reduction is defined as reducing the annual damages by at least 50 percent. The 50 percent threshold was selected to eliminate alternatives while allowing for evaluation of a reasonable range of alternatives.

The screening criteria narrow the range of alternatives to those that substantially reduce flood damages and meet the purpose and need and include the following:

A. Alternatives must provide substantial flood damage reduction.
    - This criterion is dependent on meeting the purpose of the project. The minimum flood damage reduction has been set at a 50 percent reduction to annual damages incurred by flooding within this study area (e.g., 50 percent of $173,600, or at least $86,800).

B. Alternatives must be compliant with existing codes and regulations.
    - This criterion is reasonable for the logistics of alternative implementation. Existing codes and regulations are maintained by the Missouri Department of Public Safety State Emergency Management Agency and the Federal Emergency Management Agency (FEMA). Additionally, state and local codes and regulations related to land acquisition and zoning must be followed.

C. Alternatives must not increase peak flows downstream to Locust Creek.
    - Increasing peak flows could cause damages downstream. Alternatives that increase peak flows to reduce flood damages in the project area, but cause damages downstream, do not reduce the total flood damages.

The alternatives were screened by comparing reasonable efforts necessary for the applicant to implement the project and meet the purpose and need. Alternatives that meet the screening criteria will be evaluated for the multipurpose Preferred Alternative. Alternatives that do not meet the screening criteria are evaluated in the flood damage reduction combination of alternatives section. If an alternative can be combined with another alternative to meet the screening criteria, it will be evaluated in the multipurpose alternatives analysis.

2.2.2 Flood Damage Reduction – Nonstructural Considered

No Action Alternative

If no action is taken, the land adjacent to East Locust Creek will continue to flood regularly. East Locust Creek routinely overtops its banks, even during common rain events. As many as five flood events occurred in 2010 and three flood events occurred in 2014, including a 6.9-inch downpour in September of that year.

The average annual damage to cropland, roads, bridges, and fences is estimated to be approximately $173,600. Existing damages and degradation from flooding will continue and likely increase over time. Average annual damages of $173,600 per year will continue if no action is taken and if no change in damages occurs.

The No Action alternative does not provide flood damage reduction for the existing roads, bridges, habitable structures, or agricultural lands within the 100-year floodplain and therefore does not meet the purpose and need for the project. This alternative is carried forward as a baseline for comparison.

Zoning (FA1)

This alternative would require action by the county to adopt zoning regulations to prevent future development within the 100-year floodplain. Except for the City of Browning and the City of Milan, Sullivan County does not participate in the National Flood Insurance Program, which requires that new structures be elevated above the base flood elevation and kept reasonably safe from flooding. Zoning regulations would provide protection of development within the rural areas of Sullivan County; however, zoning regulations within the City of Milan would provide no additional protection that is not already provided by the floodplain regulations.

This alternative would not alleviate the current flooding and would not reduce the amount of flooding impacts to current croplands and infrastructure; it would only protect future resources. This alternative does not meet the flood damage reduction screening criteria and is not carried forward to the multipurpose analysis or flood damage reduction combination of alternatives.

Floodplain Acquisition (FA2)

Information on land parcels obtained from geographic information system (GIS) databases was used to determine the acreage within the 100-year floodplain above the lower 22.5 miles of East Locust Creek above the confluence of Locust Creek. This alternative would include acquiring 5,040 acres of land within the 100-year floodplain. Of the 5,040 acres within the 100-year floodplain, 3,560 acres are agricultural lands. Acquisition of land under this alternative would eliminate flood damages to cropland and property from the toe of the dam to the confluence of Locust Creek; however, damages to bridges would remain. To accomplish this alternative, the applicant would need to acquire all 5,040 acres of land within the 100-year floodplain and take it out of production so that it would no longer be subject to these damages. This alternative results in an annual flood damage reduction benefit of approximately $100,000, or approximately 58 percent of the total annual damages.

Floodplain acquisition meets the flood damage reduction screening criteria and will be further evaluated in the multipurpose evaluation section.

Conservation Measures (FA3)

This alternative includes the use of best management practices (BMPs), native plant buffers, and easements, and assumes that this watershed will be maintained primarily for agricultural purposes for the foreseeable future. Agricultural conservation practices such as no-till, buffer strips, grassed waterways, terraces, contour farming, and strip-cropping would be implemented. The conservation measures would be implemented on untreated agricultural lands and future developable lands within the East Locust Creek drainage basin.

Benefits were determined by calculating the reduction in runoff caused by the implementation of conservation measures. The curve number method for calculating stormwater runoff correlates runoff to land use, conservation practices, and soil characteristics. The lower the curve numbers, the greater the flood damage reduction. The higher the curve numbers, the greater the flood damages. The curve number is based on the hydrologic soil groups in addition to the land cover.

The East Locust Creek watershed is composed primarily of hydrologic soil groups C and D. Respectively, these soil groups represent soils with moderately high and high runoff potentials.

To provide flood damage benefits to meet the screening criterion of 50 percent reduction in annual damages, conservation measures must reduce the average NRCS curve number for the watershed from 80.8 to 73.0. Achieving an average curve number of 73.0 would not be possible from conservation measures alone, because the predominant soils in the watershed belong to hydrologic soil groups C and D. The flood damage reduction benefit was analyzed by looking at the lowest curve number that could be achieved with the soils that are present in the watershed. Implementing 100 percent of all existing agricultural lands in the watershed to conservation BMPs could reduce the watershed curve number from 80.8 to 78.3, resulting in an average annual flood damage reduction benefit of $28,800 (about 17 percent) in the study area.

This alternative relies on voluntary landowner participation, which the project proponent, a joint municipal utility commission, has no authority to accomplish. Landowners currently participating in conservation measures rely on the land for income through agricultural production. Market-driven cropland prices often result in the removal of conservation measures for increased cropland acreage. Because this alternative is completely voluntary, there is no guarantee that the conservation measures would be maintained. For example, the MDC estimates that 200,000 acres of Conservation Reserve Program land was lost to contract expirations and land use conversions over a 2-year period in a similar scenario relying upon voluntary landowner participation (MDC 2012).

To accomplish this alternative, the applicant would need to acquire rights to all the existing agricultural land in the watershed, which is not reasonable or feasible. The land in the watershed totals approximately 49,800 acres. This alternative is included as part of the universe of alternatives, but analysis shows that it does not provide a 50 percent reduction in flood damages, is not reasonable because it would require purchasing all the land rights in the watershed, and is not feasible because it would otherwise rely on voluntary landowner participation. For all these reasons, this alternative is eliminated as a flood damage reduction combination alternative.

2.2.3 Flood Damage Reduction – Stream Flow Adjustment

Conveyance (FA4)

This alternative would seek to eliminate flood damages by increasing the conveyance capacity of East Locust Creek to contain the projected 100-year flow for a portion of the reach to reduce annual damages by at least 50 percent. To provide the necessary conveyance for the 100-year flow, the channel cross-section must be 375 feet wide on the upstream portion of the reach and increase to 500 feet wide at the most downstream portion with 2:1 rock-lined side slopes. The existing width on the upstream portion is approximately 50 feet wide and the existing width on the downstream portion is approximately 100 feet wide. Three bridges along the reach would also need to be widened to provide the necessary conveyance. Figure 2.2.3-1 shows a concept of this alternative.

This alternative would require the buyout of 871 acres of land for construction of a new channel and would take the land out of production so that it would no longer be subject to damages. The Conveyance alternative would concentrate flow during large storm events and increase peak flow. This alternative would reduce annual flood damages by 59 percent (criterion A), but increase peak flows and does not meet criterion C. Therefore, this alternative is not carried forward to the

multipurpose section but will be evaluated in the flood damage reduction combination of alternatives.

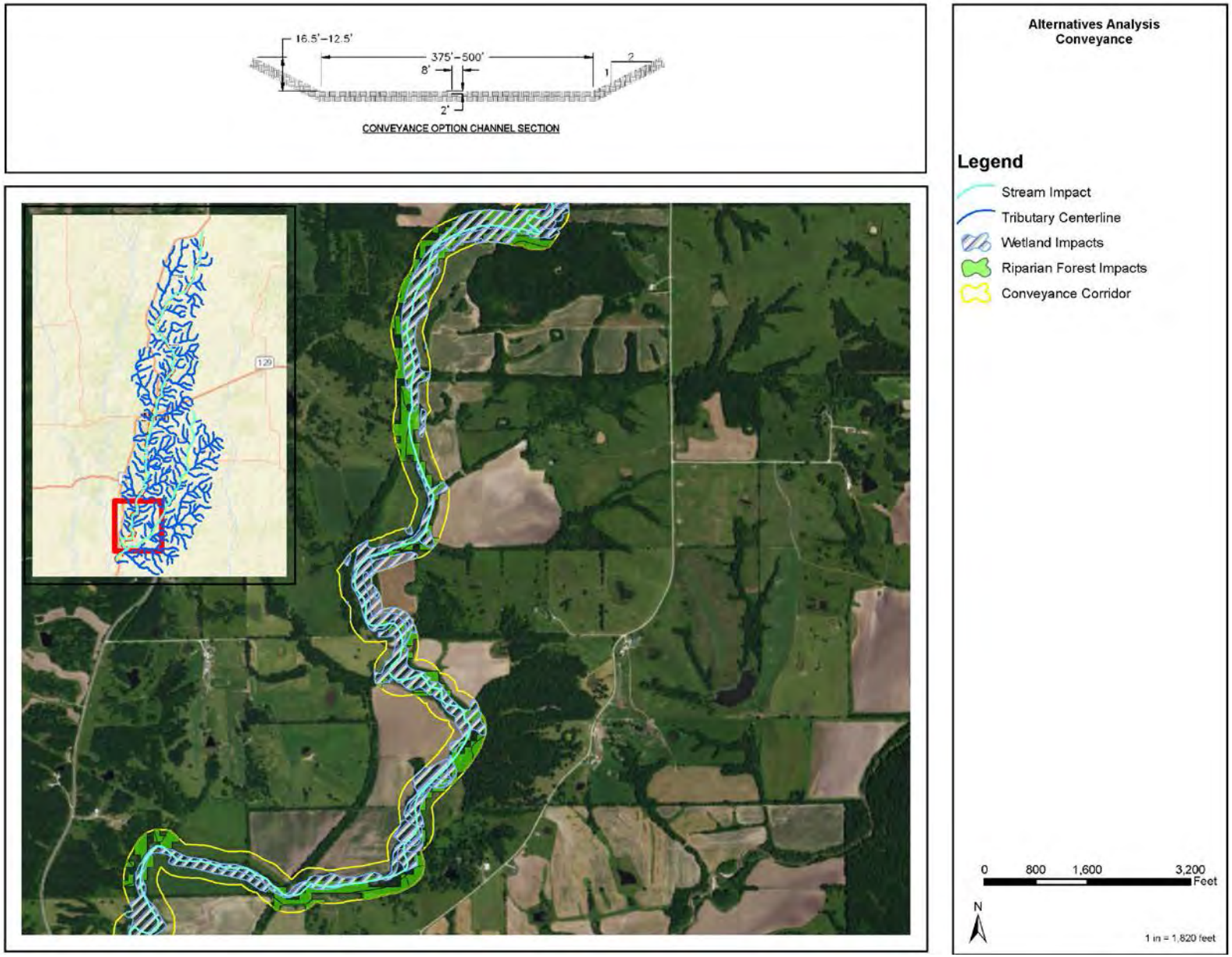


Figure 2.2.3-1. Stream Conveyance Conceptual Plan.

Levees and Raise Bridges (FA5)

This alternative would seek to eliminate flood damages by constructing earth-fill levees and raising existing bridges along East Locust Creek in the study area. Figure 2.2.3-2 shows a concept of this alternative. The construction of 24-foot-tall levees for 10 miles of the reach would result in a change in land use for 376 acres of cropland and pasture from the floodplain. Four bridges would need to be replaced, which would require approximately 21,695 square feet of new bridge construction. This would keep the existing width for each bridge but increase their lengths to span levees.

The average annual flood damage reduction benefit is estimated at $113,000. This alternative provides 65 percent in flood damage reduction and meets criterion A. However, this alternative increases peak flows and does not meet criterion C. Therefore, this alternative is not carried forward to the multipurpose section but will be evaluated in the flood damage reduction combination of alternatives.

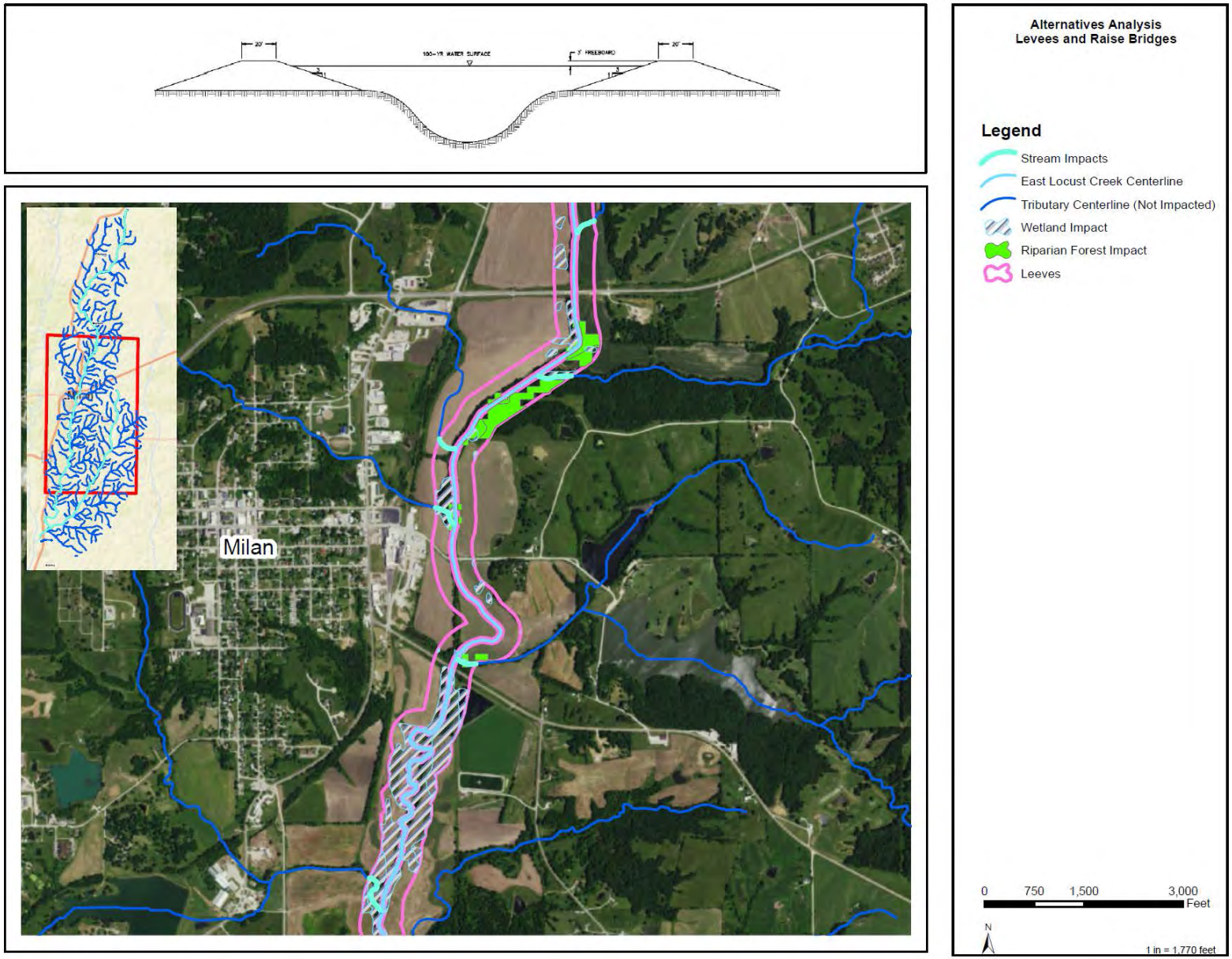


Figure 2.2.3-2. Construct Levees and Raise Bridges Conceptual Plan.

2.2.4 Flood Damage Reduction – Dams and Storage Areas

Wetland Storage Areas (FA6)

This alternative analyzed the watershed for the creation of wetland storage areas throughout the basin to reduce flood flows for East Locust Creek. Constructed wetlands within the watershed would serve as offline detention to reduce the flood flows. Each of these wetlands would be 3 feet at the berm and slope upstream. The hilly topography precludes large areas of wetland development and, because of the incised streams, extensive excavations or impoundments would be needed to create wetlands. Additionally, based on the existing soil type and hydrology, areas within the watershed that are conducive to wetland creation or enhancement are limited. Figure 2.2.4-1 illustrates the Wetland Storage Areas alternative.

Using hydric soils data from the NRCS, approximately 6,140 acres were identified as containing hydric or predominantly hydric soils (at least 66 percent hydric inclusions) in the 79,500-acre drainage basin. All other mapped soil types are non-hydric or predominantly non-hydric (less than 40 percent hydric inclusions). If all 6,140 acres are converted to 3-foot basin wetlands, an average annual flood damage reduction benefit of $116,000, or 67 percent, could be achieved. Peak-flow reduction was estimated by modifying the existing conditions in the HEC-HMS hydrology model to represent the wetland storage basins in each watershed. This model assumed all the hydric soil areas were modified to 3-foot wetland basins.

This alternative provides a 67 percent reduction in flood damages, meeting the screening criterion of 50 percent reduction in damages, and it would reduce peak-flow. Because this alternative meets the screening criteria, it will be further evaluated in the multipurpose evaluation section.

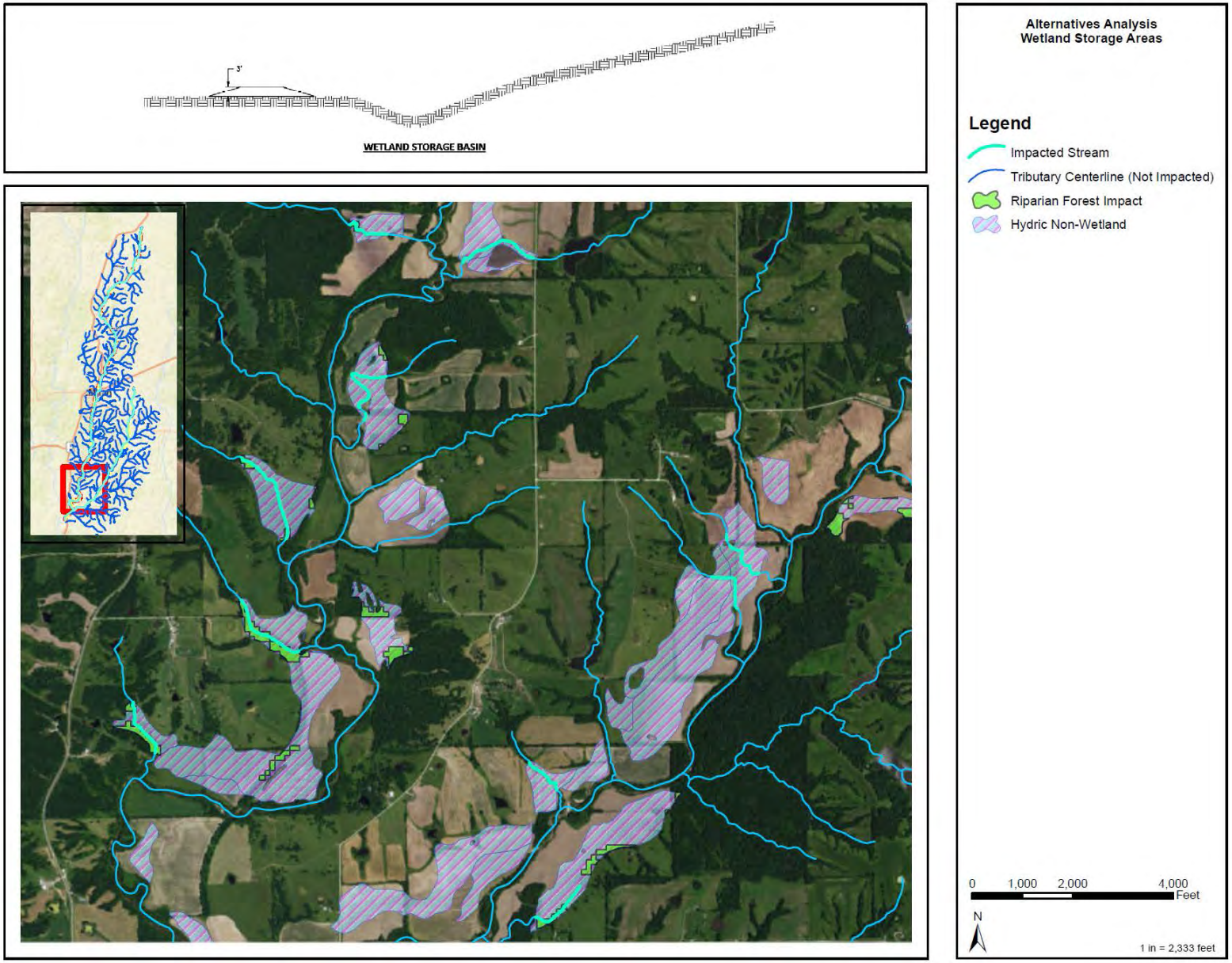


Figure 2.2.4-1. Wetland Storage Areas Conceptual Plan.

Large Dry Dam – 100-year Storage (FA7)

This alternative was designed to hold a 100-year volume of runoff at the depth of the spillway and includes the construction of an embankment solely for flood damage reduction at the location of the Proposed Action. Figure 2.2.4-2 shows a concept of this alternative. The dam under this alternative would be similar to the dam designed for the Proposed Action, but on a smaller scale with no permanent water storage. The top-of-dam elevation would be approximately 898 feet above MSL, which is 40 feet lower than the Proposed Action's top of dam.

This alternative would reduce the 100-year peak flow and would provide an average annual flood damage reduction benefit of $84,200, or 49 percent.

This alternative would reduce peak flow (criterion C) and nearly meets the 50 percent flood damage reduction target (criterion A). This alternative is carried forward to the multipurpose section.

A smaller dry dam, capable of storing the 50-year event without use of the spillway, was also considered; however, there was no substantial difference in the dam size between the 50-year and the 100-year dry dam options. The top-of-dam elevation would be approximately 896 feet above MSL, or 2 feet lower than the 100-year dry dam option. The smaller dry dam would result in similar flood reduction and impacts to wetlands, streams, and forests. Construction costs would be similar to the larger dry dam option; therefore, the smaller dry dam was eliminated from consideration.

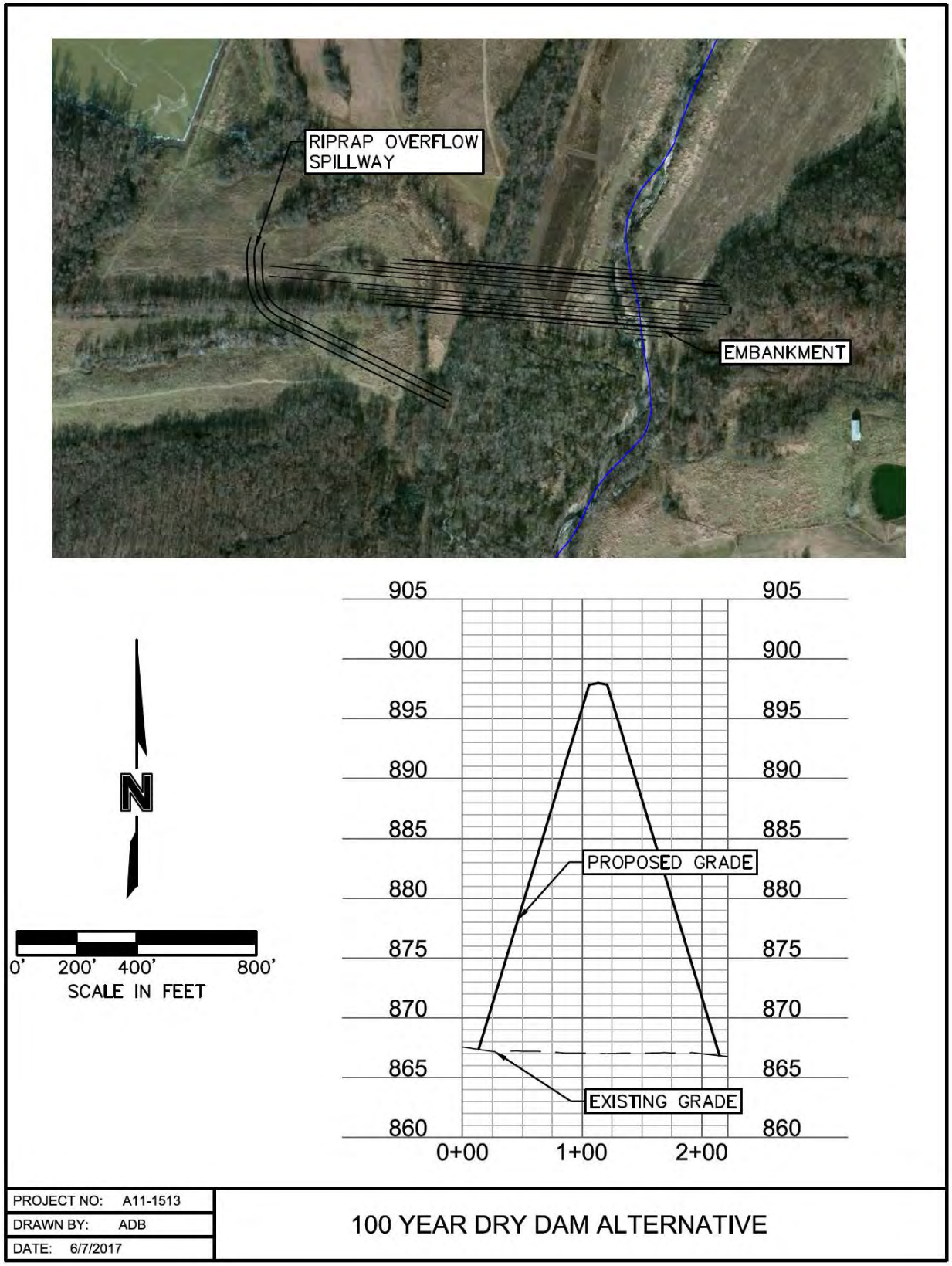


Figure 2.2.4-2. Large Dry Dam Conceptual Plan – 100-year Storage.

Small Detention Dams (FA8)

This alternative would seek to provide flood damage reduction by constructing a series of small detention dams to maximize flood storage and control upstream runoff. A total of 23 small detention dams were designed for optimal storage and flood damage reduction. These structures were conceptually designed as dry structures to reduce stream impacts. Figure 2.2.4-3 shows a concept of this alternative.

The detention dams would intercept runoff from 26.4 percent of the watershed and reduce peak flow rates from the existing condition. The HEC-HMS model estimated flow rates at the top of the flood reduction area were reduced by approximately 34 percent. Using ECON2 to analyze these flows from HEC-HMS, the average annual flood damages would be reduced by approximately 21 percent. These dams were designed to have a life span of 100 years. The average annual flood damage reduction benefit was estimated at $35,800.

The small detention dams alternative provides 21 percent flood damage reduction. This alternative does not meet the screening criteria for 50 percent flood damage reduction (criterion A); therefore, the small detention dams alternative is not carried forward as a standalone alternative to the multipurpose section. This alternative will be evaluated in the flood damage reduction combination of alternatives section.

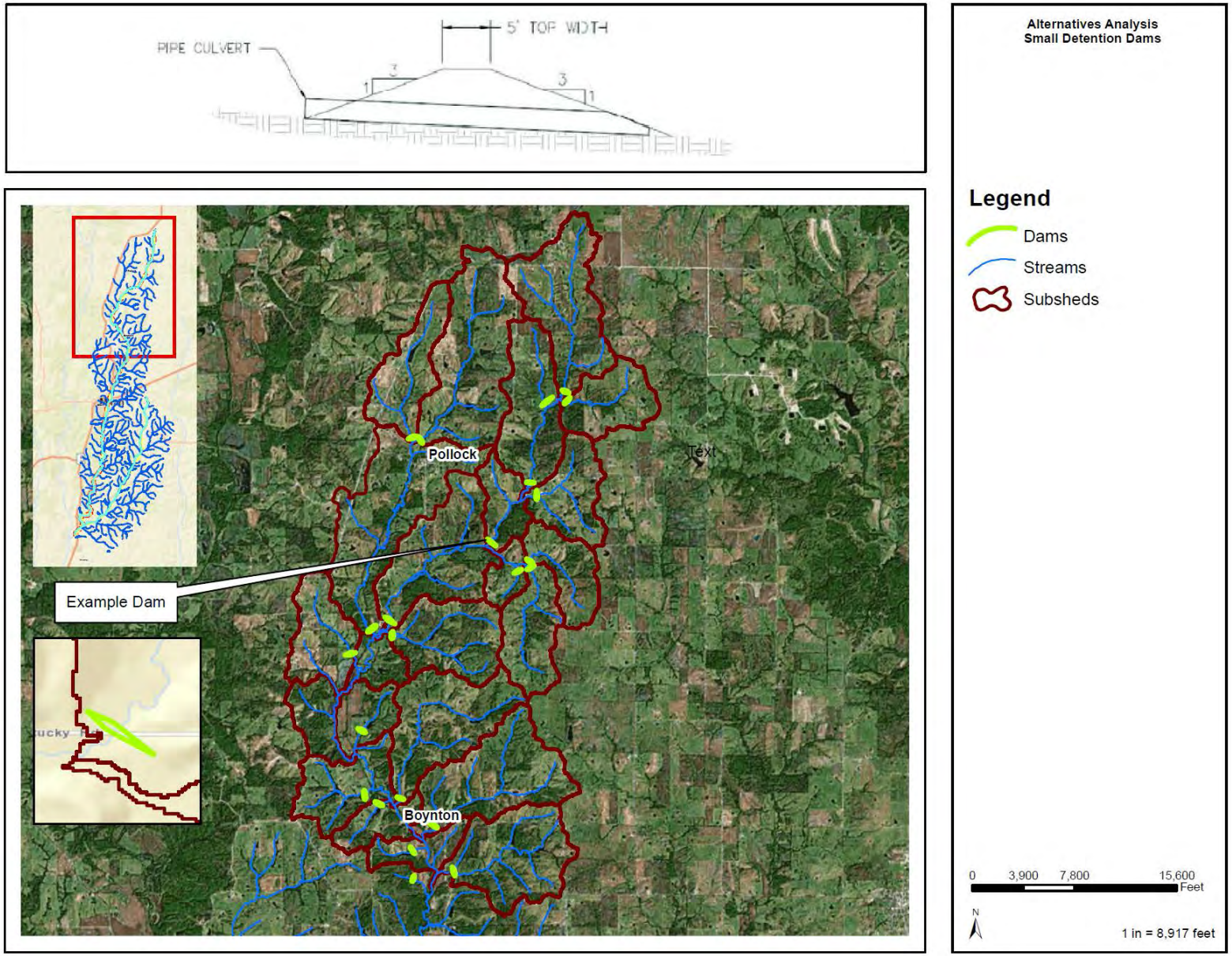


Figure 2.2.4-3. Small Detention Dams Conceptual Plan.

Proposed Action – East Locust Creek Reservoir (RW1)

The Proposed Action provides water supply, flood damage reduction benefits, and water-based recreation opportunities. The Proposed Action is described in more detail in Section 2.1.2.6 Water Supply – Creation of a New Reservoir.

The Proposed Action provides $86,800 in annual flood damage reduction benefits and meets the flood damage reduction screening criteria. The 2006 EIS describes construction of floodwater-retarding structures to be constructed as part of the Proposed Action. These have been eliminated from consideration and there will be no additional floodwater retarding structures proposed.

2.2.5 Flood Damage Reduction – Combinations of Alternatives

The Floodplain Acquisition, Wetland Storage Areas, Large Dry Dam, and Proposed Action alternatives meet the flood damage reduction screening criteria and will be considered in the multipurpose section.

The remaining alternatives do not individually meet screening criterion A (50 percent reduction in flood damages) or screening criterion C (no increase in peak flow), but were evaluated to see if they could meet criteria when combined with other alternatives.

Alternatives were considered as possible flood damage reduction combination alternatives if they provided some flood damage reduction benefit and didn't increase peak flow or depth, velocity, duration, or frequency of flooding downstream. No Action and Zoning were not considered as possible flood damage reduction combination alternatives because they did not provide any flood damage reduction benefit. The Conservation Measures alternative was not considered because it is not reasonable to purchase all the property rights within the watershed.

Table 2.2.5-1 shows the flood damage reduction alternatives. The alternatives used for further evaluation as combination alternatives are the following:

- Conveyance
- Levees and Raise Bridges
- Small Detention Dams

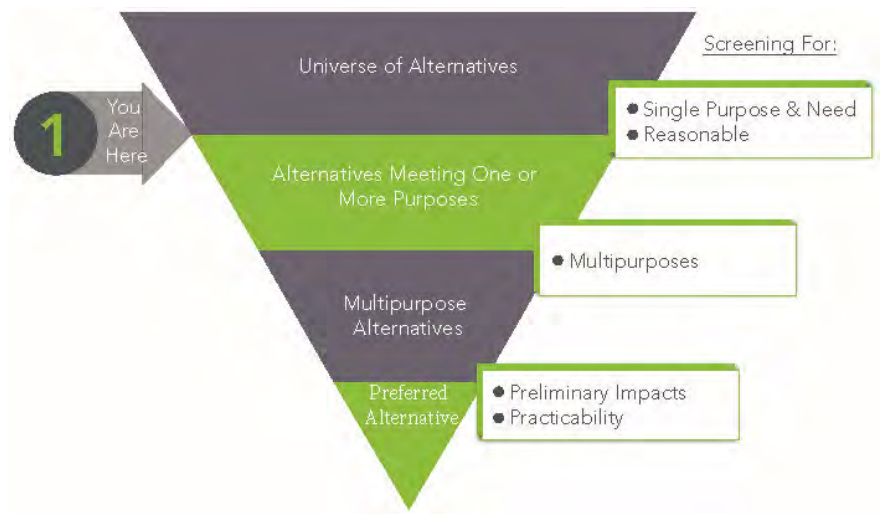
Levees and Raise Bridges and Conveyance do not meet screening criteria C because peak flow is increased for each alternative. Small Detention Dams reduces peak flow and meets screening criterion C; however, Small Detention Dams would not offset the peak flow increases from the Levees and Raise Bridges or Conveyance alternatives. Small Detention Dams are effective for 10-year peak flows but would have little effect on larger storms (i.e., 100-year storms). Thus, a combination of Small Detention Dams with either Levees and Raise Bridges or Conveyance would increase peak flows in large storm events and cause additional flood damages downstream. The Small Detention Dams and Levees and Raise Bridges or Conveyance combination are not considered as a combination alternative.

Table 2.2.5-1. Summary of Flood Damage Reduction Screening Criteria Results.

Alternative	Flood Damage Reduction (%)	Criterion A Meets Need for Flood Damage Reduction	Criterion C Meets No Increase for Peak Flow
No Action Alternative	0	No	No
FA1 – Zoning	0	No	No
FA2 – Floodplain Acquisition	58	**Yes**	**Yes**
FA3 – Conservation Measures	17	No	**Yes**
FA4 – Conveyance	59	**Yes**	No
FA5 – Levees and Raise Bridges	65	**Yes**	No
FA6 – Wetland Storage Areas	67	**Yes**	**Yes**
FA7 – Large Dam 100-year Storage	49	**Yes**	**Yes**
FA8 – Small Detention Dams	21	No	**Yes**
RW1 – Proponent's Proposed Action – East Locust Creek Reservoir	50	**Yes**	**Yes**

2.3 Water-based Recreation Alternatives Analysis

The list of alternatives was developed after determining the recreation project purpose, which is stated as the following: "Provide water-based recreation to meet the unmet demand for the 10-county RMA, including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties."



This section screens the universe of alternatives for water-based recreation.

As described in the purpose and need section, the 10-county region has a demand of 1,874,000 annual recreation user-days and a supply of 647,000 annual recreation user-days, resulting in an unmet demand of 1,227,000 annual recreation user-days. The unmet demand was calculated by subtracting the recreation supply from the recreation demand for the 10-county region. To meet the purpose and need, alternatives must be able to provide recreation to meet part of the unmet demand for the 10-county region.

Water-based Recreation Alternatives Considered

No Action

- No Action Alternative

Streams and Rivers

- Create New Stream Access (RA1)

Existing Lakes

- Expand Existing Public Lakes (RA2)
- Provide Public Access to Existing Private Lakes (RA3)

New Reservoirs or Impoundments

- Create an Offline Reservoir (DPA1)
- Create Big Locust Creek Reservoir (DPA2)
- Create Little East Locust Creek Reservoir (DAP3)
- Create West Fork Locust Creek Reservoir (DPA4)
- Create Yellow Creek Reservoir (DPA5)
- Create East Locust Creek Reservoir – Proposed Action (RW1)

Combination of Alternatives

- Combination of Expand Existing Public Lakes and Creation of an Offline Impoundment (RA4)

2.3.1 Water-based Recreation – Screening Criteria

Screening criteria for the alternatives analysis considered opportunities to provide water-based recreation in the RMA. Several criteria were used to screen alternatives and determine whether to eliminate them or carry them forward. The screening criteria are based on supply and demand determination from the purpose and need analysis and include fishing and boating/sailing/canoeing/kayaking. To meet the purpose and need, alternatives must be able to provide these recreational uses.

Criteria to meet the purpose and need for water-based recreation are the following:

A. Alternatives must allow for fishing and boating/sailing/canoeing/kayaking.
    - This criterion is dependent on providing user-days for both fishing and boating/sailing/canoeing/kayaking.

B. Alternatives must meet or exceed 5 percent of the unmet user-day demand.
    - This criterion is dependent on providing at least 61,400 annual user-days for adequate water-based recreation opportunities.

C. Alternatives must be available for public use and have public access.
    - This criterion requires public ownership and reasonable parking and walking lanes for access to the water-based recreation.

Water-based Recreation Analysis

The alternatives were screened by comparing reasonable efforts necessary for the applicant to implement a project that meets the purpose and need. Alternatives that meet the water-based recreation screening criteria are evaluated for the multipurpose section. Alternatives that do not individually meet the screening criteria are evaluated in the water-based recreation combination of alternatives section. If an alternative can be combined with another alternative to meet the screening criteria, it will be further evaluated for the multipurpose section. Alternatives that cannot individually or in combination with another alternative meet the screening criteria are eliminated from consideration.

2.3.2 Water-based Recreation – Alternatives Considered

No Action Alternative

The No Action alternative does not provide an opportunity for water-based recreation. No significant change in the amount of public or private recreational area is expected without the project. The public demand for additional recreational development will not be addressed. This alternative is carried forward as a baseline for comparison.

Create New Stream Access (RA1)

This alternative would include creating access to water-based recreation by acquiring private land and constructing access for fishing, parking, and an access lane at stream crossings along rivers within the RMA. Only rivers large enough to have existing MDC access points and provide water-based recreation were considered. Three locations were identified as potential access points that are more than 15 miles from an MDC access point. Each location was chosen at points that provided feasible access from a road easily accessible to the public and was given an assumed 12 parking spaces, which is the average for stream access points in the RMA. Points were selected approximately 15 miles from each other or from the designated MDC access points in the Create New Stream Access alternative, to eliminate redundancies. Figure 2.3.2-1 shows the new stream access points and the existing MDC stream access points.

The new stream access provided by this alternative would provide a total of 36 parking spaces (12 spaces at each of the three locations) and provide 12,468 user-days.

Using the parking correlation methodology (Uhlig 1980), the following calculations were used to determine the number of user-days supplied by these access points:

- 36 spaces x 4 people per car x 2 times per day = 288 people per day
- 288 people per day / 0.0231 (Sunday use factor; Uhlig 1980) = 12,500 annual user-days of recreation supplied

The Create New Stream Access alternative does not provide sailing and the boating would be limited by the narrow stream corridor, shallow riffles, and fallen trees in the stream channel. Additionally, the stream access does not provide 5 percent of the unmet recreational demand.

This alternative does not meet screening criteria A, B, or C; therefore, it is not carried forward as a standalone alternative to the multipurpose section. However, this alternative may be further evaluated in the water-based recreation combination of alternatives section.

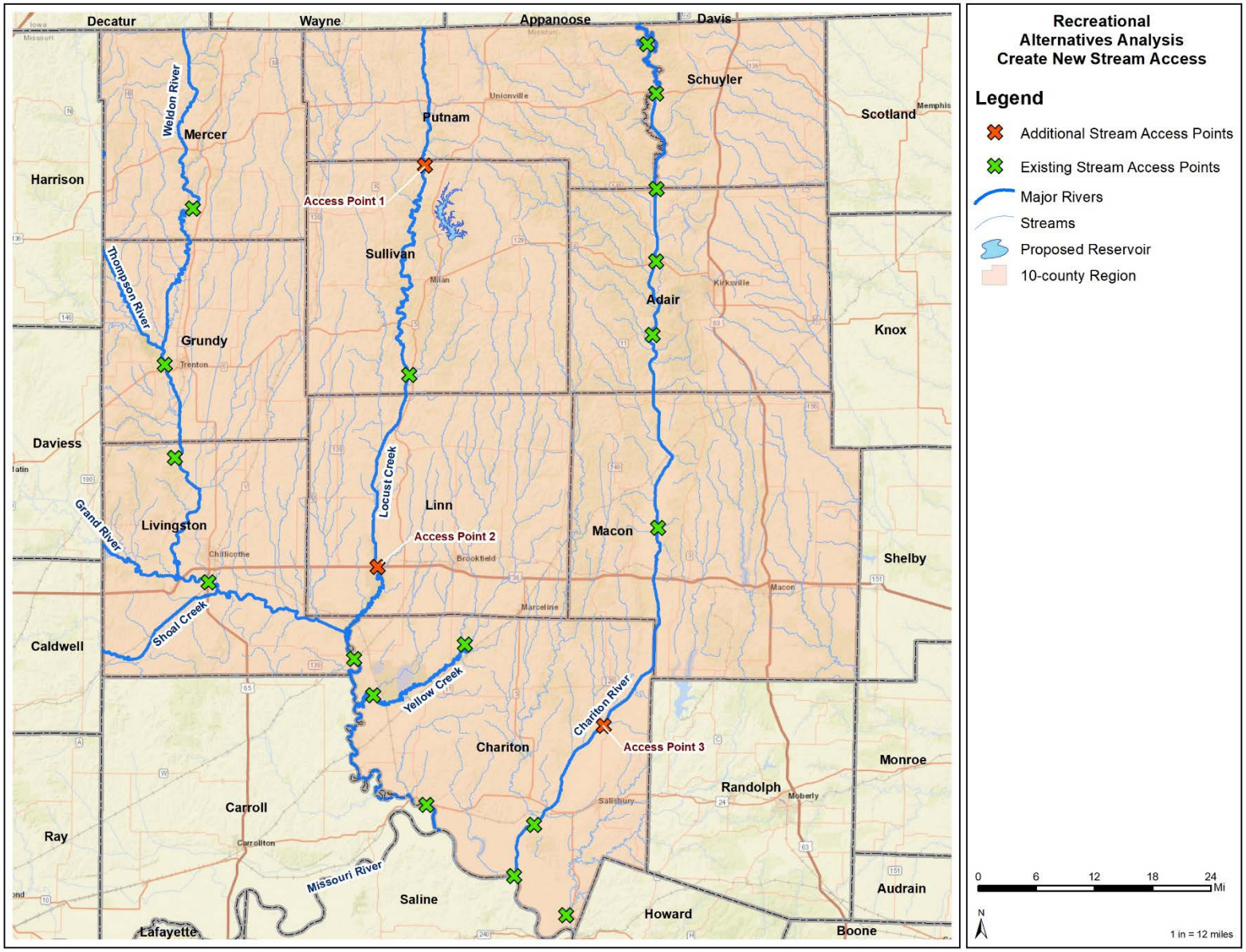


Figure 2.3.2-1. Water-based Recreation – Create New Stream Access Alternative.

Expand Existing Public Lakes (RA2)

The Expand Existing Public Lakes alternative would expand the size of four existing public lakes to provide additional recreational opportunities. Forest Lake, Green City Lake, Elmwood Lake, and Hazel Creek Lake were evaluated to determine whether the watershed would support a larger lake by reconstructing the dam. Unionville Lake (Lake Mahoney) is not considered because of its proximity to Thunderhead Lake. If the Unionville Lake dam were raised, Thunderhead Lake would receive less water and the water recharge would be reduced. Thunderhead is a private lake with docks that would be affected by the change in water recharge. Figures 2.3.2-2 through 2.3.2-5 show the public lakes to be expanded. Each lake was evaluated by recalculating the lake size based on the new elevation with the dam height raised by 20 feet. The expanded lake size and additional parking based on lake size is included in Table 2.3.2-1.

Table 2.3.2-1. Expand Existing Public Lakes – Description.

MDC Area	Current Lake Size (acres)	Expanded Lake Size (acres)	Additional Lake Size (acres)
Forest Lake (Thousand Hills)	580	882	302
Green City Lake	59	184	125
Hazel Creek Lake	530	907	377
Milan (Elmwood Lake)	220	515	295
TOTAL (amounts rounded)	**1,389**	**2,488**	**1,099**

This alternative would provide 1,099 additional lake acres, which would provide 43,411 additional user-days for the four expanded lakes. Raising the dam 20 feet would inundate environmental and infrastructure resources located outside the current lake's normal pools, but within the new lakes' elevations.

Expanding existing lakes provides 43,411 recreation user-days but does not meet screening criterion A. However, this alternative may be further evaluated in the water-based recreation combination of alternatives section.

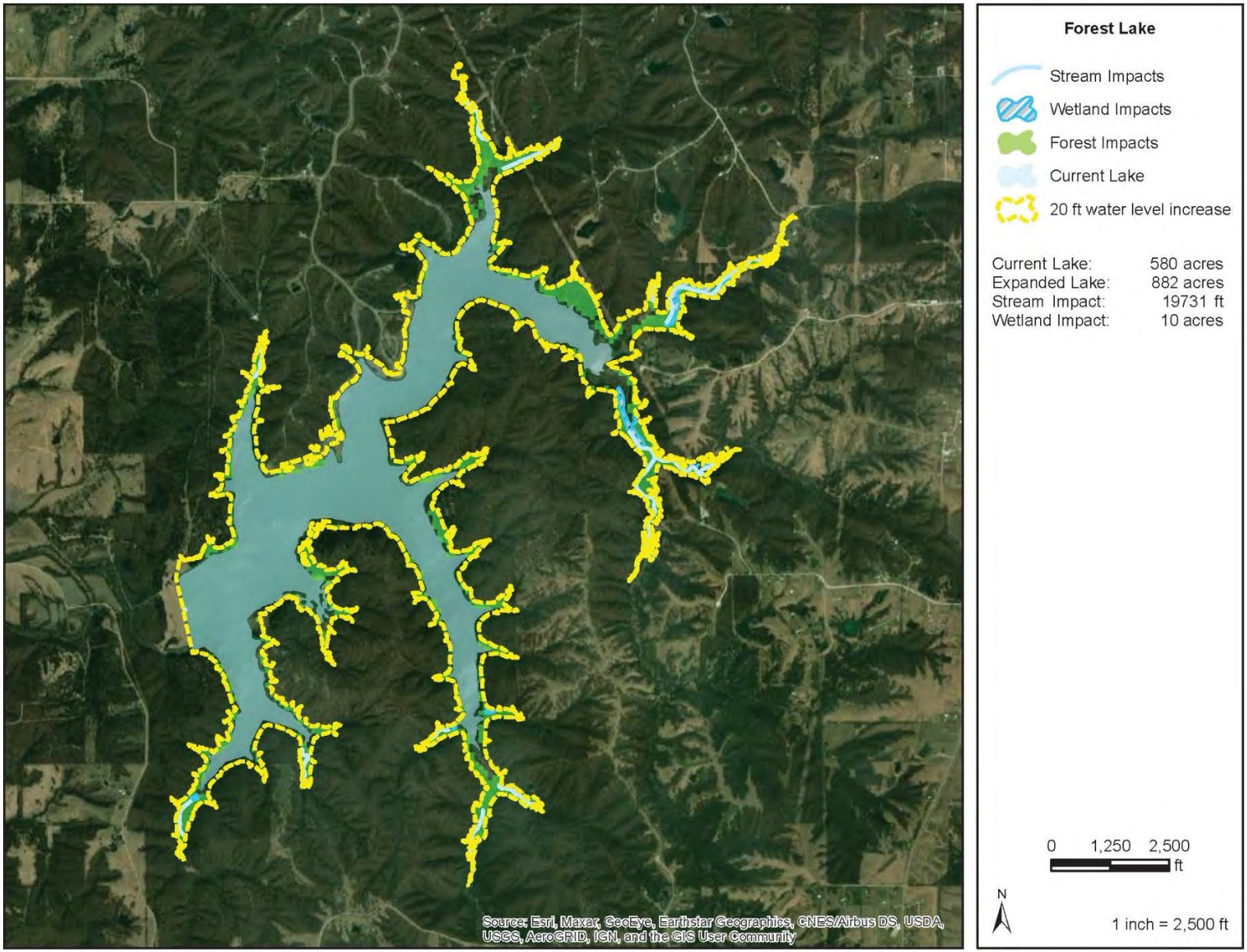


Figure 2.3.2-2. Water-based Recreation – Forest Lake (Thousand Hills) Expansion.

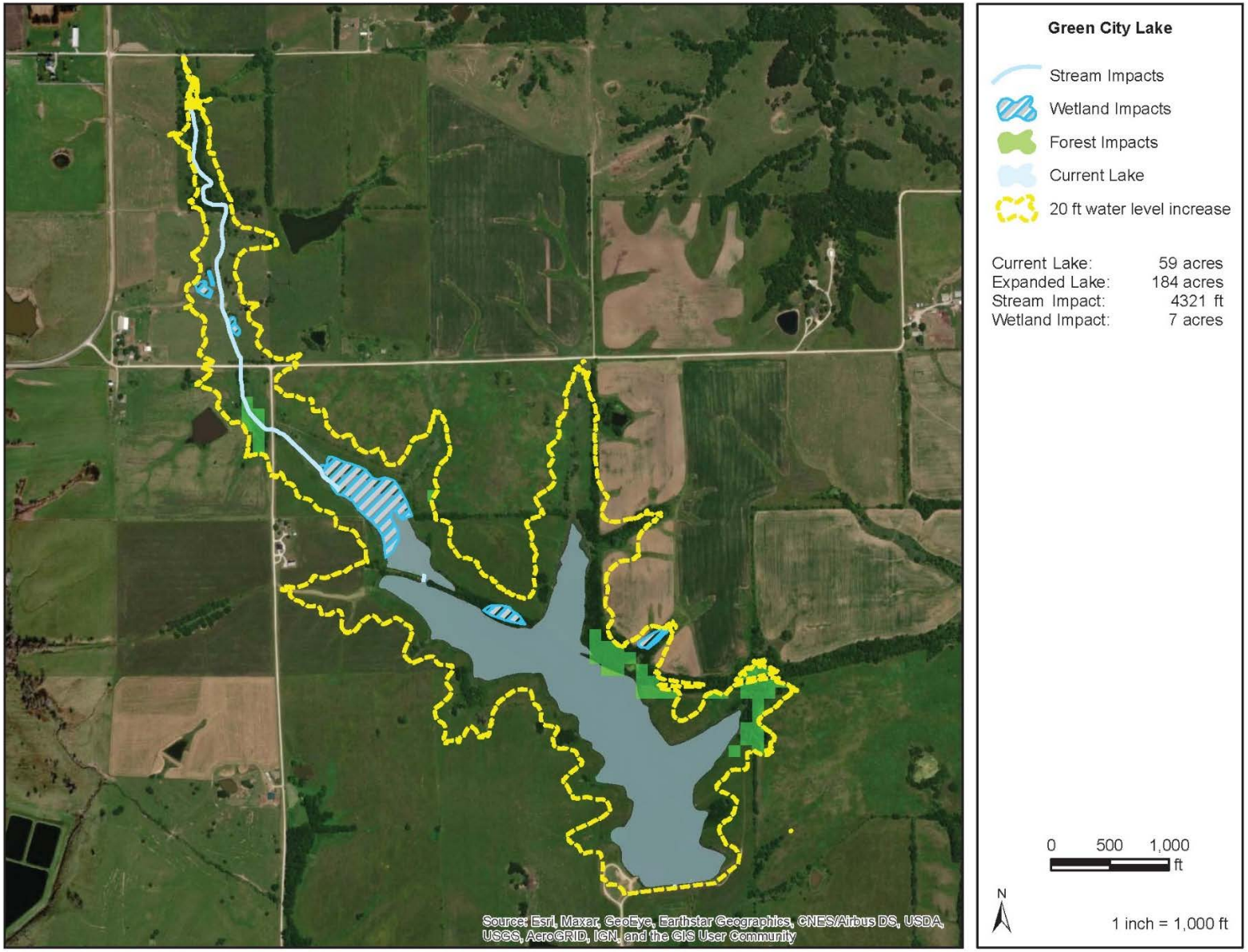


Figure 2.3.2-3. Water-based Recreation – Green City Lake Expansion.

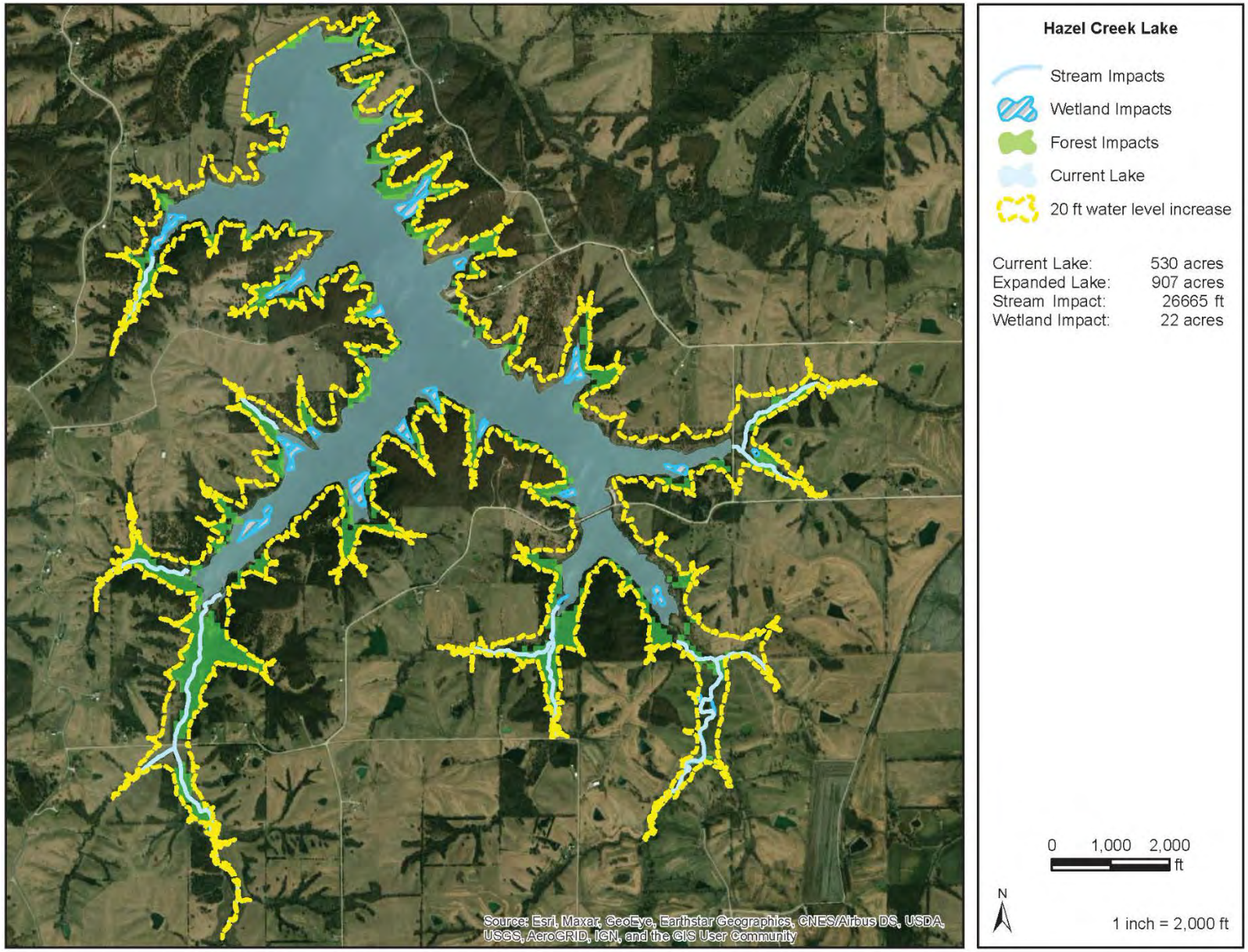


Figure 2.3.2-4. Water-based Recreation – Hazel Creek Lake Expansion.

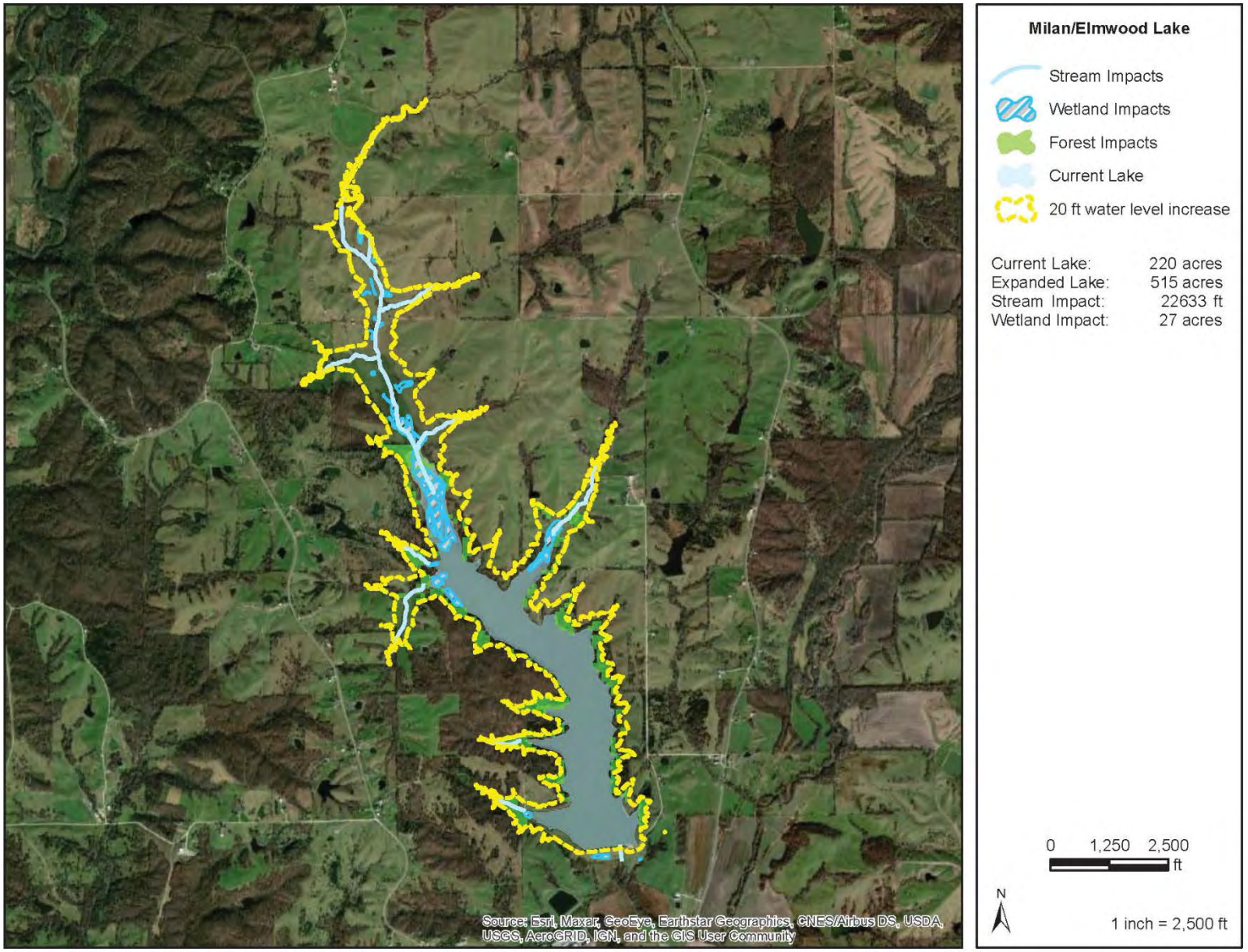


Figure 2.3.2-5. Water-based Recreation – Elmwood Lake Expansion.

Provide Public Access to Existing Private Lakes (RA3)

This alternative would include providing recreational access and parking spaces at private lake locations within the RMA. Five private lakes were identified as located within the RMA, none of which currently provide for any public user-days. Based on the collective acreages of the lakes, 57,100 user-days could be provided annually; however, because each lake is entirely privately owned, it is not feasible that the necessary user-days for public access can be achieved. Table 2.3.2-2 lists the private lakes within the RMA.

Table 2.3.2-2. Private Lakes within the Recreation Market Area.

Private Lake	Lake Size (acres)	Maximum Possible User-days Based on Acreage (totals rounded)
Spring Lake	87	3,437
Nehai Tonkayea Lake	228	9,006
Roach Lake	107	4,227
Thunderhead Lake	860	33,970
Trenton Lake	164	6,478
TOTAL	**1,446**	**57,118**

Providing public access to private lakes is not feasible or practicable because the project sponsor has no control over privately owned lakes and cannot logistically guarantee access to them. This alternative does not meet screening criterion D. The lakes are private property and could not reasonably be acquired from willing sellers. Alternatives must be available for public use and have public access. This alternative is not carried forward to the multipurpose section and is not included in the water-based recreation combination of alternatives.

Create an Offline Reservoir (DPA1)

Creating an offline reservoir provides both water supply and water-based recreation opportunities. The Create an Offline Impoundment alternative does not meet the recreation screening criteria C, because it could only provide 11,500 annual user-days of recreation. This alternative will be further evaluated in the recreation combination of alternatives section. This alternative is detailed in Section 2.1.2.6 Water Supply – Creation of a New Reservoir.

Alternative Reservoir Locations

In 2003, Burns & McDonnell developed a Water System Feasibility Study for the NCMRWC to study the regional water system. As part of that feasibility study, five reservoir locations were evaluated, including the proposed project, the Proposed Action - East Locust Creek Reservoir (RW1). The other four reservoir locations evaluated include the following:

- Big Locust Creek Site
- Little East Locust Creek Site
- West Fork Locust Creek Site
- Yellow Creek Site

Because all reservoir alternatives are in the same general area, all would have similar climate, land use, and hydrologic characteristics. These alternative reservoir locations were only evaluated at a feasibility study level, so full environmental impacts were not quantified in the 2003 study. Now, however, they will be evaluated to the same level as the other alternatives presented in this DSEIS to determine whether they can be carried forward for the recreation analysis.

Create Big Locust Creek Reservoir (DPA2)

The Big Locust Creek Reservoir alternative provides water supply and water-based recreation opportunities. The Big Locust Creek Reservoir would provide 231,000 annual user-days of recreation and meets the recreation screening criteria.

Create Little East Locust Creek Reservoir (DPA3)

The Little East Locust Creek Reservoir alternative provides water supply and water-based recreation opportunities. The Little East Locust Creek Reservoir would provide 144,000 annual user-days of recreation and meets the recreation screening criteria.

Create West Fork Locust Creek Reservoir (DPA4)

The West Fork Locust Creek Reservoir alternative provides water supply and water-based recreation opportunities. The West Fork Locust Creek Reservoir would provide 152,000 annual user-days of recreation and meets the recreation screening criteria.

Create Yellow Creek Reservoir (DPA5)

The Yellow Creek Reservoir alternative provides water supply and water-based recreation opportunities. The Yellow Creek Reservoir would provide 127,000 annual user-days of recreation and meets the recreation screening criteria.

Proposed Action – Create East Locust Creek Reservoir (RW1)

The Proposed Action provides water supply, flood damage reduction benefits, and water-based recreation opportunities. The Proposed Action would provide 92,000 annual user-days of recreation and meets the recreation screening criteria.

2.3.3 Water-based Recreation – Combinations of Alternatives

Alternatives that did not meet the screening criteria were evaluated as a water-based recreation combination alternative. Alternatives that can be combined to meet the screening criteria will be further evaluated in the multipurpose analysis.

The following alternatives did not meet the screening criteria and will be evaluated as a combination alternative:

- Create New Stream Access (RA1)
- Expand Existing Public Lakes (RA2)
- Create an Offline Reservoir (DPA1)

Alternatives that do not allow fishing and boating/sailing/canoeing/kayaking access or are not available for public use do not meet the purpose and need, and they cannot be combined to meet the screening criteria. Screening criteria A and C cannot be achieved by combining alternatives.

However, screening criterion B is based on providing approximately 61,400 recreation user-days and can be achieved by combining alternatives if the user-days are available from an alternative. Table 2.3.3-1 summarizes the results of the screening criteria for the alternatives considered for the combination of alternatives.

Table 2.3.3-1. Summary of Water-based Recreation Screening Criteria Results.

Alternative	Screening Criteria		
	A Allows Fishing and Boating/Sailing/ Canoeing/Kayaking	B Provides 61,400 Recreation User Days	C Available for Public Use?
No Action Alternative	**No**	**No (None)**	**No**
Create New Stream Access (RA1)	**No**	**No (12,470)**	**Yes**
Expand Existing Public Lakes (RA2)	**Yes**	No (43,411)	**Yes**
Provide Public Access to Private Lakes (RA3)	Yes	No (57,120)	No
Create an Offline Reservoir (DPA1)	**Yes**	No (11,450)	**Yes**
Big Locust Creek Reservoir (DPA2)	**Yes**	**Yes**	**Yes**
Little East Locust Creek Reservoir (DPA3)	**Yes**	**Yes**	**Yes**
West Fork Locust Creek Reservoir (DPA4)	**Yes**	**Yes**	**Yes**
Yellow Creek Reservoir (DPA5)	**Yes**	**Yes**	**Yes**
East Locust Creek Reservoir (RW1)	**Yes**	**Yes**	**Yes**
Combination of Expand Existing Public Lakes and Create an Offline Impoundment (RA4) *	**Yes**	No (54,861)	**Yes**

* The combination alternative is described below.

The Create New Stream Access alternative and Provide Public Access to Private Lakes alternative cannot be combined to provide additional user-days because they do not meet screening criteria A, B, and/or C. The Existing Public Lakes alternative and Create an Offline Reservoir alternative can be combined with each other to provide additional user-days and are further evaluated.

Combination of Expand Existing Public Lakes and Create an Offline Impoundment (WA4)

The total user-days created by Expand Existing Public Lakes and Create an Offline Impoundment is 54,861 recreation user-days.

The recreation user-days do not meet screening criterion B, so the recreation combination alternative is eliminated from consideration. There are no alternatives that can be combined to meet the screening criteria for water-based recreation and then further evaluated in the

multipurpose evaluation. However, for comparison purposes, Expand Existing Public Lakes is carried forward. Adding the Offline Impoundment alternative to create a combination alternative provides minimal additional user-days for the high cost of construction.

2.4 Multipurpose Alternative Analysis

The NEPA and CWA require federal agencies consider all reasonable and practicable alternatives that meet project purposes.

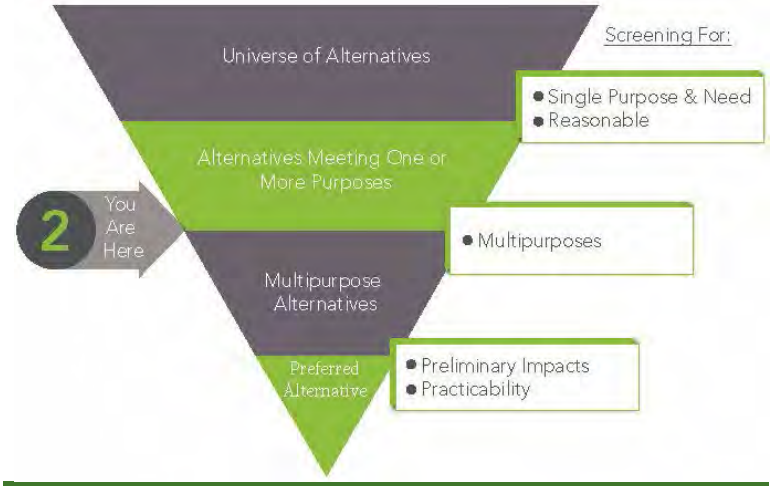
The multipurpose analysis evaluates the following:

- Multipurpose alternatives that meet the screening criteria for each of the three project purposes.
- Analysis of impacts to aquatic resources including streams and wetlands.
- Analysis of whether the alternative is practicable. Practicability means the alternative is available and capable of being done, and it includes a consideration of cost, logistics, and technology regarding the project purposes.
- As required by the Endangered Species Act, an analysis of impacts to rare species habitat. In this case, forest is used because it is habitat for threatened and endangered bats.

All possible multipurpose alternatives will be generated from individual alternatives that met the screening criteria for one or more of the project purposes. In this document, to determine the multipurpose Preferred Alternative, Section 2.4.1 will combine individual alternatives (if necessary), Section 2.4.2 will evaluate the multipurpose alternatives, and Section 2.4.3 will determine the multipurpose Preferred Alternative.

2.4.1 Multipurpose Combination of Alternatives

Creating Alternative Combinations. Alternatives were screened to determine if they met criteria for any of the three project purposes of water supply, water-based recreation, and flood damage reduction. The following describes how alternatives were carried forward for combination with other alternatives.



This section evaluates alternatives that meet all three project purposes.

Multipurpose Alternatives (MA) meeting criteria for all three purposes. These alternatives are not combined with other alternatives. The Proposed Action was the only alternative that met the screening criteria for all three purposes; therefore, the Proposed Action is not combined with any other alternative.

Dual Purpose Alternatives (DPA) meeting criteria for two project purposes. Alternatives that met the screening criteria for two of the three project purposes are combined with an alternative that meets the third purpose and are not combined with an alternative for the purposes it already met.

Alternatives meeting criteria for one project purpose (Water Supply [WA], Water-based Recreation [RA], or Flood Damage Reduction [FA] Alternatives). Alternatives that met one of the project purposes and had the fewest environmental impacts for wetlands, streams, wetlands and streams, or forest, or that had the lowest cost, were carried forward to be combined with other alternatives in this section.

No Action Alternative Although this alternative does not meet any of the project purposes, it is carried forward as a baseline comparison.

Table 2.4.1-1 shows the environmental impacts and costs of the No Action alternative, the Proposed Action, and other alternatives meeting the screening criteria for each purpose. Estimated stream impacts are based on two data sets that are available for the alternatives being considered. The USGS 1:24,000 scale National Hydrography Dataset (NHD) and the Missouri Stream Classification (CSR 2014) provide a relative ranking of stream impacts. Both datasets exclude ephemeral streams and underestimate total stream impacts. Upon creation of multipurpose alternative(s) using combinations of alternatives with the fewest environmental impacts or lowest cost, all multipurpose alternatives (those meeting all three project purposes and needs) are carried forward for further analysis. Further analysis is intended to determine the Preferred Alternative and follows the 404(b)(1) guidelines (40 CFR 230) for alternative analysis. The alternatives analysis will focus on aquatic resources and consider impacts to threatened or endangered species. Environmental impacts that were evaluated include wetlands, streams, and forests. Aquatic impacts were evaluated consistent with the CWA and included jurisdictional streams and wetlands. Forest impacts were evaluated as a proxy for impacts to the Endangered Species Act listed Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*). Other environmental resources and impacts are evaluated in detail in other parts of the DSEIS.

As shown in Table 2.4.1-1, the following alternatives meet one or more of the project purposes:

- <u>Alternatives carried forward for comparison purposes</u>
    - No Action
    - Water Supply Combination Alternative
    - Expand Existing Public Lakes Recreation Alternative
- <u>Alternatives meeting all three project purposes</u> Only the Proposed Action, East Locust Creek (RW1) meets all three of the project purposes.
- <u>Alternatives meeting two project purposes</u> The following four alternatives meet the screening criteria for water supply and water-based recreation project purposes:
    - Big Locust Creek reservoir (DPA2)
    - Little East Locust Creek reservoir (DPA3)
    - West Fork Locust Creek reservoir (DPA4)
    - Yellow Creek reservoir (DPA5)

- Alternatives meeting one project purpose Five alternatives met only the screening criteria for water supply, and three alternatives met only the screening criteria for flood damage reduction.

  Alternatives that met only the screening criteria for water supply are:

  - Missouri River Alluvium Wells (WA3)
  - Mississippi River Alluvium Wells (WA4)
  - Grand River Alluvium Wells (WA5)
  - Mark Twain Lake Pipeline (WA19)
  - Create an offline reservoir (DPA1) *Note: The offline reservoir did not meet the screening criteria for recreation and thus is categorized as a single purpose alternative.*

  Alternatives that met only the flood damage reduction screening criteria are the following:

  - Floodplain Acquisition (FA2)
  - Wetland Storage Areas (FA6)
  - Large Dry Dam 100-year Storage (FA7)

Alternatives that met one or two of the project purposes of water supply, water-based recreation, or flood damage reduction can be combined with other alternatives to meet the multipurpose criteria.

Table 2.4.1-1. Comparison of Individual Alternatives Meeting the Screening Criteria.

Alternative	Meets Project Purpose of			Project Costs[1] ($)	Connected Actions Costs[1] ($)	Environmental Impacts						
	Water Supply	Flood Damage Reduction	Recreation			NHD Stream[2] (miles)	MSC Stream[3] (miles)	Temp NHD[2] (miles)	Temp. MSC[3] (miles)	Wetland[4] (acres)	Temporary[4] Wetland (acres)	Forest[5] (acres)
No Action				0	0	0	0	0	0	0	0	0
WATER SUPPLY ALTERNATIVES												
Proposed Action – East Locust Creek Reservoir (RW1)	X	X	X	102,900,000	81,500,000	30.4	18.6	0.02	0.02	256.0	0.9	914.2
Offline reservoir (DPA1)	X			N/A	N/A	N/A	0.7	0.6	0.4	9.5	4.3	89.0
Big Locust Creek (DPA2)	X		X	212,500,000	81,500,000	60.6	31.8	0.2	0.07	1,422.0	0.2	1,088.0
Little East Locust Creek (DPA3)	X		X	173,300,000	81,500,000	37.6	24.1	0.5	0.3	269.0	2.1	889.0
West Fork Locust Creek (DPA4)	X		X	163,100,000	81,500,000	40.0	23.6	0.4	0.2	372.0	1.3	506.0
Yellow Creek (DPA5)	X		X	188,300,000	81,500,000	37.8	26.0	1.0	1.0	179.1	3.3	1,04.02
Missouri River Alluvium Wells (WA3)	X			N/A	N/A	N/A	0.0	2.9	1.9	10.9	24.1	112.0
Mississippi River Alluvium Wells (WA4)	X			N/A	N/A	N/A	0.0	4.2	2.4	14.3	23.3	208.0
Grand River Alluvium Wells (WA5)	X			N/A	N/A	N/A	0.0	2.6	1.7	22.7	14.3	74.7
Mark Twain Lake (WA19)	X			N/A	N/A	N/A	0.0	5.3	3.1	7.7	38.0	253.7
Water Supply Combination Alternative	x			260,600,000	81,500,000	13.2	10.4	5.3	2.8	67.5	26.5	535.0

Alternative	Meets Project Purpose of			Project Costs[1] ($)	Connected Actions Costs[1] ($)	Environmental Impacts						
	Water Supply	Flood Damage Reduction	Recreation			NHD Stream[2] (miles)	MSC Stream[3] (miles)	Temp NHD[2] (miles)	Temp. MSC[3] (miles)	Wetland[4] (acres)	Temporary[4] Wetland (acres)	Forest[5] (acres)
FLOOD DAMAGE REDUCTION ALTERNATIVES												
Floodplain Acquisition (FA2)		X		16,800,000	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland Storage Areas (FA6)		X		81,700,000	0	74.0	43.4	0.0	0.0	0.0	0.0	1,154.0
Large Dry Dam 100-year Storage (FA7)		X		7,300,000	0	0.13	0.04	0.0	0.0	4.0	0.0	3.0
WATER-BASED RECREATION ALTERNATIVE												
Expand Existing Public Lakes (RA2)			X	238,200,000	0	13.2	10.4	0.0	0.0	66.0	0.0	535.0

Note: Green rows indicate alternatives carried forward for more analysis, and red rows indicate alternatives that were eliminated from consideration as a combined multipurpose alternative.
[1] Life cycle costs were calculated based on source: USDA 2013. Connected actions include water treatment and transmission to water systems.
[2]Source: NHD (USGS 2017b). [3]Source: Missouri Stream Classification (CSR 2014).[4]Source: NWI (USFWS 2017). [5]Source: NLCD (Homer et al. 2015).

Combining Alternatives to Create Multipurpose Alternatives

WATER SUPPLY ONLY ALTERNATIVES

The following five water supply alternatives would need to be combined with an alternative or alternatives that provide water-based recreation and flood damage reduction in order to meet all three project purposes:

- Missouri River Alluvium Wells (WA3)
- Mississippi River Alluvium Wells (WA4)
- Grand River Alluvium Wells (WA5)
- Offline reservoir (DPA1) Note: The offline reservoir did not meet the screening criteria for recreation and so is categorized as a single-purpose alternative.
- Mark Twain Lake Pipeline (WA19)

No alternatives provided recreation without also providing water supply. Combining any of these five alternatives with alternatives that already met the water supply screening criteria would have increased life cycle costs and environmental impacts without contributing to the project purpose.

These five alternatives were not considered for combinations that met all three purposes, and they were eliminated from further consideration for the multipurpose Preferred Alternative.

WATER SUPPLY AND WATER-BASED RECREATION DUAL PURPOSE ALTERNATIVES

The following four alternatives provide water supply and water-based recreation and would need to be combined only with a flood damage reduction alternative to meet all three project purposes:

- Big Locust Creek Reservoir (DPA2)
- Little East Locust Creek Reservoir (DPA3)
- West Fork Locust Creek Reservoir (DPA4)
- Yellow Creek Reservoir (DPA5)

A fifth dual purpose alternative can be created by combining the Expand Existing Public Lakes recreation alternative (RA2) with the Water Supply Combination alternative (WA20). While these two alternatives do not meet the screening criteria for their respective purposes, they are considered for a multipurpose alternative for comparison purposes. These two alternatives both include replacing the dams on Green City Lake and Forest Lake.

These five alternatives were considered for combination with alternatives that met the flood damage reduction criteria.

FLOOD DAMAGE REDUCTION ALTERNATIVES

Three alternatives met the screening criteria for the single purpose of flood damage reduction, and could be combined with the four water-supply and recreation alternatives:

- Floodplain Acquisition (FA2)
- Wetland Storage Areas (FA6)
- Large Dry Dam 100-year Storage (FA7)

Among these alternatives, the Large Dry Dam 100-year Storage flood damage reduction alternative is the lowest life cycle-cost flood damage reduction alternative, but it is not the lowest environmental impacts alternative. The floodplain acquisition alternative results in fewer

environmental impacts than the Large Dry Dam 100-year Storage alternative and other flood damage reduction alternatives. The Floodplain Acquisition alternative was chosen to be combined with the Big Locust Creek, Little East Locust Creek, West Fork Locust Creek, and Yellow Creek alternatives to create multipurpose alternatives for the Preferred Alternative evaluation.

Alternatives Eliminated from Consideration as the Multipurpose Preferred Alternative. The following alternatives are eliminated from consideration because they could not be combined with another alternative to meet the three purposes and needs or had more environmental impacts than another alternative:

- Missouri River Alluvium Wells (WA3)
- Mississippi River Alluvium Wells (WA4)
- Grand River Alluvium Wells (WA5)
- Offline Reservoir (DPA1)
- Mark Twain Lake Pipeline (WA19)
- Wetland Storage Areas (FA6)
- Large Dry Dam 100-year Storage (FA7)

Alternatives Carried Forward for Consideration as the Multipurpose Preferred Alternative The multipurpose alternative evaluations include an evaluation of the following multipurpose alternatives:

- No Action alternative
- East Locust Creek Reservoir- Proposed Action (RW1)
- Yellow Creek Reservoir and Floodplain Acquisition (MA2)
- West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3)
- Big Locust Creek Reservoir and Floodplain Acquisition (MA4)
- Little East Locust Creek Reservoir and Floodplain Acquisition (MA5)
- Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)

2.4.2 Multipurpose Alternative Evaluation

The multipurpose evaluation included the No Action, RW1, and MA2 – MA6 alternatives described above. The multipurpose alternative evaluation includes an environmental evaluation and practicability evaluation. The environmental evaluation reviewed wetland, stream, and threatened and endangered species impacts. The practicability evaluation reviewed costs, logistics, and existing technology. Section 2.4.3 includes the preferred alternative selection and includes both environmental impacts and practicability considerations.

ENVIRONMENTAL EVALUATION (EVALUATION 1 OF 2)

As illustrated in Table 2.4.2-1, the Big Locust Creek Reservoir and Little East Locust Creek Reservoir multipurpose alternatives result in greater environmental impacts and life cycle costs than the Proposed Action; therefore, these multipurpose alternatives are eliminated from further consideration.

The four remaining multipurpose alternatives (East Locust Creek Reservoir [RW1], Yellow Creek Reservoir and Floodplain acquisition [MA2], West Fork Locust Creek Reservoir and Floodplain

Acquisition [MA3], and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition [MA6]), will be further evaluated to determine the preferred alternative.

Table 2.4.2-1. Multipurpose Alternatives Comparison.

Multipurpose Alternative	Environmental Impacts						
	NHD Stream (miles)	MSC Stream (miles)	NHD Temporary Stream (miles)	MSC Temporary Stream (miles)	Wetland (acres)	Temporary Wetland (acres)	NLCD Forest (acres)
No Action							
Proposed Action – East Locust Creek Reservoir (RW1)	**30.4**	**18.6**	0.2	0.02	256.0	0.9	914.2
Yellow Creek and Floodplain Acquisition (MA2)	37.8	26.0	1.0	1.0	**179.1**	3.3	1,042.0
West Fork Locust Creek and Floodplain Acquisition (MA3)	40.0	23.6	0.4	0.2	372.0	1.3	**506.0**
Big Locust Creek and Floodplain Acquisition (MA4)	60.6	31.8	0.2	0.07	1,423.0	1.1	1,088.0
Little East Locust Creek and Floodplain Acquisition (MA5)	37.6	24.1	0.5	0.3	269.0	2.1	889.0
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	13.9	10.4	5.3	2.8	67.5	26.7	53.05

Note: Alternatives highlighted in green indicate those with the least stream, wetland, or forest impacts, based on existing database analysis. The least impact numbers for each resource are indicated by bold font. Source: NWI (USFWS 2017), NHD (USGS Missouri stream classification (MSC, CSR 2014), NLCD (Homer et al. 2015)

[1] Project costs were calculated as indicated in Appendix A. Connected actions include water treatment and transmission to water systems.

Note: The preferred alternative is based on the fewest environmental impacts and practicability.

Detailed Multipurpose Alternative Evaluation The following multipurpose alternative evaluation will provide a more detailed analysis of impacts to streams, wetlands, and forests as a proxy for threatened and endangered species and practicability. The five alternatives discussed in detail are the following:

- No Action alternative
- Proposed Action – East Locust Creek Reservoir (RW1)
- Yellow Creek Reservoir and Floodplain Acquisition (MA2)
- West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3)
- Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)

Stream Impacts and Analysis

Method of Stream Impact Analysis In order to compare all alternatives equitably, stream impacts were based on the Missouri stream classification (CSR 2014). Streams were categorized

according to stream type (Class P and Class C) and stream impacts (temporary and permanent). The streams affected by the multipurpose reservoirs will be inundated and will function as a lacustrine system. The types of impacts (i.e., permanent impacts from inundation or fill and temporary impacts from pipeline construction) are assumed to be similar for the four multipurpose alternatives. The change in stream function from a riverine to lacustrine system is considered a high loss in stream function, according to the Missouri Stream Mitigation Method (USACE 2013b).

Results of Stream Impact Analysis. Table 2.4.2-2 compares the stream impacts for the East Locust Creek Reservoir (RW1), West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3), Yellow Creek Reservoir and Floodplain Acquisition (MA2), and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6). A combination of NHD and MSC data is provided for comparison. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) has the fewest stream impacts with less than half the total stream length impacts. Of the three multipurpose reservoirs, East Locust Creek Reservoir (RW1) has the fewest permanent stream channel impacts (NHD – 30.4 miles or MSC 18.6 miles). Both the Yellow Creek Reservoir and Floodplain Acquisition (MA2) and West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) alternatives result in greater stream channel permanent impacts. The three multipurpose alternatives also result in temporary impacts related to pipeline construction. The temporary impacts are considered to result in a low loss in stream function.

Table 2.4.2-2. Multipurpose Alternatives Impacts to Streams.

Alternative	NHD Total Stream Impacts (miles)	NHD Perennial (miles)	NHD Intermittent (miles)	MSC Total Stream Impacts (miles)	Class P Stream Impacts (miles)*	Class C Stream Impacts (miles)*
East Locust Creek Reservoir (RW1)	30.4	5.8	24.6	18.6	0.0	18.6
Yellow Creek Reservoir (MA2)	37.8	1.6	36.2	26.0	1.7	24.3
West Fork Locust Creek Reservoir (MA3)	40.0	8.5	31.6	23.4	0.0	23.4
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	13.9	13.2	0.7	10.4	0.0	10.4

Stream Type Impact Analysis. Class P streams, which have water during dry periods, are able to provide higher aquatic resource functions than Class C streams, which can have dry conditions during drought. The Missouri stream classification list shows that East Locust Creek Reservoir (RW1) and West Fork Locust Creek Reservoir (MA3) are Class C streams for the entire length. Yellow Creek Reservoir (MA2) changes from a Class P stream to a Class C stream within the

areas of impact. Yellow Creek Reservoir (MA2) has 1.7 miles of Class P stream and 24.3 miles of Class C stream. The NHD data classifies the streams by intermittent and perennial flow. East Locust Creek Reservoir (RW1) has 5.8 miles of perennial flow versus 1.6 miles of perennial flow for Yellow Creek Reservoir (MA2). The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has no impact Class P streams and 13.2 miles of impact to NHD perennial streams.

Summary of Stream Impact Analysis. The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest stream impacts with less than half the total stream lengths. Of the multipurpose reservoir alternatives, East Locust Creek Reservoir (RW1) has the fewest total stream impacts and temporary stream impacts of the three multipurpose reservoirs based on both NWI and MSC data. Class P stream impacts and Class C stream impacts are also fewest for RW1. The Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative has the most Class P stream impacts with 1.7 miles of Class P stream impacts and the most Class C stream impacts with 0.9 miles more than the West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) alternative and 5.7 miles more than the East Locust Creek Reservoir (RW1) alternative. East Locust Creek Reservoir (RW1) alternative has 4.2 miles of additional perennial stream impacts based on NHD data.

Wetland Impacts and Analysis

Method of Wetland Impact Analysis. Wetlands were categorized by total wetland impacts and by Cowardin classification (Cowardin et al. 1979), as shown on NWI maps (USFWS 2017). In addition, aerial photograph interpretation was done. Cowardin classifies wetlands by where they are found in the landscape and the vegetation that grows in them. Wetlands were also analyzed for function, using the Missouri Wetland Assessment Method (USACE 2016).

Results of Wetland Acreage Impact Analysis. Table 2.4.2-3 shows the wetlands impacts for each multipurpose alternative, based on NWI maps. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest total wetland impacts in all categories. Of the multipurpose reservoir alternatives, Yellow Creek Reservoir and Floodplain Acquisition (MA2) has the lowest total wetland acres affected, followed in turn by East Locust Creek Reservoir (RW1) and West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3). East Locust Creek Reservoir (RW1) impacts approximately 60.6 more wetland acres, and the West Fork Locust Creek Reservoir and Floodplain Acquisition alternative (MA3) impacts approximately 189 more wetland acres than the Yellow Creek Reservoir and Floodplain Acquisition alternative (MA2).

Types of wetlands affected vary between the three multipurpose alternatives. East Locust Creek Reservoir (RW1) impacts the most palustrine emergent (PEM) wetland acres and the fewest palustrine forested (PFO) wetland acres. The West Fork Locust Creek Reservoir and Floodplain Acquisition alternative (MA3) impacts the fewest palustrine scrub-shrub (PSS) wetland acres and the fewest palustrine unconsolidated bottom (PUB) waters acres.

Table 2.4.2-3. Multipurpose Alternatives Impacts to Wetlands.

Alternative	Total Wetlands (acres)	PEM (acres)	PSS (acres)	PFO (acres)	PUB (acres)
East Locust Creek Reservoir	256.0	114.0	1.0	127.1	13.9
Yellow Creek Reservoir (MA2)	182.4	38.3	6.8	121.4	15.9
West Fork Locust Creek Reservoir (MA3)	373.3	71.4	0.4	289.8	11.7
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	67.5	30.8	1.2	35.4	0.0

Results of Wetland Functional Assessment Analysis Not all wetlands provide the same level of function. Wetland functional assessment was based on the aquatic resource type as described in the State of Missouri Wetland Assessment Method (USACE 2016). Aquatic resource type is a group of wetlands that perform similar levels of wetland functions. According to this assessment method, PFO wetlands score the highest in wetland function while PEM and PSS wetlands have a medium wetland function. Impacts to PFO wetlands result in a loss of function for a longer time, relative to other types of wetlands, because mature forest takes more years to develop. Farmed wetlands and PUB aquatic sites score the lowest in wetland function.

To analyze wetland functions further, aerial photographic interpretations were made for PEM wetlands. Aerial photograph review of the PEM wetlands identified wetlands that were currently farmed or were previously farmed. East Locust Creek Reservoir (RW1) had 57 acres of farmed wetlands, Yellow Creek Reservoir and Floodplain Acquisition (MA2) had 25.4 acres of farmed wetlands, West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) had 43.1 acres of farmed wetlands, and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) had 0 acres of farmed wetlands.

Table 2.4.2-4 summarizes the analysis of wetland function for these three alternatives, based on Cowardin classification and aerial photographic interpretation.

Table 2.4.2-4. Multipurpose Alternatives Wetland Acres by Function.

Alternative	Total Wetlands (acres)	High-Function Wetlands (PFO)	Medium-Function Wetlands (PSS and Non-farmed PEM)	Low-Function Wetlands (Farmed PEM and PUB)
East Locust Creek Reservoir (RW1)	256.0	127.1	58.0	70.9
Yellow Creek Reservoir (MA2)	182.4	121.4	19.7	41.3
West Fork Locust Creek Reservoir (MA3)	373.3	289.8	28.7	54.8
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	67.5	35.4	32.1	0.0

Summary of Wetland Impact Analysis. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) has the fewest total wetland impacts and is a third less than the next highest. Of the three multipurpose reservoir alternatives, the West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) has the most total wetland impacts and the most high-function wetland impacts. The Yellow Creek Reservoir and Floodplain Acquisition (MA2) has the fewest wetland impacts in all categories, fewest medium-function wetland impacts, and the fewest low-function wetlands. East Locust Creek Reservoir (RW1) has a total of 73.6 more acres of wetland impacts than the Yellow Creek Reservoir and Floodplain Acquisition (MA2), the additional 73.6 wetland acres includes 5.7 acres of high-function wetlands, 38.3 acres of medium-function wetlands and 29.6 acres of low-function wetlands.

Federal Threatened and Endangered Species

Habitat for the northern long-eared bat and Indiana bat is forested area, with an emphasis on wetland forests. Stream corridors also provide foraging habitat for bat species.

Methods of Bat Habitat Impact Analysis. Bat habitat was analyzed by using the NLCD to determine forest-acre impacts, and the results of the previous stream and wetland impact analyses to determine stream and forested wetland impacts.

Results of Bat Habitat Impact Analysis. Table 2.4.2-5 summarizes impacts to threatened and endangered bat species habitat. The West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) alternative would result in the fewest total forest impacts, but the most wetland forest impacts and total stream corridor impacts. East Locust Creek Reservoir (RW1) alternative has the lowest impacts to stream corridors and wetland forests and is second lowest for total forest impacts. The Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative has the highest total forest impacts and the second lowest impacts to wetland forest and stream corridors. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the second fewest total forest impacts and the fewest stream corridor and forested wetland impacts.

Table 2.4.2-5. Threatened and Endangered Bat Species Habitat.

Alternative	Total Forest Acres[1]	Wetland Forest (PFO acres)[2]	Stream Corridor[3] (miles)
East Locust Creek Reservoir (RW1)	914.2	117.9	18.6
Yellow Creek Reservoir (MA2)	1,041.7	121.4	26.0
West Fork Locust Creek Reservoir (MA3)	506.0	289.8	23.6
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	535.0	35.4	10.4

[1] Source: NLCD (Homer et al. 2015) [2] Source: NWI (USFWS 2017) [3] Source: Missouri stream classification (CSR 2014)

Summary of Bat Habitat Impact Analysis. This analysis shows there is no clear best or worst alternative with regard to bat habitat. The presence of suitable bat habitat and the use of the habitat present is highly variable. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest impacts to forested wetlands and the stream corridor and is one of the lowest impacts to total forest acres.

PRACTICABLE SCREENING EVALUATION (EVALUATION 2 OF 2)

Consistent with the 404(b)(1) guidelines, the Preferred Alternative analysis includes practicability of a project, which is based on whether it is available and capable of being done. This includes life cycle costs, logistics, and technology considerations.

LOGISTICAL CONSIDERATIONS

For logistical reasons, MDNR has supported and directed the NCMRWC to provide a regional water system. In February 2010, Michael Wells (MDNR, Appendix A), provided a letter of support to the NCMRWC stating that regional water systems are more efficient and cost effective. He also stated that MDNR gives priority to assistance to regional water supply systems. More recent letters of support by Sara Parker Pauley (MDNR, Appendix A) also support a regional water system. Many water suppliers in the region have closed or face challenges meeting drinking water standards and cost constraints. A regional water system that provides an adequate and dependable water supply would lower costs through economies of scale, meet the current water demand during the drought of record, provide resilience to climate change, promote business development, and allow for population growth.

MDNR has requested a regional water system to meet the logistical challenges of water supply and distribution. The three multipurpose reservoir alternatives (RW1, MA2, and MA3) provide a regional water system at a central location in the 10-county region. Important to that central location is the Milan water treatment plant, which can efficiently provide water throughout the 10-county region. A single water treatment plant allows for adherence to ever-changing drinking water standards that have closed many small water treatment plants in the 10-county region. The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative provides water through seven different water supplies and varying quantities of water and varying potential treatment options.

Maintenance is an important logistical consideration in managing a workforce, equipment, and property. The multipurpose reservoir alternatives (RW1, MA2, and MA3) provide a single water

treatment plant and a single water supply resulting in an efficient use of personnel and equipment, and allow for efficient care for property. MA6 alternative has seven different water sources and extensive pipelines to maintain that are spread throughout the 10-county region. The regional distribution would add to the workforce, equipment, and property logistical maintenance challenges.

Similar to maintenance, management considerations can provide logistical challenges when an alternative is spread across different resources, counties, and political subdivisions. The NCMRWC does not have the ability to control water sources and must coordinate and obtain permission from the individual counties. Management spread acoss multiple counties provides difficult logistical considerations. For example, each of the four existing reservoirs included in MA6 are owned and managed by different entities. Forest Lake is owned and managed by MDNR but current water supply from the lake is managed by the City of Kirksville. Green City Lake is owned and managed by the City of Green City and no longer serves drinking water through the city. Hazel Creek Lake is owned by the City of Kirksville, managed by MDC, and provides water through the City of Kirksville. Elmwood Lake is owned by the City of Milan, managed by MDC, and the water is sold through NCMRWC. For the MA6 alternative to be implemented, management and maintenance agreements would have to be made with all of these entities. Furthermore, the NCMRWC would not have the authority to manage the sources primarily for water supply, which means that multiple agencies would have to be involved with day-to-day management and incident responses.

LIFE CYCLE COST CONSIDERATIONS

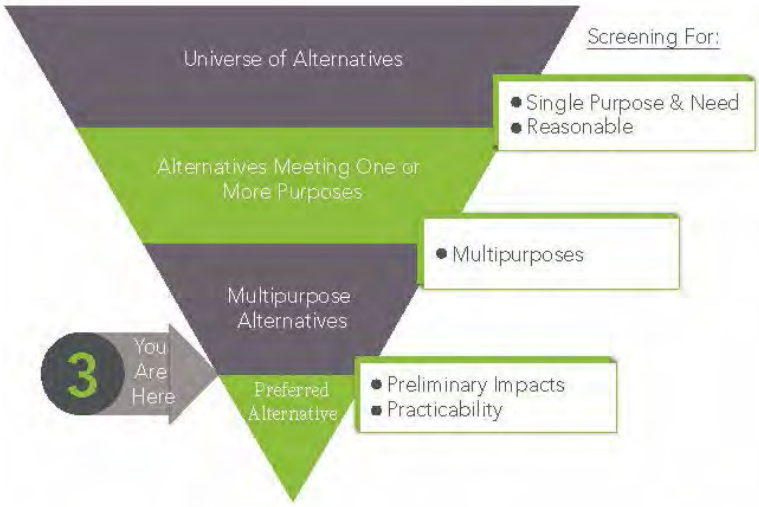
For this Preferred Alternative analysis, life cycle costs of different alternatives are an important consideration. An alternative with life cycle costs that are substantially more than another may not be considered to be practicable.

Table 2.4.2-6. Alternative and Life Cycle Cost.

Multipurpose Alternative	Project Cost ($)[1] 0	Connected Action Life Cycle Cost ($)[1]
No Action		
Proposed Action – East Locust Creek Reservoir (RW1)	102,900,000	81,500,000
Yellow Creek and Floodplain Acquisition (MA2)	205,100,000	81,500,000
West Fork Locust Creek and Floodplain Acquisition (MA3)	179,900,000	81,500,000
Big Locust Creek and Floodplain Acquisition (MA4)	229,300,000	81,500,000
Little East Locust Creek and Floodplain Acquisition (MA5)	190,100,000	81,500,000
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	515,600,000	81,500,000

Summary of Life Cycle Cost Analysis. The West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) is $77,000,000 (75 percent) more than East Locust Creek Reservoir (RW1), the Yellow Creek Reservoir and Floodplain Acquisition (MA2) is $102,200,000 (99 percent) more than East Locust Creek Reservoir (RW1), and the Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) is $395,900,000 (385 percent) more than East Locust Creek (RW1).

2.4.3 Preferred Alternative Evaluation



This section determines the preferred alternative and provides the alternative analysis to meet the Clean Water Act Section 404 guidelines.

This section analyzes the multipurpose alternatives with the fewest environmental impacts that are practicable to identify the Preferred Alternative for the project. As mentioned above, the Preferred Alternative analysis follows the 404(b)(1) guidelines, which focus primarily on aquatic resources.

The multipurpose Preferred Alternative analysis is based on the evaluation of these four alternatives that meet all three project purposes and needs:

- East Locust Creek Reservoir - Proposed Action (RW1)
- Yellow Creek Reservoir and Floodplain Acquisition (MA2)
- West Fork Creek Reservoir and Floodplain Acquisition (MA3)
- Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)

The remaining alternatives and combinations of alternatives have been eliminated through the alternative analysis process, including the screening criteria, the combining of alternatives, and the evaluation of environmental impacts.

The multipurpose evaluation from the previous section reviewed wetlands impacts, stream impacts, threatened and endangered bat species habitat impacts, and life cycle costs. Table 2.4.3-1 provides a summary of the multipurpose evaluation.

Table 2.4.3-1. Ranking of Least to Most Environmental Impacts and Cost.

Alternative	Least Wetland Impact	Least High-Function Wetland Impact	Least Stream Impact	Least Threatened and Endangered Bat Species Habitat Impact	Lowest Project Costs	TOTAL RANKING
Proposed Action (RW1)	3	2	2	Undetermined	1	**8**
Yellow Creek Reservoir (MA2)	2	3	4	Undetermined	3	**12**
West Fork Locust Creek Reservoir (MA3)	4	4	3	Undetermined	2	**13**
Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6)	1	1	1	Undetermined	4	**7**

The West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) has the highest environmental impacts for two categories (wetland impacts, forested [high-function] wetland impacts) and is not the lowest life cycle cost alternative. Thus, the West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) is eliminated from further consideration as the Preferred Alternative. East Locust Creek Reservoir (RW1), Yellow Creek Reservoir and Floodplain Acquisition (MA2), and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) will be discussed further.

Threatened and Endangered Bat Species Habitat Evaluation. The multipurpose alternative with the least impacts to threatened and endangered bat species habitat could not be determined with certainty. The Yellow Creek Reservoir and Floodplain Acquisition (MA2) has more total forest acres, wetland forest acres, and stream corridor length affected than East Locust Creek Reservoir (RW1). The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest forested wetland and stream corridor length and least overall project footprint. As discussed later in the DSEIS, based on field surveys, the presence of both Indiana and northern long-eared bats has been confirmed at the proposed East Locust Creek Reservoir (RW1) site. Bats may also be present at Forest Lake (Thousand Hills State Park).

Surveys have not been completed on the other multipurpose alternative sites and cannot be conducted because the land is not under the sponsor's control. However, the habitat present at the Yellow Creek Reservoir site and the Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) sites includes large blocks of timber with stream corridors and forested area. Additionally, the Yellow Creek Reservoir site is within 15 miles of East Locust Creek Reservoir (RW1). The likelihood is very high that northern long-eared bats and/or Indiana bats are present at the Yellow Creek Reservoir site and the Forest Lake site.

However, because surveys have not been completed at the Yellow Creek Reservoir alternative site or the Forest Lake site, the alternative with the least threatened and endangered bat species habitat impacts cannot be determined with certainty.

Wetland Evaluation. The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest wetland impacts in all categories. East Locust Creek Reservoir (RW1) alternative has 60.6 more acres of wetland impacts than the Yellow Creek Reservoir and Floodplain Acquisition alternative (MA2). While the Yellow Creek Reservoir and Floodplain Acquisition alternative (MA2) has fewer total impacts to wetlands, it has more impacts to high-function wetlands (3.5 acres more). East Locust Creek Reservoir (RW1) alternative has more impacts to low-function wetlands (28.8 acres more) than the Yellow Creek Reservoir and Floodplain Acquisition alternative (MA2).

Stream Evaluation. The Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has the fewest stream impacts. Based on MSC and NHD data, East Locust Creek Reservoir (RW1) alternative has 7.4 fewer miles of stream impacts than the Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative. Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative has 1.7 more miles of Class P stream impacts and 5.7 more miles of Class C stream impacts. Based on NHD data, East Locust Creek Reservoir (RW1) alternative also has 4.2 more miles of perennial stream impacts and 11.6 fewer miles of intermittent stream impacts than Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative.

Practicability Evaluation

LOGISTICAL CONSIDERATIONS

Logistical considerations are similar for the two multipurpose reservoir alternatives. Based on the description above, the Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has logistical concerns including management, maintenance, and efficiency. These logistical considerations are the reason MDNR supports a regional water system. Based on the description above, Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative is not reasonable because of the logistical challenges.

LIFE CYCLE COSTS

In terms of life cycle costs, East Locust Creek Reservoir (RW1) alternative is over $100,000,000 less than the Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative and the Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative. Because the Yellow Creek Reservoir and Floodplain Acquisition (MA2) and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternatives are over $100 million dollars more (2 times more) than the Proposed Action, the alternatives are considered to be “unreasonably expensive to the applicant” and therefore are not considered to be a practicable alternative.

Summary of Preferred Alternative Analysis. The practicability evaluation determined that Yellow Creek Reservoir and Floodplain Acquisition (MA2) and Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternatives are not practicable because they are “unreasonably expensive to the applicant” and are therefore eliminated.

Additionally, Yellow Creek Reservoir and Floodplain Acquisition (MA2) alternative has more stream impacts and more high-function wetland impacts. Expand Existing Public Lakes, Water Supply Combination, and Floodplain Acquisition (MA6) alternative has additional logistical concerns. West Fork Locust Creek Reservoir and Floodplain Acquisition (MA3) alternative has more wetland (low- and high-functioning wetlands) and more stream impacts than East Locust Creek Reservoir (RW1) alternative. Thus, given the fewer stream impacts, lower impacts to high-function wetlands, and practicability, the Proposed Action – East Locust Creek Reservoir (RW1) is the Preferred Alternative.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

3.0 Affected Environment and Predicted Environmental Consequences

3.1 Resources Not Evaluated in Detail

Rangeland Resources

This issue was eliminated from further study because there are no properties in the project area classified as rangeland under the Public Rangeland Improvement Act.

Protected Lands

This issue was eliminated from further study because there are no properties in the project area classified as a state or federal park or wildlife refuge or funded with Land and Water Conservation funds.

Air Quality

This issue was eliminated from further study because there have been no substantial changes in air quality since the 2006 FEIS.

Invertebrate Species

This issue was eliminated from further study because no rare or endangered invertebrate species are listed in the area of the Proposed Action.

Soils

This issue was eliminated from further study because there have been no substantial changes in soils since the 2006 FEIS.

Minerals

This issue was eliminated from further study because there have been no substantial changes in minerals since the 2006 FEIS.

Geology

This issue was eliminated from further study because there have been no substantial changes in geology since the 2006 FEIS.

3.2 Climate

3.2.1 Affected Environment

The project area is entirely located in Sullivan County, approximately 0.5 mile south of Pollock, Missouri, and approximately 113 miles northeast of Kansas City, Missouri. Land use within the county is primarily agricultural. August is typically the hottest month and January is the coldest. Average annual total rainfall is 45.42 inches.

Table 3.2.1-1 shows patterns from 2006 – 2016. Data was retrieved from the Kirksville, Missouri, U.S. COO234544 Weather Station, which is located approximately 26 miles east-southeast of the Proposed Action (NOAA 2016).

Table 3.2.1-1. 2006 – 2016 Sullivan County Climate Patterns from Kirksville Weather Station.

Year	Mean Max (degrees Fahrenheit)	Mean Min (degrees Fahrenheit)	High (degrees Fahrenheit)	Month	Low (degrees Fahrenheit)	Month	Total Precipitation (inches)
2016	63.8	43.5	97	June	-9	Dec.	33.64
2015	62.6	41.8	93	July	-7	Feb.	58.44
2014	58.8	38.0	93	Aug.	-14	Jan.	45.17
2013	60.4	39.1	102	Aug.	-11	Dec.	41.45
2012	66.9	43.6	105	July	5	Jan.	30.7
2011	61.9	41.1	98	Aug.	-8	Feb.	46.84
2010	61.35	40.8	96	Aug.	-17	Jan.	60.23
2009	59.8	39.7	94	June	-12	Jan.	57.92
2008	59.4	39.1	94	July/Aug.	-6	Jan.	61.92*
2007	62.7	40.2*	99	Aug.	-4*	Feb.	36.87
2006	66.9*	46.2*	98*	July	-3*	Feb.	22.42*

(Source: NOAA 2016)
*Missing data for one or more months

The Midwest region is vulnerable to climate variability and climate change. The annual high temperature varied by 12 degrees and the annual low temperature varied by 22 degrees over the 10-year period. Precipitation varied from a low of 30.7 inches in 2012, a year with complete data, to at least 61.92 inches in 2008, a year with incomplete data, which is a difference of at least 31.22 inches.

3.2.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impacts on the overall climate of Sullivan County or the 10-county region, which in addition to Sullivan County includes Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, and Schuyler counties. There would be no increase or decrease of greenhouse gas emissions as a result of the No Action alternative.

3.2.3 Direct and Indirect Effects of the Proposed Action

The Proposed Action would not have any negative impacts on the climate of Sullivan County or the 10-county region and is not expected to result in an increase of greenhouse gas emissions. Given the concern that global climate change is likely to cause increased drought and flood frequency in Missouri with negative impacts on agriculture, industry, and quality of life, the Proposed Action provides resiliency in mitigating future impacts from extreme weather events for Sullivan County.

3.3 Land Use

3.3.1 Affected Environment

There have been no substantial changes to land use within the Proposed Action since preparation of the FEIS and signing of the ROD in 2006. Figure 3.3.3-1 summarizes NLCD land uses in the project area.

3.3.2 Direct and Indirect Effects of the No Action Alternative

If the Proposed Action is not constructed, current land use would be unchanged.

3.3.3 Direct and Indirect Effects of the Proposed Action

Acquisition of land for the Proposed Action began March 2009 and was essentially completed August 2017. A total of 4,326 acres was purchased from 103 different parcels and 83 different owners. Funding for acquisition of land was provided by NRCS throughout that period. NRCS funding for the SEIS was made available beginning August 2014.

Construction of this alternative would result in inundation of land within the normal pool and construction of recreational amenities around the lake. The current land use is idle or leased for agriculture.

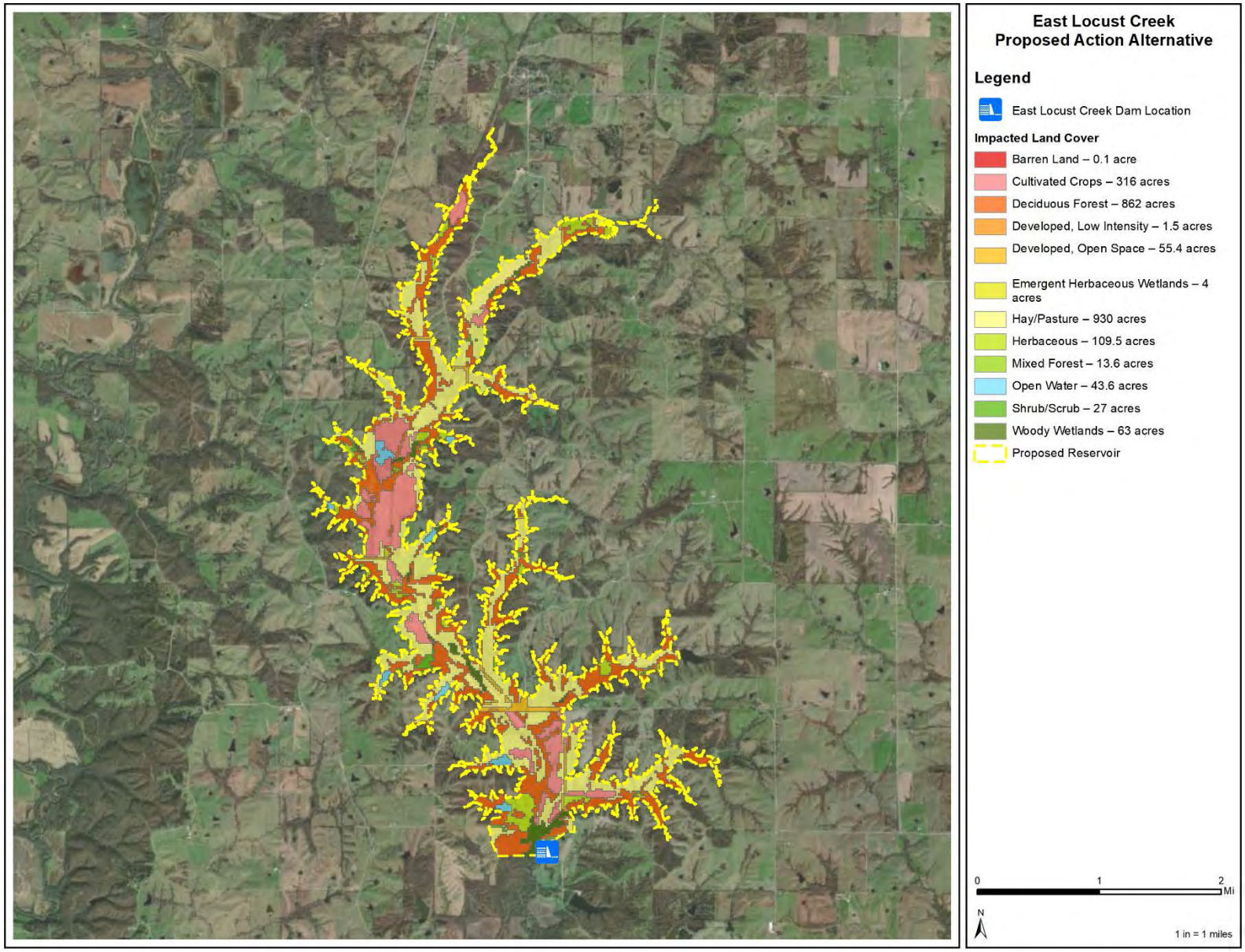


Figure 3.3.3-1. National Land Cover Database Land Use in the Project Area.

3.4 Farmland Resources

Under the Farmland Protection Policy Act (FPPA), federal agencies must identify and consider the adverse effects of federal programs on the preservation of prime or unique farmland. The purpose of the FPPA is to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses and to assure that federal programs are compatible with state and local policies to protect farmland.

3.4.1 Affected Environment

The Proposed Action is located entirely in Sullivan County. According to the 2012 Census of Agriculture, Sullivan County has 798 farms with an average size of 405 acres, totaling 323,005 acres of farmland. Of the total acres, 158,840 acres (49 percent) are characterized as cropland, and 99,726 acres are characterized as harvested cropland (USDA 2012).

3.4.1.1 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impacts on farmlands.

3.4.1.2 Direct and Indirect Effects of the Proposed Action

There are approximately 273 acres of cropland and approximately 1,078 acres of hay/pastureland in the project area that would be inundated or purchased for the creation of the Proposed Action (Homer et al. 2015). This totals 1,351 acres and represents approximately 0.4 percent of the total farmland within the county. This farmland consists mainly of corn, soybean, and wheat cropland and pastureland.

Approximately 407 acres within the project area are .classified as prime farmland or farmland of statewide importance based on soil types: 53 acres is classified as prime farmland, 163 acres is classified as prime farmland if drained, and 191 acres is classified as farmland of statewide importance. This is 1.5 percent of the 27,000 acres of prime farmland or farmland of statewide importance in Sullivan County. Prime farmland is determined based on soil types and does not always indicate cropland. NRCS has completed and filed FORM AD-1006 as required by the FPPA. Figure 3.4.1.2-1 shows the prime farmland and farmland of statewide importance in relation to the Proposed Action.

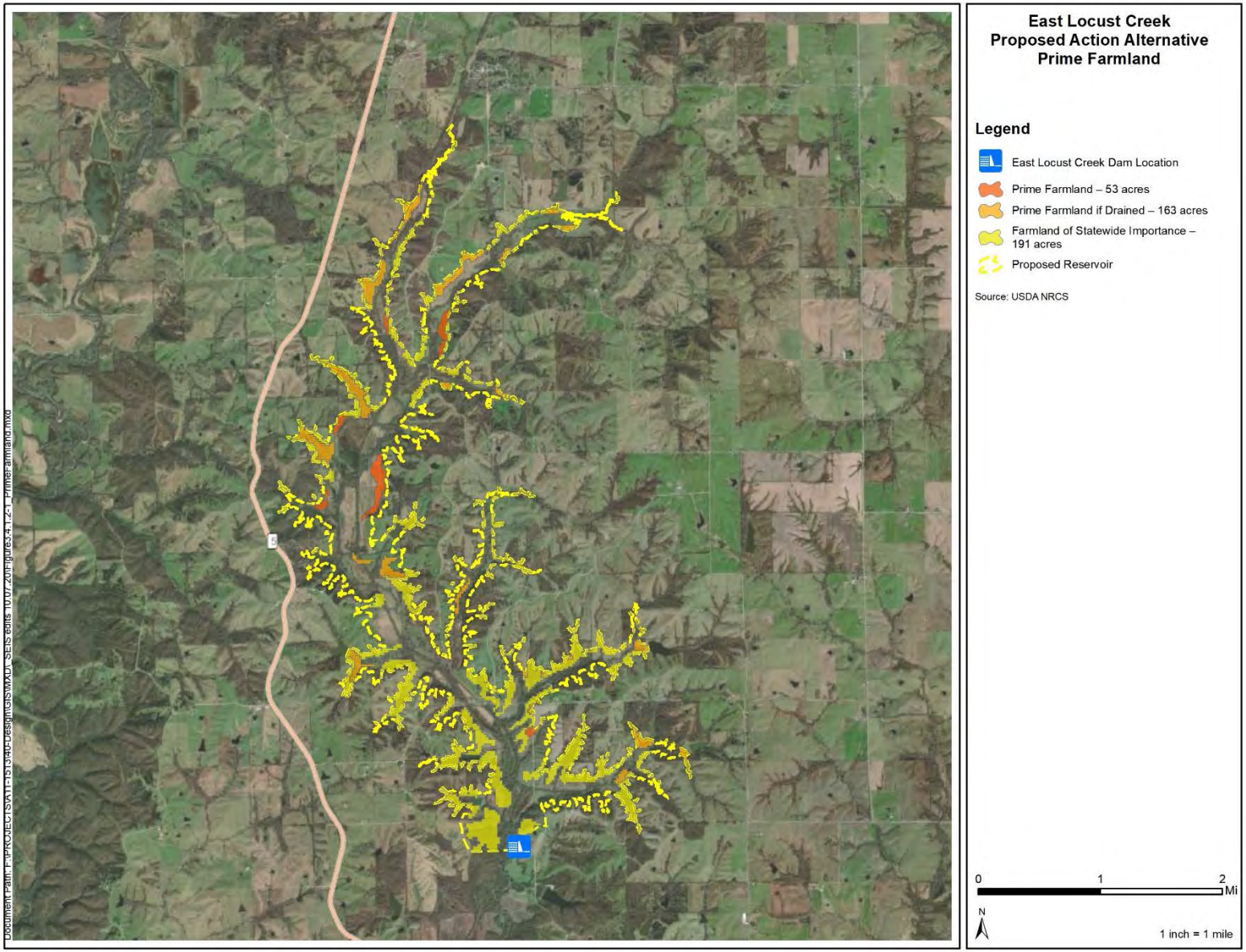


Figure 3.4.1.2-1. Prime Farmland in the Project Area.

3.5 Forest/Woodland Resources

3.5.1 Affected Environment

There has been no substantial change to forest resources within the project area since they were described in the affected environment and impact analysis portion of the FEIS and since the signing of the ROD in 2006. A Forest and Field Inventory report for the Proposed Action was completed July 7, 2016, and described the forested areas within the project area as "highly fragmented, consisting mainly of riparian corridors and upland drainageways" (Arndt 2016). The report also found that larger blocks of forest, greater than 20 acres, are scattered throughout the area. These are dominated by shingle oak (*Quercus imbricaria*), American elm (*Ulmus americana*), honeylocust (*Gleditsia triacanthos*), and shagbark hickory (*Carya ovata*) in the old-field/early successional areas; large-diameter oaks (*Quercus* sp.), hickory (*Carya* sp.), cottonwood (*Populus* sp.), and assorted small-diameter trees along upland drainages; white oak (*Quercus alba*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), and shagbark hickory in the mixed upland hardwood forest areas; and silver maple (*Acer saccharinum*), eastern cottonwood (*Populus deltoides*), and green ash (*Fraxinus pennsylvanica*) in the bottomland forests. Black walnut (*Juglans nigra*) was also found scattered throughout the project area (Arndt 2016).

3.5.1.1 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impacts on woodland or forest resources.

3.5.1.2 Direct and Indirect Effects of the Proposed Action

The Proposed Action could result in the conversion of 1,410 acres of forest over the 100-year project life (Table 3.5.1.2-1). The normal pool inundation would include 973 acres of forest conversion, based on an aerial imagery review and NLCD forest layer. Forest impacts reported in the alternatives analysis were based on NLCD only for comparison to other alternatives.

Table 3.5.1.2-1. Project Forest Impacts.

Project Element	Projected Forest Conversion (acres)
Normal Pool Inundation	973[a]
Fence Construction	67
Recreational Facilities Development	27
Utilities and Road Relocation	34
Dam Construction, Borrow Sites, Spillway Construction, and Temporary Dam Access Roads	23
Water Treatment, Transmission, and Distribution	55[b]
Future Development Outside NCMRWC Property	162[c]
Tree Clearing on NCMRWC Property because of Development	69[d]
TOTAL FOREST CONVERSION	**1,410**

[a] To improve accuracy, an aerial imagery review was included with the NLCD forest layer.
[b] Includes 25 percent of the NLCD forest layer that occurs in the conceptual water transmission lines.
[c] Includes forest clearing as a result of potential development outside of the Proposed Action area.
[d] Includes tree clearing on NCMRWC property to support development.

3.6 Residential

3.6.1 Affected Environment

The area to be served by the Proposed Action includes 10 counties in north-central Missouri. This 10-county region includes Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties. The 2010 population of the 10-county region was 107,130 people (U.S. Census 2010) and is comprised largely of agricultural, rural land. The City of Kirksville is the largest urban area in the 10-county region and is located in the center of Adair County. Other communities within the 10-county region include Chillicothe, Trenton, Milan, Macon, and Brookfield.

3.6.1.1 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would result in the continuation of inadequate water supply for the communities surrounding the Proposed Action area. Residents within the vicinity of East Locust Creek Reservoir would also see a continuation of flood events and a continuation of the damages, road closures, unsafe conditions, and costs associated with such events.

The 2010 population of the 10-county region was 1 percent less than the 2000 Census data (U.S. Census 2010). The implementation of a reliable water supply in the 10-county region could help stabilize population and increase both population and per capita water usage as more industry and development are attracted to the area.

3.6.1.2 Direct and Indirect Effects of the Proposed Action

The unincorporated community of Boynton (population unknown) would be inundated by the permanent pool of the Proposed Action. Twenty-one buildings located in Boynton were coded as residential. Acquisition complying with the Uniform Act has been provided to owners of all residential properties purchased in conjunction with construction of the reservoir and related works of improvement. Buildings on purchased parcels have been demolished and cleared.

As a result of installation of the Proposed Action, current and future water shortage problems experienced by communities in the 10-county region would be greatly reduced. In addition, floodwater damages related to cropland and pastures, fences, commercial and urban properties, roads, bridges, rerouting of traffic, maintenance, and clean-up would all be reduced. Costs to Sullivan County communities for such damages would be reduced. Disruption to daily traffic, mail delivery, emergency services and other vehicle movement, and unsafe flooded roadway conditions would be reduced as infrastructure flooding is reduced.

Many water suppliers within the 10-county region need alternative water sources to meet the needs of their customers. The Proposed Action would provide an adequate and dependable water supply for residents in the 10-county region.

The Proposed Action would improve recreational opportunities and quality of life for local residents by providing 91,956 of the unmet annual user-days for water-based recreation in the region.

Some field and residential drives would be temporarily affected during construction and during necessary regrading or realigning of drive approaches.

3.7 Commercial/Industrial/Infrastructure/Utilities/Other

3.7.1 Affected Environment

There are no commercial or industrial facilities, utility buildings, or substations within the project area. Public and private utilities (i.e., electric power, water, communication) are present in the project area. Missouri Highway 5, Missouri Highway M, Missouri Highway B, and Missouri Highway Y border the project area and Missouri Highway N and several local roads run through the project area.

3.7.1.1 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would not have an impact because there would be no change to the existing utility service within the project area.

3.7.1.2 Direct and Indirect Effects of the Proposed Action

EXISTING DRINKING WATER LINES

The Project will affect drinking water lines and pressure zones through dam creation and inundation. Impacts will occur to two pressure zones that will affect the flows, pressures, and recovery rates of the two elevated storage tanks.

To maintain the existing flow, pressures, and system recovery capacity, the existing radial lines that will be inundated will be combined prior to inundation and replaced with two lake crossings in the area of Knob Hill Road and the dam. Construction of the new lines would be included with electrical and telecommunication line relocations.

TRANSPORTATION AND UTILITY RELOCATION

The Project will inundate 5 miles of existing county roads and 1 mile of state highway. The Project inundation results in the loss of East Locust Creek crossings from Highway 6 at Milan to the Village of Pollock located approximately 13 miles to the north. Funding has been identified through the BUILD grant program. Through this program, federal funding is provided through the project sponsor (MoDOT) to invest in road, rail, and transit projects. Additional information on the BUILD grant road improvements and relocations can be found in Appendix E.

The Project will inundate 5 miles of existing county roads and 1 mile of state highway. The Project inundation results in the loss of two East Locust Creek bridge crossings that represent the only stream crossings between Missouri Highway 6 at Milan to the Village of Pollock, located approximately 13 miles to the north. The bridges will be left in place and would be inundated after dam construction.

The BUILD grant surface transportation project will result in the improvement of a network of roads that include the relocation of Missouri Route N, the extension of Missouri Route VV to Missouri Route 5, improvements to Missouri Route 5 between relocated Missouri Route N, and the new intersection of Missouri Route VV at Missouri Route 5 and upgrades to county roads accessing the new reservoir. This surface transportation project is needed to assist in funding the

transportation roadway safety and capacity improvements for safe access, emergency response, and intersection turn lanes (Figure 3.7.1.2-1).

The Project will affect single-phase and three-phase power lines and telecommunication lines located along Missouri Route N and nearby gravel roads. To replace the existing service, the areas with disconnected service would be served by a new utility corridor south of the dam and by an earthen utility corridor built across the Project along the Knob Hill Road to the Missouri Highway VV corridor. The Proposed Action would require relocation or coordination of the utilities listed below. Coordination with the utilities is ongoing.

- North Central Missouri Electric
- Northeast Missouri Rural Telephone
- Sullivan County PWSD No. 1
- Utility Safety and Design
- Windstream

WATER TREATMENT FACILITY

The current 2.2 MGD NCMRWC water treatment plant at Milan would need to be upgraded over the 100-year project life to provide the 7 MGD water supply for the 10-county region. The water treatment plant upgrade will occur onsite and will not impact streams or wetlands. Wholesale water will be sold to water systems within the region without water production capabilities.

WATER TRANSMISSION LINES

The water transmission lines have not been designed and the routes provided in Figure 2.0-1 above are conceptual only. The exact location of the transmission lines would be designed as the distribution system is built out over time. Construction of the distribution system would have temporary impacts to streams and wetlands. Permanent impacts are considered for forested areas and for PFO wetlands. The forest impacts based on the conceptual diagram total 210 acres and the PFO wetlands impacts total 30 acres.

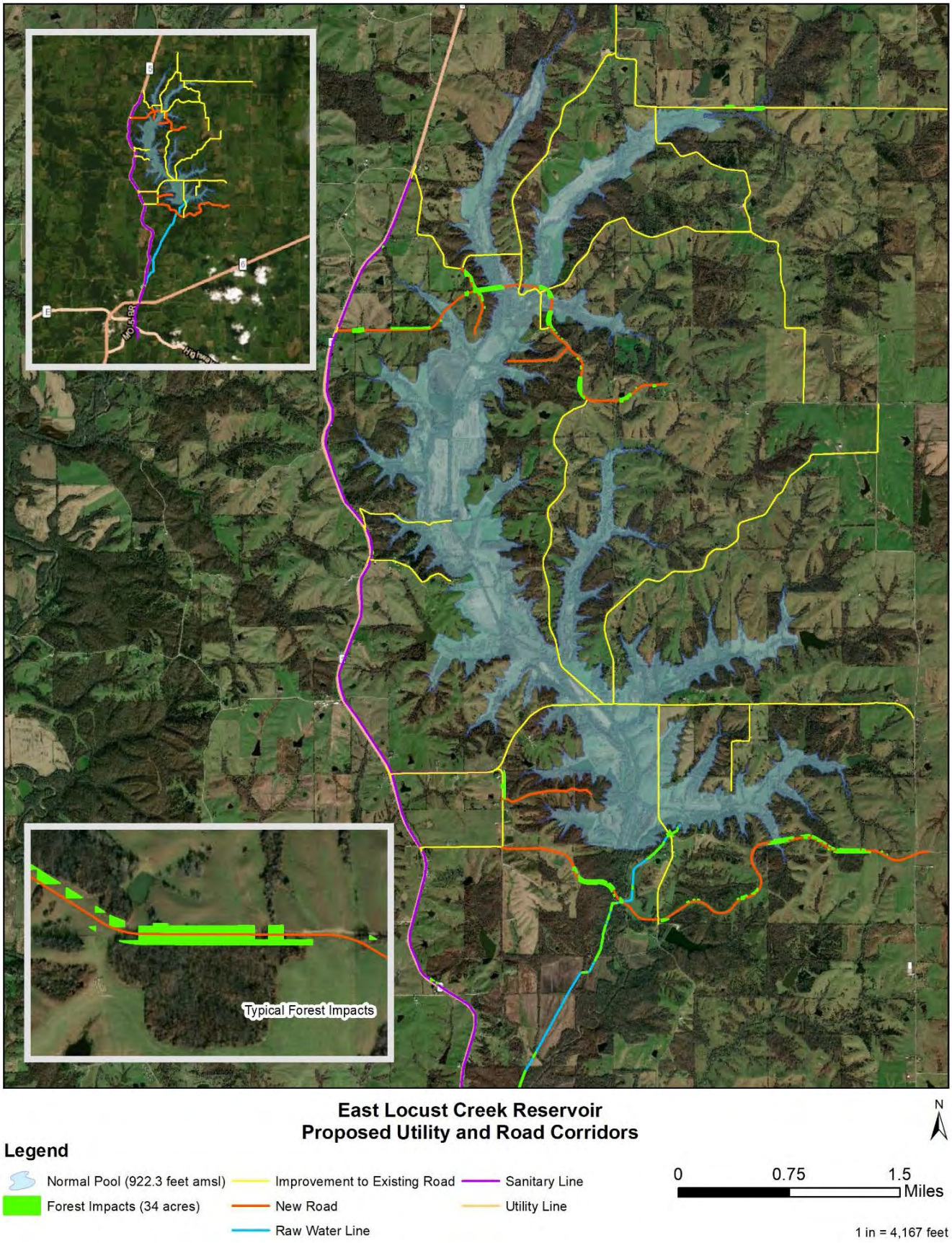


Figure 3.7.1.2-1. Proposed Utility and Road Corridors.

3.8 Water Resources

3.8.1 Streams

3.8.1.1 Affected Environment

East Locust Creek, from the mouth to Missouri Highway 6, is classified by the State Of Missouri (10 CSR 20-7.031) as "P," which identifies "streams that maintain permanent flow even in drought periods." From Missouri Highway 6 to Section 12, Township 64N, Range 20W, near Pollock, the stream is classified as "C," which identifies "streams that may cease flow in dry periods but maintain permanent pools which support aquatic life" (10 CSR 20-7.031). The remainder of the stream is unclassified. The state-designated beneficial uses for East Locust Creek are for livestock and wildlife watering and for the protection of warm water aquatic life and human health – fish consumption (10 CSR 20-7.031). Whole-body contact recreation is also a designated beneficial use for East Locust Creek (10 CSR 20-7.031).

According to the 2006 FEIS, the majority of the creek within the project area is laden with sandy sediment. The creek is incised from past degradation but appears relatively stable and has natural and artificial grade control at several locations. Substrate of the creek is primarily coarse to fine sand with occasional riffles over resistant clay or weathered shale, with rare exposures of bedrock and a few private cobble low-water crossings (NRCS 2006).

In 2015 and 2016, a stream assessment was conducted for all streams within the normal pool of the Proposed Action. The stream assessment reports are available on the NCMRWC website (NCMRWC 2017). The stream assessment identified 49.1 miles of stream, which included 27.6 miles of ephemeral, 12.6 miles of intermittent, and 8.9 miles of perennial streams within the normal pool. The stream assessments for East Locust Creek (perennial) measured the ordinary high-water mark width of 12 to 25 feet and the top-of-bank width from 35 to 60 feet. The buffer vegetation along East Locust Creek included black walnut, multiflora rose (*Rosa multiflora)*, red mulberry (*Morus rubra*), American elm, white oak, black willow (*Salix nigra*), shagbark hickory, tall fescue *(Schedonorus arundinacea)*, silver maple, hackberry (*Celtis occidentalis*), and river birch (*Betula nigra*). East Locust Creek had natural stream characteristics but was incised or had excessive erosion in areas. Figure 3.8.1.1-1 shows photographs of East Locust Creek.

Figure 3.8.1.1-1. Typical East Locust Creek Photos.

The Locust Creek Basin Management Plan indicates that 45 fish species within 11 families had been previously identified within a distribution range that includes the Locust Creek Basin (MDC 1994). Thirty-seven of those species have been collected in the Locust Creek basin, (which includes East Locust Creek but is not limited to it); 33 of those species were collected in 1988, the most recent collection date. Red shiner (*Cyprinella lutrensis*) was the most abundant species at 40 percent of all collected. Bigmouth shiner (*Notropis dorsalis*) was the second most collected. Other commonly collected species were creek chub (*Semotilus atromaculatus*), sand shiner (*Notropis stramineus*), bluntnose minnow (*Pimephales notatus*), suckermouth minnow (*Phenacobius mirabilis*), river carpsucker (*Carpiodes carpio*), green sunfish (*Lepomis cyanellus*), redfin shiner (*Lythrurus umbratilis*), and Johnny darter (*Etheostoma nigrum*).

Two species considered to be intolerant of poor water quality, stonecat (*Noturus flavus*) and trout-perch (*Percopsis omiscomaycus*), were also found. No threatened or endangered aquatic species have been found in the basin (MDC 1994). The Locust Creek Basin Management Plan did not specify how many species were found in East Locust Creek; however, all species in the distribution range were identified to occur in the region.

3.8.1.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impact on streams.

3.8.1.3 Direct and Indirect Effects of the Proposed Action

Based on the 2014/2015 stream assessments (Olsson 2016), implementation of the dam and normal pool would result in the inundation of the 49.1 miles of stream. Utilities and road relocations and improvements would cause permanent or temporary impacts to 0.3 mile of stream crossings based on the 2020 field delineation (Olsson 2020).

As mentioned earlier in the DSEIS, the stream impact numbers are based on a detailed site investigation rather than the Missouri stream classification, which was used to calculate effects in the alternatives analysis section. A preliminary jurisdictional determination has been provided by the USACE for the site. Figure 3.8.1.3-1 shows the affected streams in the project area.

Dams alter two critical elements of the geomorphic system: the ability of the river to transport sediment and the amount of sediment available for transport (Grant et al. 2003). If the transport capacity exceeds the available supply, a sediment deficit exists, and the channel can be expected to remove sediment from its bed and/or banks. If the transport capacity is less than the available sediment supply, then the channel can be expected to accumulate sediment. Both scenarios can occur below a dam, depending on the distance from the dam, input from tributaries, and the difference between pre-dam flows and dam releases (Collier et al. 1996). There are many adjustable attributes of a channel – its cross-section, bed material, planform, and gradient – and the response of a channel to sediment deficit or surplus varies. Typical downstream responses can include channel bed degradation or incision, textural changes such as coarsening or fining of surface grain-size distributions, and lateral adjustments, including both expansion and contraction of channel width (Petts 1980, 1982; Williams and Wolman 1984; Carling 1988; Brandt 2000).

The Proposed Action's dam and associated operation would fragment East Locust Creek and alter the movement of aquatic species, nutrients, and sediment upstream and downstream. The water budget model (Appendix D) describes operation and flow of the Proposed Action. The proposed reservoir spillway is a two-stage labyrinth weir with the first stage at normal pool and the second stage at the 25-year flood level. Approximately 10 feet below normal pool will be a passive flow system that will pass 0.5 cfs to East Locust Creek below the reservoir when the reservoir is at normal pool. The opening will pass flow at diminishing rates as the reservoir drops, until the flow ceases when the lake is approximately 10 feet below normal pool. The openings are fitted with removeable orifice plates so that outfall rates can be modified through an adaptive management process. Additional downstream flow will occur through minor seepage through the dam. The passive water releases would have altered physical and chemical water characteristics. Additionally, the dam would block aquatic species from moving upstream and restrict species' movement downstream. The East Locust Creek Reservoir Water Budget Model (Appendix D) describes the in-stream flow releases, reservoir stage outflow, and reservoir stage storage.

Changes in fish diversity below the reservoir may occur because of the altered stream flows, nutrient flows, sediment flows, and temperature changes. Changes in flow regime and temperature may adversely affect aquatic species that are sensitive to flow or temperature conditions. Reservoirs are susceptible to low dissolved oxygen in their deeper portions. If the dam releases flows through the bottom of the reservoir, the downstream water may be a reduction in temperature to the receiving stream and low in dissolved oxygen. If it is released from the top of

the dam, the flow could be warmer than the downstream water. Thermal shocks can adversely affect susceptible stream species in the receiving tributary.

Dam leakage and stable flows may maintain a stable stream flow during drought conditions, which may minimize impacts to current aquatic species populations. Recreational development and the water treatment plant are anticipated to avoid additional permanent stream impacts, although water transmission lines may result in temporary impacts.

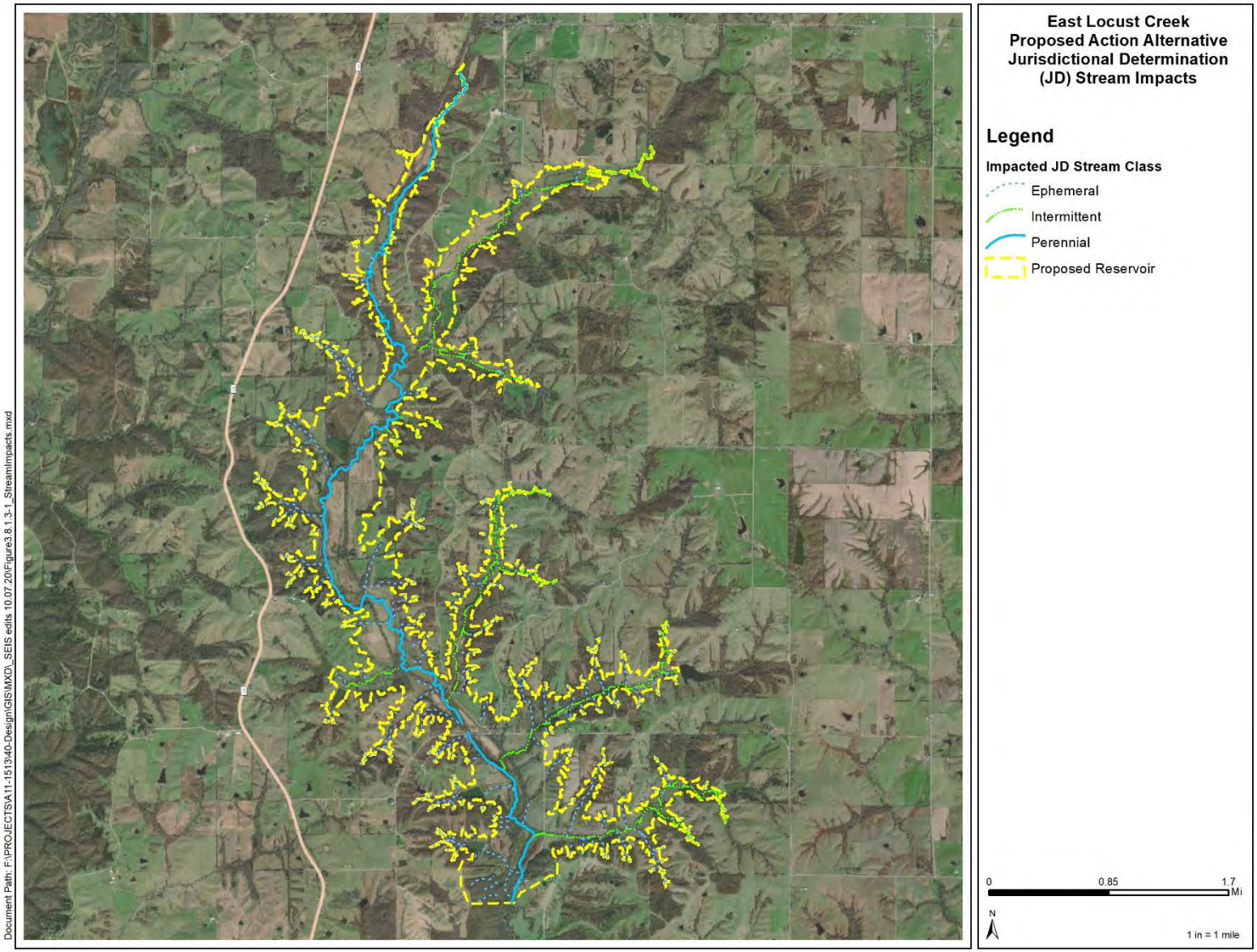


Figure 3.8.1.3-1. Stream Impacts in the Project Area.

3.8.2 Groundwater

3.8.2.1 Affected Environment

The 10-county region has three different types of groundwater sources; these are glacial drift, bedrock, and Missouri River alluvium aquifers. The percentage of each aquifer type within the region is as follows: 91.6 percent glacial drift, 7.1 percent bedrock, and 1.3 percent Missouri River alluvium.

Useable groundwater in this region is found in isolated pockets of remnant glacial aquifers and in alluvial aquifers adjacent to surface water streams. The glacial aquifers are somewhat randomly dispersed with no interconnectivity. Likewise, the alluvial aquifers may follow along surface water, but it is increasingly difficult to locate wells that produce useful yields.

3.8.2.2 Direct and Indirect Effects of the No Action Alternative

Groundwater concerns are not applicable to the No Action alternative.

3.8.2.3 Direct and Indirect Effects of the Proposed Action

There have been no substantial changes to groundwater resources within the proposed Project area since they were described in the affected environment and impact analysis portion of the FEIS and since the signing of the ROD in 2006.

Four registered groundwater wells are located within the project area. These wells were installed in the project area as part of a dam geological investigation and will be properly abandoned at the appropriate time. An unknown number of unregistered wells may be located along the project area. Approximately 20 shallow cisterns (< 20 feet deep) have been found within the project area and are in the process of being filled. No cisterns deeper than 20 feet have been found.

Any registered or unregistered wells affected by the project would be properly decommissioned according to Missouri Minimum Design Standards for Community Drinking Water Systems, paragraph 3.1.4.1.c, as well as the Code of State Regulations (CSR), 10 CSR 23-3.110 – Plugging of Water Wells (MDNR 2013b; MDNR 2014a). Proper decommissioning of affected wells would not have a significant impact on groundwater quality.

The next nearest groundwater public drinking water source, Princeton Municipal Water, is 28 miles northwest of the proposed dam. It is in the Weldon River alluvium. Given the distance and the lack of connectivity to the East Locust Creek alluvium, there is no chance of any impacts from the proposed dam.

3.8.3 Wetlands

For the purposes of the CWA and this DSEIS, wetlands are defined as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (33 Code of Federal Regulations [CFR] 328). Wetlands are determined in accordance with the methods set forth in the *1987 U.S. Army Corps of Engineers Wetlands Delineation Manual* (USACE 1987) and *Regional Supplement to the U.S. Army Corps of Engineers Wetland Delineation Manual: Midwest Region* (USACE 2010).

3.8.3.1 Affected Environment

A wetland delineation was completed for the Proposed Action's normal pool area in 2015 and 2016. As discussed earlier in the DSEIS, the numbers in this section are based on detailed site investigations rather than on the NWI, which was the source used for the alternative analysis section. The wetland delineation reports can be found on the NCMRWC website (NCMRWC 2017). Based on the wetland delineation conducted for the project (Olsson 2016), approximately 362 acres of wetlands were determined to be in the normal pool. Identified wetlands have been classified according to the Cowardin Wetlands Classification system (Cowardin *et al*. 1979). The 362 total wetland acres consist of 273 acres of PEM wetlands, which are dominated by herbaceous vegetation, 79 acres of PFO wetlands, which are dominated by trees, and 10 acres of PSS wetlands, which are dominated by small woody plants. An existing 181-acre Emergency Wetland Reserve Program easement (EWRP) would be mostly inundated by the RW1 alternative and is included in the wetland delineation values. According to federal rules at 7 CFR 1468.6 and NRCS program policy (Title 440, Conservation Programs Manual, Part 528.170), this easement must be replaced with a wetland of equal or greater functions and values; no net loss of program acres, and equal or greater economic value. The EWRP replacement is detailed in Appendix F. All CWA aspects of this easement replacement are addressed in the Compensatory Mitigation Plan. Figure 3.8.3.1-1 shows the delineated wetlands.

Wetland impacts were determined for the utilities relocations and the road relocations and improvements. NWI data shows that 3.05 acres of PEM wetlands and 9.19 acres of PFO wetlands are within the utility and road improvements. A wetland delineation is planned to confirm these values.

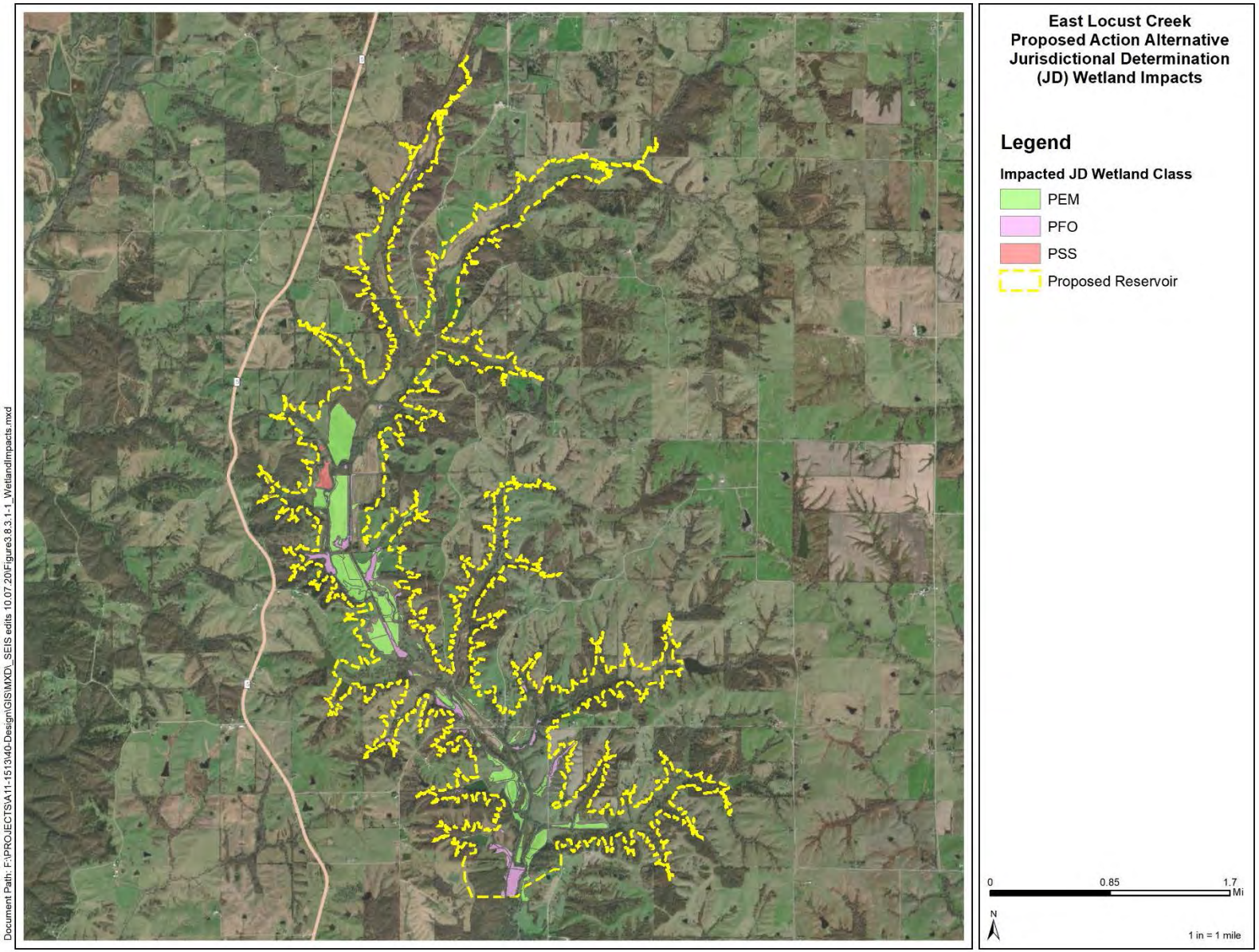


Figure 3.8.3.1-1 Wetland Impacts in the Project Area.

The wetlands had no standing water present or had water depths of less than 1 foot deep. Persistent standing water was not common among the wetlands delineated. An abandoned railroad line impacts the hydrology within part of the normal pool area and appears to contribute to the wetland development by pooling sheet flow across the area.

The wetland quality is reduced for 224.5 wetland acres, because the wetlands were previously farmed, are currently farmed, or consist of over 50 percent cover of reed canarygrass, which is an invasive species that does not provide many wetland functions.

A 39.5-acre PEM wetland was created by the NRCS EWRP and is included in the total PEM wetlands within the normal pool. The WRP program "offers landowners the opportunity to protect, restore, and enhance wetlands on their property" (NRCS 2014). The EWRP replacement is described in Appendix F. Figure 3.8.3.1-2 shows example wetlands identified with the proposed Project footprint.

Figure 3.8.3.1-2. Typical East Locust Creek Wetland Photographs.

3.8.3.2 Direct and Indirect Effects of No Action Alternative

The No Action alternative would have no impact on wetlands within the footprint of the Proposed Action.

3.8.3.3 Direct and Indirect Effects of the Proposed Action

The Proposed Action would affect 368 acres of wetlands that were determined by the wetland delineations in 2014, 2015, and 2020 (Olsson 2016 and Olsson 2020). The wetlands delineated within the normal pool generally did not have standing water over 1 foot deep. The Proposed Action would result in water with depths up to 56 feet. The wetlands would lose the ability to support vegetative communities except shoreline areas that were less than about 6 feet deep. Lake level fluctuation could limit the aquatic or wetland vegetative communities along the shoreline. Road improvements and utility relocations resulted in 6 acres of impacts.

The Proposed Action would alter the flow regime and remove water from the East Locust Creek watershed for water supply use. The change in flow and water available may impact the hydrology of wetlands downstream of the dam along East Locust Creek. The water budget model (Appendix D) has information on the stream flow and future changes. Downstream flow would be maintained through a passive flow system and seepage from the reservoir. High flow events would completely pass through the spill way and downstream flows would be consistent with current high-flow events.

3.8.4 Water Quality

Missouri state water quality regulations (10 CSR 20-7) classify waters by type, establish beneficial uses, and define general (10 CSR 20-7.031(3)) and specific water-quality criteria. Water bodies that fail to meet either general or numeric criteria are required to be listed as impaired water bodies under Section 303(d) of the federal CWA.

3.8.4.1 Affected Environment

East Locust Creek from Pollock to south of Milan has been included on the draft of Missouri's 2018 303(d) List of Impaired Waters because of low dissolved oxygen and high *E. coli* levels (MDNR 2017a). Missouri Highway 5 poses a risk of water pollution by deicers and by automotive and combustion byproducts through runoff from the highway. Though agricultural nonpoint source pollution has not been associated with any impairment to water quality in East Locust Creek, cropland or pasture mismanagement in close proximity to the reservoir poses a risk to water quality.

Phase I and Phase II Environmental Site Assessments (ESA) were done throughout the project area for the identification and assessment of recognized environmental conditions (RECs), including the town of Boynton. The Phase I and Phase II ESAs are provided on the NCMRWC website (NCMRWC 2017). The ESA results identified potential contaminants associated with an abandoned railroad line in excess of state established health-based benchmarks. Flooding along the abandoned railroad line may result in minor arsenic releases from the railroad bed. The releases are anticipated to be small and have negligible effects on water quality. A memo describing the arsenic releases is included in Appendix B.

Additional threats to water quality in the East Locust Creek watershed are from sediment, pathogens, nutrients, and toxic materials. Sediment sources include unstable channel banks, road ditches, and inadequately protected cropland, pasture, and forestland. Pathogens and nutrients can also arise from human, livestock, and wildlife sources.

3.8.4.2 Direct and Indirect Effects of the No Action Alternative

No streams or water bodies would be affected by the No Action alternative. Current water quality concerns include sediment, pathogens, nutrients, and toxic materials from unstable channel banks, road ditches, railroad lines, and inadequately protected cropland, pasture, and forestland.

3.8.4.3 Direct and Indirect Effects of the Proposed Action

It is likely that the Proposed Action would increase the dissolved oxygen level and reduce the *E. coli* concentration within the inundated section. The Proposed Action may provide sufficient flow to reduce summer effluent-dominated flow impairments downstream as well.

Sediment from the watershed and shoreline are primary pollutants that can compromise water quality. Erosion and sedimentation rates would be reduced in the watershed as a result of sediment capture in the reservoir and development of a vegetated buffer around the reservoir.

The proposed Project is a long, narrow reservoir that may be susceptible to shoreline erosion. Planning activities include a conservative approach based on consultation with lake managers from Iowa and Nebraska. All operational and structural mechanisms to enhance shoreline protection are being explored. These mechanisms include restricting the number of boats allowed; motor size restrictions; displacement restrictions; zonal prohibitions; extensive use of no-wake zones that allow wave energy dissipation; wing dikes; planning ramp locations; dock licenses and dock configuration; minimal tree clearing in portions of the lake above 911 feet MSL; vertical abutment bridge structures; shoreline and maintenance and strategic shoreline protection that includes hard structures, rip rap, and vegetation establishment. A Shoreline Protection Plan is included in Appendix G.

In 2009, the NCMRWC began contemplating water protection, source water protection, land oversight and habitat preservation when it drafted and advocated for passage of first-of-kind Lake Authority Legislation that provides the NCMRWC the ability to control and prevent contamination threats from the top of the watershed to the dam even on private property (NCMRWC 2017). The Lake Authority was passed as Revised Statute of Missouri 67.4520 and allows zoning and planning powers. The NCMRWC advocated for the Lake Authority legislation that was signed into law on August 28, 2011. This legislation enabled the NCMRWC to reduce the footprint of its property from 5,800 acres to approximately 4,550 acres by removing the need for a 300-foot buffer. In essence, in exchange for buffer acreage, the Lake Authority can exercise control over development and potential contaminating activities in the East Locust Creek Watershed from the top of the watershed to the dam.

The NCMRWC has also implemented a 100-foot buffer along streams within the High Impact Zone. The High Impact Zone extends 500 feet outside NCMRWC-owned property and surrounds the reservoir. The High Impact Zone was established through Resolution #6-2018 by the NCMRWC. The 100-foot buffer preserves 50 forest acres and will protect water quality within the High Impact Zone.

A source water protection plan was developed to protect existing water sources and public health and keep water treatment costs to a minimum. The source water protection plan followed MDNR

guidelines for developing a source water protection plan and for community water systems. A steering committee consisting of seven citizens and affiliate members consisting of eight resource professionals were consulted for guidance. A copy of the source water protection plan is included in Appendix H.

The National Pollutant Discharge Elimination System (NPDES) rules require a Storm Water Pollution Prevention Plan (SWPPP) on construction sites disturbing one or more acres. Although this plan would be prepared for the site, a short-term decline in water quality may occur as a result of sediment discharge associated with construction activities.

3.9 Fisheries

PL 83-566 projects are local projects installed with federal assistance and are exempt from the provisions of the Fish and Wildlife Coordination Act (FWCA; 16 USC 661-667e, Ch. 55 *as amended*). However, PL 85-624, which contained the 1958 amendments to the FWCA, added section 12 to PL 83-566. Section 12 (16 U.S.C. Section 1008) applies the principles of the FWCA to the PL 83-566 program. The NRCS state conservationist must notify the USFWS so it may provide recommendations for fish and wildlife resources, in accordance with the provisions of PL 83-566 Section 12.

Affected Environment

East Locust Creek is the primary stream within the project area and would be affected. From the mouth of the creek to Missouri Highway 6 in Milan, East Locust Creek is classified as perennial, which means it can provide habitat value for aquatic resources (NRCS 2006). However, no threatened or endangered fish species, fisheries of concern, or essential fish habitat (EFH) are known to be present within the water bodies in the project area (USFWS 2017).

During drought conditions, East Locust Creek has no flow and pools are dry. Restocking the stream when flow returns occurs from downstream reaches and from ponds and lakes in the watershed. The current fish community is described in section 3.8.1.1

3.9.1 Direct and Indirect Effects of the No Action Alternative

No threatened or endangered fish species, fisheries of concern, or EFH would be affected by the No Action alternative.

3.9.2 Direct and Indirect Effects of the Proposed Action

The Proposed Action will inundate approximately 13 acres of ponds that contain fish. No threatened or endangered fish species, fisheries of concern, or EFH would be affected by the Proposed Action.

The Proposed Action would provide recreational fishing opportunities to the residents of the 10-county region. See the purpose and need section for the recreational demand. Lakes in Missouri provide habitat for largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), bluegill (*Lepomis macrochirus*), and channel catfish (*Ictalurus punctatus*), among other species. A stocking program with similar species is anticipated in coordination with MDC.

3.10 Terrestrial Vegetation

3.10.1 Affected Environment

There have been no substantial changes to terrestrial vegetation within the project area since it was described in the affected environment and impact analysis portion of the FEIS and since the signing of the ROD in 2006. The Forest and Field Inventory Report for the Proposed Action described the forested areas within the project area as “highly fragmented, consisting mainly of riparian corridors and upland drainageways” (Arndt 2016). Further, NLCD included in Figure 3.3.3-1 (Section 3.3) shows the normal pool is predominantly hay/pastureland, deciduous forest, and cultivated crop land.

A 2016 study of potential habitat for Mead’s milkweed, which is federally threatened and state-endangered, found the current land use to be upland pasture on the steep terrain and crop fields on the flat ground. Upland pastures were found to primarily be reseeded with and have more than 80 percent establishment of tall fescue. Prairie species-dominated grassland was identified at four locations that totaled 18.7 acres.

3.10.2 Direct and Indirect Effects of No Action Alternative

The No Action alternative would have no impacts on terrestrial vegetation.

3.10.3 Direct and Indirect Effects of the Proposed Action

The Proposed Action will affect terrestrial vegetation in areas of inundation and dam construction. Additional areas would be indirectly affected by a change in land use.

None of the terrestrial vegetation species located in this area are federally threatened or endangered.

Disturbance of vegetation for construction activities could result in the introduction of nonnative or invasive species into unvegetated areas. BMPs and restoration of vegetation will be incorporated into the project to minimize this potential impact.

3.11 Wildlife

Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act (MBTA; 16 USC 703-712: Ch. 128 *as* amended), construction activities in grassland, wetland, stream, and woodland habitats and those that occur on bridges (which may affect swallow nests on bridge girders, for example) that would otherwise result in the taking of migratory birds, eggs, young, and/or active nests, should be avoided. Although the provisions of MBTA are applicable year-round, most migratory bird nesting activity in Missouri occurs during the period of April 1 to July 15. However, some migratory birds are known to nest outside the aforementioned primary nesting season period. For example, raptors (hawks, falcons, and owls) can be expected to nest in woodland habitats during February 1 through July 15, whereas sedge wrens (*Cistothorus platensis*), which occur in some wetland habitats, normally nest from July 15 to September 10.

Bald and Golden Eagle Protection Act

Bald and golden eagles have specific protection under the Bald and Golden Eagle Protection Act (BGEPA; 16 USC 668-668c), which is administered by the USFWS. Protections under this act prohibit "take" of bald and golden eagles. Bald eagles (*Haliaeetus leucocephalus*) use tall trees for roosting or nesting and nearby open water for foraging; golden eagles (*Aquila chrysaetos*) use shortgrass and mixed-grass prairies for foraging and rock cliffs, tall trees, and other high places for nesting.

There are no known bald or golden eagle nest locations within the project area. According to a USFWS data request, the nearest bald eagle nest is 2.5 miles from the Proposed Action.

3.11.1 Affected Environment

There have been no substantial changes to terrestrial vegetation within the project area since it was described in the affected environment and impact analysis portion of the FEIS and since the signing of the ROD in 2006. Typical wildlife for the project area includes deer, coyote, raccoon, opossum, skunk, squirrels, snakes, turtles, and frogs. The most common wildlife habitats that would be affected are cultivated cropland, pastureland, and deciduous forest.

The area lying within the normal pool is primarily agricultural fields consisting of hay/pasture field and deciduous forest. Forested areas, trees, and brush thickets associated with the riparian corridor may provide nesting habitat for migratory bird and eagle species. Further, the Proposed Action and the adjacent forested areas could provide suitable habitat for bald eagles.

3.11.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impacts on wildlife.

3.11.3 Direct and Indirect Effects of the Proposed Action

Vegetation removal for construction of the Proposed Action would decrease the amount of upland habitat available in the project area. The deciduous forest may provide nesting, foraging, and cover habitat for many species of birds, raptors, bats, deer, coyote, and small mammals. Sullivan County has approximately 95,530 acres of forest habitat. The Proposed Action would affect 1,410 acres of forest habitat, which is 1.5 percent of the forest habitat within the county. In addition, hay/pastureland may provide suitable grassland habitat for wildlife.

Given the limited nature of the Proposed Action's impact on wildlife habitat in Sullivan County and the availability of similar habitat in the general area, the Proposed Action would generally have a minimal impact on the region's wildlife. Mobile species, such as most birds and larger mammals, would be expected to move out of the project area once construction activities commence. The site would diversify the available habitat for many species by providing a reliable source of water, even in drought conditions. The open water habitat and flooded timber would provide feeding and roosting habitat for waterfowl, shorebirds, and bald and golden eagles that migrate through the area. The construction of the project would be done in compliance with the MBTA and the BGEPA.

INVASIVE SPECIES

Because of the change in land use from private, agricultural land to public, recreational land, invasive species have the potential to colonize the project area. The public aspect of the land use

change allows invasive species to be transferred from different geographic areas through public use. The recreational project purpose that includes boating and fishing could introduce aquatic invasive species including zebra mussels, hydrilla, and invasive fishes. Additionally, the upland land cover could be susceptible to colonization of invasive trees and shrubs, land invertebrates, forbs, and mammals. Invasive species currently present within the Project area include:

- Common carp (*Cyprinus carpio)*
- Sericea lespedeza (*Lespedeza cuneata*)
- Musk thistle (*Carduus nutans*)
- Reed canarygrass (*Phalaris arundinacea)*
- Multiflora rose (*Rosa multiflora)*
- Japanese honeysuckle (*Lonicera japonica)*
- Tall fescue (*Festuca arundinacea)*
- White sweet clover (*Melilotus albus)*
- Yellow sweet clover (*Melilotus officinale)*

Invasive species problematic to Missouri include the following species (MDC 2020):

Fishes		**Forbs and Grasses**	
Bighead Carp	*Hypophthalmichthys nobilis*	Canada Thistle	*Cirsium arvense*
Black Carp	*Mylopharyngodon piceus*	Chinese Yam	*Dioscorea oppositifolia*
Grass Carp	*Ctenopharyngodon Idella*	Crown Vetch	*Securigera varia*
Common Carp	*Cyprinus carpio*	Japanese Knotweed	*Fallopia japonica*
Silver Carp	*Hypophthalmichthys molitrix*	Johnson Grass	*Sorghum halepense*
Snakehead Carp	*Channa* spp.	Leafy Spurge	*Euphorbia esula*
Land Invertebrates		Reed Canarygrass	*Phalaris arundinacea*
Asian Long-horned Beetle	*Anoplophora glabripennis*	Sesbania	*Sesbania herbacea*
Emerald Ash Borer	*Agrilus planipennis*	Tall Fescue	*Festuca arundinacea*
European Wood Wasp	*Sirex noctilio*	White Sweet Clover	*Melilotus albus*
Gypsy Moth	*Lymantria dispar*	Yellow Sweet Clover	*Melilotus officinalis*
Trees and Shrubs		Yellow Bluestem	*Bothriochloa ischaemum*
Autumn Olive	*Elaeagnus umbellata*	Teasel	*Dipsacus fullonum*
Bradford Pear	*Pyrus calleryana*	Spotted Knapweed	*Centaurea stoebe*
Golden Rain Tree	*Koelreuteria paniculata*	Sericea Lespedeza	*Lespedeza cuneata*
Japanese Honeysuckle	*Lonicera japonica*	Purple Loosestrife	*Lythrum salicaria*
Multiflora Rose	*Rosa multiflora*	Musk Thistle	*Carduus nutans*
Tree-of-heaven	*Ailanthus altissima*	Kudzu	*Pueraria montana*
Wintercreeper	*Euonymus fortunei*	Japanese Stiltgrass	*Microstegium vimineum*
Russian Olive	*Elaeagnus angustifolia*	Indian Strawberry	*Duchesnea indica*
Mimosa	*Albizia julibrissin*	Garlic Mustard	*Alliaria petiolata*
Heavenly Bamboo	*Nandina domestica*	Common Reed	*Phragmites australis australis*
Common Buckthorn	*Rhamnus cathartica*	Caucasian Bluestem	*Bothriochloa bladhii*
Bush Honeysuckles	*Lonicera* spp.	**Aquatic Invertebrates**	
Mammals		Zebra Mussel	*Dreissena polymorpha*
Feral Hogs	*Sus scrofa*	Chinese Mystery Snail	*Cipangopaludina chinensis malleata*
Nutria	*Myocastor coypus*	**Aquatic Vegetation**	
		Hydrilla	*Hydrilla verticillata*

3.12 Threatened and Endangered Species

Federally listed threatened and endangered species are protected under the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.). Adverse effects on a federally listed species or its habitat would require consultation with the USFWS under Section 7 of the Endangered Species Act. Section 7 of this act, as amended, requires federal agencies to ensure that actions that they authorize, fund, or carry out are not likely to jeopardize the continued existence of proposed, endangered, or threatened species or result in the destruction or adverse modification of their critical habitat.

3.12.1 Affected Environment

The USFWS generates an Information for Planning and Conservation document that lists federally listed threatened and endangered species for the project area and the MDC Missouri Natural Heritage Program provides state-listed threatened and endangered species for Sullivan County (USFWS 2017, MDC 2017b). Both resources were used for further analysis of potential threatened and endangered species impacts. Table 3.12.1-1 identifies state and federally listed threatened and endangered species that may be located within the project area.

Table 3.12.1-1. Federal- and State-listed Species in Sullivan County.

Common Name	Scientific Name	Status	Habitat
Indiana Bat	*Myotis sodalis*	FE, SE	Migrates from colonial caves to summer roost trees. Summer roost trees are typically large trees, often dead, with exfoliating bark. Roost trees are typically found in riparian zones, bottomland and flood plain habitats, forested wetlands, and upland communities. Foraging habitat typically includes semi-open to closed forest habitat, forest edges, and riparian areas.
Northern Long-eared Bat	*Myotis septentrionalis*	FT	Prefer mature forests for foraging, but they also use open spaces such as small forest clearings, water, and along roads. Summer habitats consist of roost trees of varying sizes and species.
Gray Bat	*Myotis grisescens*	FE	The gray bat inhabits caves year-round and occupies cold hibernating caves in the winter and warm caves during the summer. Maternity colonies are formed on the cave ceilings and range from a few hundred individuals to a few thousand individuals. Summer foraging habitat includes open water of rivers, streams, and lakes or reservoirs.
Plains Spotted Skunk	*Spilogale putorius interrupta*	SE	Found in open grasslands, brushy areas, and cultivated lands. Dens located below ground in grassy banks, rocky crevices, or along fence rows.
Mead's Milkweed	*Asclepias meadii*	FT, SE	Occurs along with dry-mesic to mesic tallgrass virgin prairie or glade/barren habitat.

FE – Federally Endangered
FT – Federally Threatened
SE – State Endangered

The project area is upland pastures and woodland on the steep terrain and crop fields on the flat ground. The upland pastures have been reseeded with and have more than 80 percent establishment of tall fescue. Wooded areas consist of American elm, white oak, burr oak (*Quercus macrocarpa*), black walnut, green ash, and shagbark hickory. There are no critical habitats, wildlife refuges, or fish hatcheries within the project area.

The USFWS provided information stating that the Indiana bat and the Mead's milkweed, which are both federal and state endangered species, may occur in the watershed. Further studies have been conducted to determine the presence of the Indiana bat and Mead's milkweed. In addition, the project area provides potential habitat for the state-listed plains spotted skunk.

Indiana Bat, Gray Bat, and Northern Long-eared Bat

Surveys were conducted to determine the presence of Indiana bat, gray bat, and northern long-eared bat habitat following the USFWS Range-wide Indiana Bat Summer Survey Guidelines (USFWS 2016). The woodland habitat within the reservoir area was divided into nine regions; each survey region is approximately 123 acres in size, per USFWS regulations. Bat survey methodology for the nine regions consisted of acoustic monitoring, mist netting, radio tracking, emergence counts, and bat habitat assessments. The use of multiple survey collection methods ensured that each region was surveyed as thoroughly as possible.

Acoustic surveys were conducted from June 2, 2016 to June 11, 2016, prior to mist netting a given region. Mist net surveys were then completed from June 15, 2016 to July 10, 2016, in locations where the acoustic survey recorded potential Indiana bat calls. During the mist net surveys, radio transmitters were attached to pregnant or lactating female bats and/or appropriately sized juveniles captured in the net to better locate maternity colonies and roost locations. Emergence counts were then conducted at each identified maternity roost and secondary roost. In addition, a total of three bat habitat assessments were completed in each region.

Five of the nine regions had positive Indiana bat detections through both acoustic monitoring and mist netting. These five regions contain approximately 595 acres of woodland habitat. Indiana bats were detected through acoustic surveys in an additional three regions; however, no species were caught during the mist-netting surveys. These three regions contain 463 acres of woodland habitat.

Roost trees were identified for Indiana bats in three regions and maternity roost trees were identified in two regions. The two regions with identified maternity roost trees contain a total of approximately 217 acres of woodland habitat that would be inundated by the Proposed Action. Two additional maternity roost trees were identified just outside the project boundary in a large woodland area. This area would not be affected by the Proposed Action.

Northern long-eared bat species were detected through acoustic monitoring in seven of nine regions. This species was also caught through mist netting in four of the nine regions. No gray bats were detected through acoustic monitoring or caught through mist netting.

Mead's Milkweed

Mead's milkweed surveys were conducted through an initial desktop review and a field verification. The desktop review identified areas that could likely contain Mead's milkweed and eliminated areas that would not provide suitable habitat. Following the desktop review, a field

verification survey was performed during the probable blooming period of the species, from June 14, 2016 to July 7, 2016. The field verification survey did not identify any occurrence of the species within the project area (Olsson 2017).

Plains Spotted Skunk

Based on the NLCD, cropland, hay/pasture, and forested areas exist within the project area. Surveys and habitat assessments have not been done for the plains spotted skunk.

3.12.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impacts on threatened and endangered species.

3.12.3 Direct and Indirect Effects of the Proposed Action

Northern Long-eared Bat

Direct Effects

Direct effects are defined as Project impacts that occur immediately (i.e., injuring or killing northern long-eared bats). Tree clearing activities for all Project elements will occur during the northern long-eared bat hibernation period (November 1 – March 31) and thus minimize direct effects on northern long-eared bats. A reservoir water budget model indicates inundation will occur over a period of 2 to 10 years and the timing cannot be determined ahead of time or controlled. The model shows the reservoir would fill slowly over time and that during the wettest period since 1900, the reservoir would take 1.9 years to fill. Based on the model results, the bats would likely be able to avoid direct impact.

Indirect Effects

Indirect effects are defined as Project impacts that are reasonably certain to occur but occur later in time (i.e., forest loss that reduces maternity roost habitat and causes lower population size). Forest loss and impacts to maternity roosting colonies are the indirect effects further described.

<u>Potential Forest Impacts</u>

The Project will affect northern long-eared bat summer foraging and roosting habitat. The forest loss caused by Project construction and predicted future forest loss would reduce the available forest habitat by 1,341 acres and represents a 0.17 percent forest decline in the 10-county region and a 1.36 percent forest decline in Sullivan County.

<u>Maternity Roosts and Home Range Impacts</u>

Northern long-eared bats were not tracked during the field study and the maternity roost locations are not known. Two lactating northern long-eared bats were captured at the same mist-net site, but in separate nets. Based on the 3-mile range of capture sites, there are assumed to be primary and alternative maternity roost trees nearby or affected by the Project elements.

Within the 3-mile home range, there are 5,727 forest acres and 1,013 forest acres affected by Project elements. This represents a loss of 18 percent of the northern long-eared bat colony's forested home range.

Loss of Individuals and Reduction in Population Size

The loss of roosting and foraging habitat could result in lower fecundity (reproductively) or lower survivorship. The loss of roosting and foraging habitat would require northern long-eared bats to find alternative maternity roosts and foraging areas. Depending on the populations' health following hibernation, the energy requirements to find alternative maternity roosting and foraging habitat could result in lower fecundity or survivorship of the existing population. Emergence counts were not conducted for northern long-eared bats, so population estimates are not available within the Project area.

Winter Habitat

Northern long-eared bat winter habitat consists of large hibernacula. Because of the increased presence of white-nose syndrome (WNS), hibernacula have become of primary interest for northern long-eared bat conservation efforts. The closest winter habitat is in Howard County, placing the 10-county region outside winter habitat.

Conservation

The forest planting and preserving and associated permanent conservation easements would occur on 683 acres for forest preservation and 553 acres for forest tree planting. Permanent conservation easements would be established on 1,236 acres of tree planting and forest preservation. Within the 3-mile buffer there are 1,013 forest acres affected that equals 18 percent of the total forest. Tree plantings within the 3-mile buffer total 201 acres and tree preservation totals 496 acres. The tree plantings and preservation total 697 acres and equal 69 percent of the forest loss in the 3-mile buffer.

Additional conservation will occur through the stream and wetland mitigation and by the zoning in the High Impact Zone. The High Impact Zone is a 500-foot buffer around land owned by the NCMRWC that will have restricted tree clearing in riparian areas. The wetland mitigation will include a minimum of 79 acres of PFO wetland and the High Impact Zone will include 50 acres of forest preservation.

Indiana Bat

Direct Effects

Direct effects are defined as Project impacts that result in direct injury to or killing Indiana bats. Tree clearing activities for all Project elements will occur during the Indiana bat hibernation period (November 1 – March 31) and thus have no direct effects on Indiana bats. Inundation will occur over a period of 2 to 10 years and the timing cannot be determined or controlled. The reservoir would fill slowly over time and the bats would be able to avoid direct impact.

Indirect Effects

Maternity Roost Impacts

The 2017 East Locust Creek Bat Survey Report (Olsson 2017) documented the capture of 10 Indiana bats within the normal pool. The Indiana bats were tracked back to their maternity roost trees and their maternity roost trees were classified by their emergence counts as primary (more than five bats observed) and alternative (five or fewer bats observed). Two Indiana bats were tracked to four primary maternity roost trees within or near the Project area. Two of the primary

maternity roosts were located within the normal pool. Additionally, there were nine alternative maternity roost trees identified with three alternative maternity roost trees in the normal pool. The two primary maternity roost trees and three alternative maternity roost trees within the normal pool would be inundated by the Project and would no longer provide roost tree habitat. To avoid inundation during the maternity roosting period, the trees would be cut down during the November 1 to March 31 hibernation period.

Potential Forest Impacts

The Project will affect Indiana bat summer foraging and roosting habitat. The forest loss caused by Project construction and predicted future forest loss would reduce the available forest habitat by 1,341 acres and represents a 0.17 percent forest decline in the 10-county region and a 1.36 percent forest decline in Sullivan County.

Home Range Impacts

Project elements would result in the loss of approximately 1,341 acres within the 10-county region. Forest loss within the home range of Laela's and Sushi's (names given to captured Indiana bats) maternity roost trees include 1,039 acres. There are 6,611 total forested acres within Laela's and Sushi's 2.5-mile home range, with 92 acres of overlap. The loss of 1,039 acres represents 16 percent of the total forested acres in the two bats' home ranges. Laela's home range has 3,778 forested acres and Sushi's home range has 2,925 forested acres. For Laela, the loss of 813 forested acres represents 22 percent of the forested home range, and for Sushi, the loss of 226 forested acres represents 8 percent of the forested home range.

Forest impacts within the 2.5-mile colony forest buffer would be partially offset by tree planting and tree preservation. There are 1,236 acres of tree plantings and tree preservation within Laela's and Sushi's home ranges. There are 179 acres of tree plantings planned for Laela's home range, which equals 21 percent of the forest impacts. There are 301 acres of tree plantings planned for Sushi's home range, which equals 130 percent of the forest impacts. All tree plantings would result in a temporal loss, which includes the amount of time required for a tree planting to fully replace the forest loss. The temporal loss is estimated at 15 to 30 years for tree plantings to establish and provide roosting and foraging habitat.

Loss of Individuals and Reduction in Population Size

The loss of roosting and foraging habitat could result in lower fecundity or lower survivorship. The loss of roosting and foraging habitat would require Indiana bats to find alternative maternity roosts and foraging areas. Depending on the populations' health following hibernation, the energy requirements to find alternative maternity roosting and foraging habitat could result in lower fecundity or survivorship of the existing population.

The existing Indiana bat population size, based on the emergence counts, is estimated to be two colonies of 31 and 40 individuals. The colonies are likely slightly larger because of individual Indiana bats roosting in alternative maternity roost trees.

Winter Habitat

Indiana bat winter habitat consists of large hibernacula. Because of the increased presence of WNS, hibernacula have become of primary interest for Indiana bat conservation efforts. There are no known Indiana bat hibernacula within the 10-county region.

Conservation

The forest planting and preserving and associated permanent conservation easements would occur on 683 acres for forest preservation and 553 acres for forest tree planting. Permanent conservation easements would be established on 1,236 acres of tree planting and forest preservation. Forest preservation and planting within the 2.5-mile buffers total 1,202 acres, and the forest loss within the 2.5-mile buffers totals 1,039 forest acres.

Additional conservation will occur through the stream and wetland mitigation and by the zoning in the High Impact Zone. The wetland mitigation will include a minimum of 79 acres of PFO wetland and the High Impact Zone will include 50 acres of forest preservation.

Mead's Milkweed

There are approximately 452 grassland acres at 58 sites within the East Locust Creek normal pool. Native vegetation is present at four of the 58 sites and totals 18.7 acres. The native vegetation indicates the sites may provide potential Mead's milkweed habitat that includes virgin, tallgrass prairies that is managed for light grazing and hay production. The four sites were traversed for 30 minutes, but no Mead's milkweed ramets were identified.

The Project elements will affect 1,236 grassland acres in Sullivan County. All grassland impacts outside Sullivan County will be temporary; however, temporary impacts could have permanent impacts on Mead's milkweed habitat. The impacts outside Sullivan County are anticipated to occur on existing utility corridors that would not provide habitat for Mead's milkweed because the utility corridors would have already been disturbed. Because Mead's milkweed has not been documented within the Project area, the proposed Project will have no effect on Mead's milkweed.

Plains Spotted Skunk

Species impacts are unknown. The MDC has produced a list of BMPs to use during project construction, and these will be followed (MDC 2015b). The BMPs are as follows:

- Limit the use of pesticides and herbicides.
- Avoid burning or clearing fence rows, brush piles, and downed logs or trees where skunks may be present, especially during the late spring and summer months when young skunks may be in dens.
- Where skunks are unwanted, remove scrap lumber piles, haystacks, and unused farm machinery to eliminate potential skunk habitat.

3.13 Economic and Social Resources

Issues to be considered include such items as permanent or temporary changes or impacts on travel patterns or accessibility; school districts or their operations (busing); recreational facilities; police and fire services; highway safety; impacts on businesses; and impacts related to the available water supply of the 10-county region.

3.13.1 Affected Environment

The 10-county region is comprised of communities that fit the MDNR definition of a disadvantaged community, which is defined as "a community with a population less than 3,300, whose [water] user rates will be at or above 2 percent of the state median household income, and the

community's median household income is at or below 75 percent of the state average median household income" (NCMRWC 2013).

As reported by the MDED, the 10-county region had a labor force of 48,373 as of May 2017. Unemployment in the region was 2,017 (4.2 percent) that year, compared to 4.1 percent both statewide and nationally (MDED 2015). The region's 10-county 2015 median household income averaged approximately $38,895. Median household income in 2015 for Missouri was $48,173, while the 2015 U.S. median household income was $56,277 (U.S. Census 2015).

The lack of available and sustainable water sources in the region is a significant factor leading to the region having some of the highest water rates in the state. Counties in the 10-county region all display water rates that equal or exceed 1 percent of the median household income. The region includes three counties that display water rates that equal or exceed 2 percent of the median household income, which is the highest percentage category recorded (NCMRWC 2013).

3.13.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would not provide a dependable long-term water supply and therefore would not meet a projected 100-year demand for the 10-county region. The No Action alternative would also lead to a continuation of the need for water by rural businesses, which could result in businesses closing or moving elsewhere (Section 1.5.1).

3.13.3 Direct and Indirect Effects of the Proposed Action

The Proposed Action would supplement or replace the existing water supply for the 10-county region. The new water supply system would be an economically efficient, regional, sustainable, long-term water supply. A reliable water supply could increase business development, diversify the economic base of the region, and increase jobs available in the region. Increased recreational opportunities could also contribute to economic stability (NCMRWC 2013). The Proposed Action is also expected to reduce flood damage by approximately $86,800 annually (Section 2.2.3).

According to MDNR (2015), "the value-added contribution to the regional economy due to East Locust Creek Reservoir is $118.5 million". The Proposed Action is estimated to support 1,144 jobs paying 26.3 million annually. Approximately 550 jobs would be short-term and related to project construction activities (MDNR 2015).

The Proposed Action would be built with minimal disruption to the traveling public. Traffic would be maintained on the existing Missouri Highway 5, Missouri Highway M, Missouri Highway B, and Missouri Highway Y. School and emergency service routes, truck delivery for manufacturing and businesses, traffic transporting goods and services, and general traffic would be minimally inconvenienced during construction equipment movements and material deliveries. Lane closures may be necessary to accommodate specific construction activities/phases. These activities could include delivery of materials, equipment mobilization, and the construction of tie-ins and cross-overs and would be temporary.

The Proposed Action would close Missouri Highway N for approximately 0.86 mile. Approximately 2.46 miles of local road would also be inundated and approximately 1.2 miles of local road would be elevated to keep the road open. A midlake infrastructure crossing is planned that would carry roads and utilities across the center portion of the Proposed Action.

Project construction activities may lead to short-term impacts. These impacts typically include such things as construction noise, traffic accommodations during construction activities, access to adjoining properties, and construction accommodations needed to build the project. No long-term noise impacts are anticipated. Noise associated with heavy equipment is common in the agricultural region during planting and harvest periods. An increase in recreational opportunity within the area may result in an increase of visitors; however, traffic and noise associated with recreation would be incremental and seasonal in nature.

Some field and residential drives would be temporarily affected during construction and during necessary regrading or realigning of drive approaches.

3.14 Recreation and Visual Resources

3.14.1 Affected Environment

The 10-county region has an unmet demand of 1,226,859 user-days for fishing and boating water-based recreation (Purpose and Need, Section 1.5). Supply and demand data were used to quantify the need for water-based recreation. Results were incorporated in this report as part of Section 2.3, Recreation Alternatives Analysis. The analysis used a population within the 10-county region surrounding the proposed East Locust Creek reservoir site.

No federal, state, or locally designated visual resources of significance, such as scenic highways or National Wild and Scenic Rivers, and no historic properties that would have a viewscape within the vicinity of the project.

3.14.2 Direct and Indirect Effects of the No Action Alternative

No significant change in the amount of public or private recreational area is expected with the No Action alternative. The community's desire for additional recreational development would not be addressed.

3.14.3 Direct and Indirect Effects of the Proposed Action

Development of the Proposed Action and recreational facilities would provide much-needed opportunities for fishing and boating recreation. The reservoir would supply approximately 91,956 annual user-days for fishing and boating. Recreational facilities and fish and wildlife habitat development would include facilities such as a boat ramp, parking facilities, restroom facilities, a hiking trail, a shelter house, a fishing pier (platform), and tree, shrub, and other vegetative plantings. Hunting or trapping may also be available if the sponsors determine those activities would be allowed.

The existing visual resources associated with the project area would change incrementally, but they would be consistent with the existing land use. Construction and operational visual impacts would be limited to the project boundaries.

3.15 Public Safety and Hazardous Materials

Hazardous materials are defined as substances that because of their quantity, concentration, or physical, chemical, or infectious characteristics may present an imminent threat to public health or the environment if released. Solid wastes are designated as hazardous if they are corrosive,

ignitable, explosive, chemically reactive, or toxic, as defined in 40 CFR 261, Subpart C. The EPA and other federal and state agencies regulate hazardous materials under the Toxic Substances Control Act; Comprehensive Environmental Response, Compensation, and Liability Act; Resource Conservation and Recovery Act (RCRA); Superfund Amendments and Reauthorization Act; and Emergency Planning and Community Right-to-Know Act. RCRA gives the EPA the authority to control hazardous waste from the "cradle to grave." RCRA controls the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also sets forth a framework for the management of nonhazardous solid wastes. Amendments to RCRA in 1986 enabled the EPA to address environmental problems that could result from underground storage tanks containing petroleum and other hazardous substances. Hazardous wastes are regulated through the MDNR.

The MDNR Brownfields Voluntary Cleanup Program (BVCP) was first established in 1994 and is administered by the MDNR Hazardous Waste Program's BVCP Section to provide oversight for voluntary cleanups of properties contaminated with hazardous substances. Property owners, business operators, or prospective buyers initiate cleanup to reach standards acceptable to the state and receive certification of the cleanup from MDNR (MDNR 2017b).

3.15.1 Affected Environment

The Proposed Action is located in a rural section of Sullivan County, in an area largely comprised of agricultural land. The City of Milan is located approximately 5 miles south of the project site, and Missouri Highway 5 is directly west of the Proposed Action. MDNR's *Hazardous Substance Site Locator Map* was used to identify parcels of land within the project area that are possible hazardous substance investigation or cleanup sites (MDNR 2017c). Between February 2012 and August 2016, 25 separate investigations of these parcels, including Phase I ESAs, Phase II ESAs, and Brownfields Targeted Assessments, have been conducted on these properties to more fully characterize their potential environmental impacts. All hazardous material reports are available on the NCMRWC website (NCMRWC 2017).

The February 23, 2012, Phase I ESA Report, *East Locust Creek Phase IA Property Acquisitions* (Olsson 2012a), and the subsequent Limited Phase II ESA report, dated April 23, 2012 (Olsson 2012c), produced for the NCMRWC, are summarized here. The Phase I ESA report identified nine RECs that warranted further investigation. The Phase II ESA report presented information concerning the detection of arsenic and lead in soils above State of Missouri Risk-Based Corrective Action (MRBCA) default target levels (DTLs), but below residential risk-based threshold levels, which are based on the groundwater pathway for exposure under a residential land use scenario. The report also described how concentrations of arsenic and lead in soils were within the margins of concentrations normally found in soils. The Phase II ESA report concluded "results of the field observations and laboratory analyses are that the soils underlying the evaluated portions of the assessment properties have not been affected by contaminants."

An additional report, the June 19, 2012, Phase I ESA Report, *East Locust Creek Round 2 Property Acquisitions* (Olsson 2012b), identified no additional RECs for these properties.

Between August 2012 and August 2016, Tetra Tech Inc. (Tetra Tech) completed 11 additional Phase 1 Targeted Brownfields Assessments (the equivalent of a Phase I ESA), and 11 subsequent Phase II Targeted Brownfields Assessments (the equivalent of a Phase II ESA).

These reports can be found on the NCMRWC website (NCMRWC 2017). According to the analytical data contained in these reports, arsenic, barium, chromium, mercury, motor oil, and lead were detected in the soil at several different locations. However, the reported concentrations of barium, chromium, mercury, and motor oil were all below MRBCA DTLs. Arsenic and lead were reported at all locations in concentrations above their respective screening DTLs, but in most locations, below the MRBCA Tier 1 risk-based threshold levels (RBTLs) established for nonresidential land use. The arsenic and lead concentrations in most of the soil samples were also determined to be within the range of “normal” background concentrations for these metals in native soils in Sullivan County, as published in 2013 by the USGS (USGS 2013). Thirteen soil samples collected by Tetra Tech along the former Chicago Burlington & Quincy (CB&Q) railroad corridor consistently exhibited arsenic concentrations exceeding all MRBCA RBTLs and in concentrations generally greater than the average background soil arsenic concentrations in Sullivan County. These 13 samples had a mean arsenic concentration of 46.74 mg/kg, compared with the USGS average background arsenic concentration of 8.469 mg/kg.

Of the contaminants identified, the only one present at a high enough concentration to suggest a need for further investigation is arsenic that is located along the former CB&Q rail line. Additional arsenic investigation of the rail line was completed in 2017. Arsenic was again identified at concentrations above residential risk-based standards; however, no concentrations were detected at high enough levels to negatively affect water quality in the Proposed Action. A memo describing the arsenic concentrations is included in Appendix B.

Other contaminants detected in notable concentrations include lead and various compounds in the category of semivolatile organic compounds. For example, one soil sample collected at a former residence was reported to contain lead at a concentration of 9,100 mg/kg. The sample location was identified as 2E05-REC-1, a location reported to be within the “drip zone” of the house, and therefore likely the result of lead-based paint. However, because the property is located outside the inundation zone of the proposed reservoir, this detection is not considered to be a REC relevant to this study. These other contaminants detected within the normal pool are highly localized and are therefore not expected to negatively affect water quality in the proposed reservoir. Additionally, these localized impacts are all associated with existing structures within the normal pool and are expected to be mitigated as structures are demolished prior to construction of the proposed reservoir, further reducing any potential impacts to water quality.

Samples collected by Tetra Tech at some locations were reported to contain slightly elevated concentrations of semivolatile organic compounds, such as benzo(a)pyrene, benzo(b)flouranthene, and dibenzo(a,H)anthracene. Some of these samples were collected from isolated locations such as adjacent to former trash-burning locations; more commonly, however, they were collected along the former CB&Q railroad corridor. Reported concentrations for these contaminants are slightly greater than their respective MRBCA Tier 1 RBTLs for residential soils in nearly all instances. Such compounds are commonly attributed to burned wood products and are also often associated with wood preservatives, such as would be found in railroad ties. These compounds are slow to degrade, they adhere very tightly to soil and organic particles, and generally have low solubility constants, which means they don’t easily dissolve into water. Because of these characteristics, they are very immobile in the environment and therefore not prone to migration.

3.15.2 Direct and Indirect Effects of the No Action Alternative

Under the No Action alternative, arsenic contamination along the CB&Q railroad corridor that exceeds MRBCA RBTLs would remain in the soil. No impacts to public safety are anticipated to occur and no change in hazardous materials would occur.

3.15.3 Direct and Indirect Effects of the Proposed Action

Based on the assessment reports, arsenic appears to be the only contaminant of concern for properties within the proposed East Locust Creek reservoir inundation zone. The former CB&Q railroad corridor, which is the location of all 13 samples with elevated arsenic concentrations, extends through much of the proposed inundation zone. Likely sources of the arsenic found in these samples is railroad ties treated with chromated copper arsenate or arsenic-based herbicides that may have been used to control weed growth along the tracks. As the railroad ties have degraded over time, it is possible that arsenic may have leached into the soil.

In addition to potential arsenic contamination along the CB&Q railroad corridor, other hazardous material impacts identified in the 25 previously conducted environmental assessments include the presence of asbestos-containing materials and household hazardous wastes (HHW) in some now-vacant structures within the project area. Identified affected properties have been enrolled in MDNR's BVCP to address the contamination. Asbestos abatement has included the removal of floor tile with associated mastic, ceiling texture, and window caulk from these structures. The HHW has been or is scheduled to be packaged and transported off-site for proper disposal.

It is unlikely any hazardous materials would be generated by construction or operation of the Proposed Action. Asbestos and HHW concerns within the project area have been or are currently being addressed through the MDNR BVCP. If any additional hazardous materials are identified during construction, appropriate agencies would be notified.

No potential water quality concerns or hazardous materials issues are expected to result from the Proposed Action. There would be no impacts to public health from implementation of the Proposed Action.

3.16 Air Quality and Noise

The Clean Air Act (CAA) was enacted in 1970 to control air pollution on a national level. The CAA identified six common air pollutants of concern (criteria pollutants): carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_x), and sulfur dioxide (SO_2). National air quality standards define allowable concentrations of criteria pollutants in ambient air (EPA 2018a).

3.16.1 Affected Environment

Most of the Proposed Action is in a rural environment with agricultural land uses. No noise-sensitive areas (residences, commercial properties, or industry) exist in the immediate vicinity of the Proposed Action. Highway traffic influences ambient noise levels in these rural areas. Milan, Missouri, is south of the project area and has a variety of land uses that influence ambient noise, including industrial and residential.

3.16.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no noise impacts.

3.16.3 Direct and Indirect Effects of the Proposed Action

Implementation and operation of the Proposed Action would result in emissions associated with personnel transport vehicles, visitor vehicles, and recreational activities. Visitor vehicle traffic and recreational activities would be seasonal and would vary day to day. Operational emissions would result in an incremental increase in criteria pollutants; however, Sullivan County is currently in attainment for all criteria pollutants (EPA 2018b). The Proposed Action would result in marginal impact to air quality; therefore, this issue was eliminated from further study.

Construction of the Proposed Action would result in temporary emissions of criteria air pollutants and fugitive dust as a result of soil disturbance and the use of on-site construction equipment. Additionally, emissions of criteria pollutants would result from off-site trucks hauling water and construction materials to the project site. Construction emissions can vary substantially from day to day, depending on the level of activity and the specific type of operation and with regard to dust, the prevailing weather conditions (i.e., wind conditions). Fugitive dust ($PM_{2.5}$) emissions would primarily result from site preparation and road construction activities. NOx and CO emissions would primarily result from the use of construction equipment and motor vehicles. Construction is anticipated to commence June 2019 and would require approximately 15 months to complete.

Prior to commencement of construction activities, a construction permit must be obtained from the Missouri Department of Natural Resources, Air Pollution Control Program. Construction activities would be subject to several control measures per the requirements of the Missouri Air Conservation Commission.

3.17 Cultural Resources

Section 106 of the National Historic Preservation Act (NHPA), as amended, and implementing regulations found at 36 CFR Part 800, require that federal agencies consider any effect a Proposed Action may have on historic properties. This is accomplished through the Section 106 compliance process, which are the following:

- Identify consulting parties.
- Identify and evaluate historic properties located within the Area of Potential Effect established for an undertaking.
- Assess adverse effects on properties that are listed, or are eligible for listing, on the National Register of Historic Places (NRHP).
- Consult with the State Historic Preservation Officer, federally recognized Indian tribes, and, as appropriate, the Advisory Council on Historic Preservation and other interested parties to resolve adverse effects.

Cultural resources include archaeological sites, historic properties, traditional culture places, and other places where significant historic activities have taken place. These sites are often

considered valuable to the human environment, and measures must be taken to ensure they are treated appropriately.

Congress passed the American Indian Religious Freedom Act of 1978 (PL 95-341) to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise their traditional religions including, but not limited to, access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional sites. The law requires that the effects of a federal undertaking on Native American sites or places (prehistoric or historic) that have religious, ceremonial, or sacred aspects be evaluated within the context of this law.

3.17.1 Affected Environment

The Proposed Action is located in a rural section of Sullivan County in an area largely comprised of agricultural land. The city of Milan is located approximately 5 miles south of the project area, and Missouri Highway 5 is directly west of the Proposed Action.

Archaeological evidence shows that humans have occupied the Sullivan County area for at least the last 10,000 years. Previously recorded sites in the watershed vary in age from Archaic through Euro-American. One highly eroded lithic scatter site suggests a Mississippian/Oneota component. Two lithic scatters suggest Woodland materials. The rest were lithic scatters listed as unknown prehistoric. The first Euro-American settlement in the project area began in the 1830s. Sullivan County was organized in 1845, with a county seat at Milan. Other 19th-century settlements in the watershed include the towns of Pollock, Boynton, and Cora (NRCS 2006).

The NRHP lists six sites in Sullivan County. Four of the sites are buildings within either Green City or Milan. The other two listings are located outside the project area (NPS 2014).

3.17.2 Direct and Indirect Effects of the No Action Alternative

The No Action alternative would have no impact to cultural resources.

3.17.3 Direct and Indirect Effects of the Proposed Action

<u>2006 Cultural Resources Survey</u>

A Phase I cultural resource survey was completed in October and November 2006. The NRHP does not list any historic sites within the project area; however, one cemetery is adjacent to the project area (NPS 2014). Construction of the Proposed Action would avoid this cemetery and the cemetery is in an upland location; therefore, there would be no impacts to the cemetery as a result. The survey identified eight previously unreported prehistoric open habitation sites and relocated four of five previously recorded sites; the fifth site was not found. All thirteen of these prehistoric sites contained very low-density lithic materials and appeared to be located within disturbed, plowed land. The sites do not meet any NRHP criteria and it was recommended that none be considered for NRHP status. Additional historic resources found during the investigation include the town of Boynton, railroad bridges and bridge remnants, a sandstone quarry, a church building, and farmstead remnants. The church building will be relocated to a public access area. None of the historic resources meet NRHP eligibility criteria. The survey produced no evidence of the presence or previously reported possibly significant cultural resources within the project area.

2020 Cultural Resources Survey

The cultural resource survey was updated in 2020 and included additional field surveys. The updated cultural resource investigations for the proposed East Locust Creek Reservoir resulted in the recording of 86 cultural resources. These consisted of four properties with standing architecture, nine road bridges, four road culverts, 17 previously recorded archaeological sites (recorded in previous 2006 cultural resources survey), 34 newly discovered archaeological sites, and 18 isolated finds. One of the sites represented the remains of the Burlington and Southwestern Railroad (originally Chicago, Burlington, and Kansas City Railroad), which included the additional recording of the railroad berm, 17 bridges, two culverts, and two rail yards with remains of depots, located in the communities of Boynton and Pollack.

According to the SHPO, there are eight sites were eligible for the NRHP, including the railroad, seven farmsteads, two habitations, the city of Boynton, and glyphs.

2020 BUILD Roads Cultural Resources Survey

The East Locust Creek Reservoir cultural resource survey for the proposed road improvements recorded 35 properties with at least one building over 40 years old (constructed prior to 1981). These buildings are within 200 feet of the proposed road center line and may be affected by indirect impacts. MoDOT and SHPO are determining if any of these buildings are eligible for the NRHP. Also, within the viewshed, there are four cemeteries: Mt. Zion, Hamilton-Gridstaff, Campbell, and Pollack. A previously unknown family plot, the Bingham family plot, was identified just south of Route N. The Bingham family plot is within the proposed construction corridor but will not be impacted by the proposed road improvements. In addition to the Bingham family plot, the survey resulted in the identification of six other previously unknown archaeological sites: two Precontact camp sites, three farmsteads, and the Fairview School.

3.18 Environmental Justice

President Clinton signed Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, in 1994. This EO focuses the attention of federal agencies on human health and environmental conditions in minority communities and low-income communities. Environmental justice analyses are performed to identify the potential for disproportionately high and adverse impacts on minority and low-income populations from Proposed Actions and to identify alternatives that might mitigate these impacts.

The analysis of environmental justice impacts relies primarily on 1997 definitions: Low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the U.S. Census Bureau's current population reports. Minority individuals are defined as members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. A minority population should be identified where either (a) the minority population of the affected area exceeds 50 percent; or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis (CEQ 1997). Note that the 2000 census updated minority definitions to include the following: Black or African

American; American Indian or Alaska Native; Asian; Native Hawaiian or Other Pacific Islander; some other race; and two or more races (U.S. Census 2000).

Minority populations included in the census are identified as Black or African American; American Indian and Alaska native; Asian; native Hawaiian and other Pacific Islander; some other race; and two or more races. Hispanic or Latino populations, which can be of any race, are also considered. Poverty status, used in this SEIS to define low-income status, is reported as the number of people with income below the poverty level. The 2010 census defines the poverty level as a weighted average annual threshold of $11,139 or less for an individual and a weighted average of $22,314 or less for a family of four (U.S. Census 2010). The poverty-weighted average annual threshold for a family of four in 2015 was $24,257 (U.S. Census 2015). However, demographics and income data from the 2010 Census of Population and Housing were used for portions of this analysis. Data from the 2000 census and the 2010 census are the latest reliable and consistent data regarding the ethnic composition and poverty status of the population, especially for subcounty divisions such as towns. Later estimates from various sources may use different methodologies and do not provide accurate comparisons.

These definitions and assessment methodologies follow the Council on Environmental Quality's Environmental Justice Guidance under NEPA (CEQ 1997).

3.18.1 Affected Environment

The 10-county region consists largely of agricultural and/or rural land. According to the 2010 census, the population density of the 10-county region averages 19.04 persons per square mile. Several communities are located within the region; the largest is Kirksville (2010 population 17,505), which is located in the southwestern portion of the region in Adair County (U.S. Census 2010).

According to the U.S. Census Bureau's 2010 data, the population of the region is 107,130. The population over 65 years of age in the region is an average of 18.9 percent, compared to 13.7 percent for the state of Missouri and 12.7 percent for the nation. The region's population is approximately 96 percent white, 1.5 percent Black or African American, 0.6 percent Asian, 0.2 percent American Indian or Alaska Native, 0.1 percent Native Hawaiian and other Pacific Islander, 0.4 percent some other race, and 1.2 percent two or more races. This is compared to Missouri's population, which is approximately 83 percent white, 11.5 percent Black or African American, 0.4 percent American Indian or Alaska Native, 1.6 percent Asian, 0.09 percent Native Hawaiian and other Pacific Islander, 1.0 percent some other race, and 2.1 percent two or more races. The Hispanic population comprises 2.4 percent of the 10-county region. The Hispanic population of Missouri is 3.5 percent of the total population.

The U.S. Census 2010 data indicates that an average of 18.0 percent of individuals in the 10-county region are below the poverty level and an average of 13.7 percent of all families of three to four persons are below the poverty level. This is compared to 13.9 percent of individuals and 11.1 percent of all families in the state of Missouri and 13.8 percent of individuals and 10.6 percent of families in the nation (U.S. Census 2010). Though not as consistent as the 2010 census data, 2015 data shows that an average of 19.02 percent of individuals in the 10-county region and an average of 13.3 percent of families are below the poverty level, compared to 15.6

percent of individuals and 12 percent of families in Missouri and 15.5 percent of individuals and 12 percent of families in the nation.

3.18.2 Direct and Indirect Effects of the No Action Alternative

Because the 10-county region consistently has a higher percentage of population below the poverty level as compared to the state and the national data and has a high cost of water because of limited water supply, the No Action alternative would not benefit minority or low-income populations.

3.18.3 Direct and Indirect Effects of the Proposed Action

There are no anticipated environmental justice factors that would influence major changes in land use or result in disproportionately adverse impacts to minority or low-income populations. In fact, the Proposed Action would provide a reliable water supply to an area that is considered economically disadvantaged. The selection of the lowest cost alternative benefits the population by generating the lowest possible water costs.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

4.0 Cumulative and Growth-inducing Effects

4.1 Cumulative Effects Boundaries

The cumulative effects boundaries include effects from the Proposed Action in the past, current, and reasonably foreseeable future in the Project vicinity.

4.2 Past, Present, and Reasonably Foreseeable Future Projects

4.2.1 Other Federal Project Activities

No additional federal projects are in the foreseeable future.

4.2.2 Other Local Projects

The water treatment plant located in Milan would be used for the foreseeable future. It is likely that an addition to the treatment plant or a new treatment plant and water distribution lines would be required during the 100-year life of the reservoir. In addition, the village of Pollock wastewater treatment facility plans to extend sewer lines to the Milan wastewater treatment plant. Conceptual designs have not been completed for recreational facilities. No new known business or residential developments have been planned or platted in the project vicinity.

4.3 Cumulative Effects Analysis

Note that direct and indirect impacts were addressed for each resource in Chapter 3. This section addresses cumulative impacts because of known past and foreseeable future private or public projects.

4.3.1 Climatology

The completion of foreseeable future projects would not have a cumulative impact on the climate of the East Locust Creek watershed, Sullivan County, or the 10-county region.

4.3.2 Land Use

4.3.2.1 Farmland Resources

The Proposed Action, including adjacent recreational areas, would affect approximately 273 acres of cropland and approximately 1,078 acres of pastureland through inundation or construction of the dam. Some of the affected agricultural land acres are designated as USDA prime farmland. Although no planned or platted developments are currently proposed, the development of the lake may lead to an additional loss of farmland if development occurs. However, it is anticipated that these impacts cumulatively would be very small percentages of the total amount of prime and statewide important farmland in Sullivan County.

4.3.2.2 Forest/Woodland Resources

Past forest changes include expansion of deciduous forest into upland areas as prairie fires were controlled and clearing of forest areas for fuel, particularly during the Great Depression of the 1930s.

Based on soils types, the 10-county region historically consists of 72 percent rangeland and 27 percent forest ecological site types, with the remaining areas consisting of water or undefined areas. NRCS mapped the ecological sites based on the region's soil types, and the ecological sites were determined by historical data, professional experience, field reviews, and scientific studies (NRCS 2015). The primary ecological sites comprise 62 percent of the 10-county region and include Till Upland Savanna (23 percent), Loess Upland Prairie (12 percent), Till Backslope Savanna (11 percent), Wet Floodplain Prairie (8 percent), and Till Protected Backslope Forest (8 percent). The remaining 43 ecological sites comprise 37 percent of the 10-county region (Table 4.3.2.2-1).

Table 4.3.2.2-1. 10-county Region Ecological Sites.

Ecological Site	Acres	Percent of 10-county Region
43 Remaining Ecological Sites Combined	1,362,271	37
Till Upland Savanna	821,398	23
Loess Upland Prairie	420,636	12
Till Backslope Savanna	391,287	11
Till Protected Backslope Forest	301,435	8
Wet Floodplain Prairie	288,998	8
Water	34,928	1
Ecological Site Undefined	14,569	n/a[1]
TOTAL ACRES	**3,635,522**	**100**

[1] Less than 1 percent
Source: NRCS 2015

Sullivan County has a similar, but more focused composition of ecological sites than the 10-county region. Based on soil types, Sullivan County consists of 67 percent rangeland and 32 percent forestland, with the remaining areas consisting of water and undefined areas. The primary ecological sites comprise 65 percent of Sullivan County and include Till Upland Savanna (41 percent), Till Backslope Savanna (13 percent), and Till Protected Backslope Forest (12 percent). The remaining 19 ecological sites comprise 34 percent of Sullivan County (Table 4.3.2.2-2).

Table 4.3.2.2-2. Sullivan County Ecological Sites.

Ecological Site	Acres	Percent of Sullivan County
Till Upland Savanna	170,384	41
19 Remaining Ecological Sites Combined	142,565	34
Till Backslope Savanna	51,944	13
Till Protected Backslope Forest	49,949	12
Water	1,682	n/a[1]
Ecological Site Undefined	412	n/a[1]
TOTAL ACRES	**416,936**	**100**

[1] Less than 1 percent
Source: NRCS 2015

Foreseeable future projects could affect forest resources for construction of distribution pipelines or the water treatment plant. Recreational facilities would generally avoid forest resources to the extent feasible because forest resources are valuable and aesthetically pleasing for recreational

activities. Relocation of some existing roads and utilities could result in small amounts of tree clearing. If residences are built nearby, some small amount of tree removal could result.

The NLCD shows the current land cover in the 10-county region by examining spectral changes in aerial images (Homer et al. 2015). Land cover in the 10-county region and in Sullivan County is primarily cultivated crops, forest, and hay/pasture/herbaceous. The primary differences between the 10-county region and Sullivan County on a relative basis is in the cultivated crops and hay/pasture/herbaceous land. Sullivan County has 14 percent less land that is cultivated crops and 13 percent more hay/pasture/herbaceous land. The remaining land covers are generally consistent with the next largest difference on a relative basis occurring between forest land covers (4 percent difference). The NLCD is summarized for the 10-county region in Table 4.3.2.2-3 and for Sullivan County in Table 4.3.2.2-4.

Table 4.3.2.2-3. 10-county Region 2011 National Land Cover Database Land Cover.

NLCD Land Cover	Acres	Percent of Total
Barren Land	2,346	0*
Cultivated Crops	848,696	23
Forest – Deciduous, Mixed, Evergreen, and Forested Wetlands	798,773	22
Developed – High, Medium, and Low Intensity and Open Space	176,330	5
Grassland – Hay, Pasture, Herbaceous, Emergent Wetlands, and Shrub/Scrub Wetlands	1,769,181	49
Open Water	40,344	1
TOTAL ACRES	**3,635,670**	**100**

* Value less than 1.

Table 4.3.2.2-4. Sullivan County 2011 National Land Cover Database Land Cover.

NLCD Land Cover	Acres	Percent of Total
Barren Land	63	0*
Cultivated Crops	38,401	9
Forest – Deciduous, Mixed, Evergreen, and Forested Wetlands	102,028	25
Developed – High, Medium, and Low Intensity and Open Space	16,741	4
Grassland – Hay, Pasture, Herbaceous, Emergent Wetlands, and Shrub/Scrub Wetlands	256,876	62
Open Water	2,827	1
TOTAL ACRES	**416,936**	**100**

*Value less than 1.

FOREST CHANGE IN THE 10-COUNTY REGION

The NLCD land covers and the ecological sites do not exactly match but can be grouped to show a general trend. Barren land and undefined land covers do not have similar corresponding land covers but comprise a small portion of the total land covers (less than 5 percent).

Comparing the historic land cover to the current land cover shows the loss of grassland and forestland resources since the 10-county region was settled and developed. The NLCD data shows the 10-county region has a 17 percent loss in forest (Table 4.3.4.4-5), and Sullivan County has a 24 percent loss (Table 4.3.2.2-6) when compared to the NRCS ecological sites. The Sullivan County ecological sites historically had 5 percent more forestland area than the 10-county region.

Table 4.3.2.2-5. Land Cover Change in the 10-county Region.

NLCD Land Cover	NLCD Land Cover (Acres)	Ecological Site Land Cover (Acres)	Land Cover Change (Acres)	Percent Change
Barren Land	2,346	0	2,346	--*
Cultivated Crops	848,696	0	848,696	--*
Forest – Deciduous, Mixed, Evergreen, and Forested Wetlands	798,773	965,369	-166,596	-17
Developed – High, Medium, and Low Intensity and Open	176,330	0	176,330	--*
Grassland – Hay, Pasture, Herbaceous, Emergent Wetlands, and Shrub/Scrub Wetlands	1,769,181	2,620,656	-851,475	-33
Open Water	40,344	34,928	5,416	16
Undefined	0	14,717	-14,717	--*
TOTAL ACRES	**3,635,670**	**3,635,670**	**n/a**	**n/a**

* Not applicable.
National Land Cover Database (NLCD)

Table 4.3.2.2-6. . Land Cover Change in Sullivan County.

NLCD Land Cover	NLCD Land Cover (Acres)	Ecological Site Land Cover (Acres)	Land Cover Change (Acres)	Percent Change
Barren Land	63	0	63	--*
Cultivated Crops	38,401	0	38,401	--*
Forest – Deciduous, Mixed, Evergreen, and Forested Wetlands	102,028	134,822	-32,794	-24
Developed – High, Medium, and Low Intensity and Open	16,741	0	16,741	--*
Grassland – Hay, Pasture, Herbaceous, Emergent Wetlands, and Shrub/Scrub Wetlands	256,876	280,020	-23,144	-8
Open Water	2,827	1,682	1,145	68.1
Undefined	0	412	-412	--*
TOTAL ACRES	**416,936**	**416,936**	**0**	**n/a**

***** Not applicable.

National Land Cover Database (NLCD)

More recent trends show a net gain in forest area in the 10-county region. From 2003 to 2013, the 10-county region had the following change in forest area (USFS 2016):

- **0 – 10 Percent Loss**: Adair County, Grundy County, and Chariton County
- **0 – 10 Percent Gain**: Sullivan County, Linn County, and Schuyler County
- **Greater than 10 Percent Gain**: Putnam County, Mercer County, Macon County, and Livingston County

Adair, Grundy, and Chariton counties are the only counties in the 10-county region that have experienced a loss in forest area of 0 to 10 percent from 2003 to 2013. Putnam, Mercer, Macon, and Livingston counties have experienced a greater than 10 percent gain in forest area. Sullivan County has had a 0 to 10 percent gain in forest area. Statewide, Missouri has experienced no net change in forest area in the same period (USFS 2016).

4.3.2.3 Residential

The location of the Proposed Action is in rural Sullivan County and is not near any residential communities. It is not anticipated to lead to extensive residential growth around the Proposed Action. Existing roadways and utilities would be sufficient to provide for local additional developments, although none are known at present.

4.3.2.4 Commercial/Industrial/Infrastructure/Utilities/Other

No known projects that would result in additional impacts to infrastructure or utilities are planned at this time. The Proposed Action is located near existing roadways that can handle anticipated recreational traffic, and no substantial impacts to utilities are anticipated. If additional businesses are located in the 10-county area, it is possible that roadway or utility improvements may be needed, but none are known at this time.

4.3.3 Water Resources

4.3.3.1 Streams

The 1987 East Locust Creek Plan-EIS called for 121 FWRs, and 72 of these structures were built. The 2006 Revised Plan-EIS called for 22 FWRs in the watershed, and nine of these structures were completed. A total of 81 of FWRs have been completed. Other changes in land use that have affected streams have also occurred, particularly during the periods of Euro-American exploration and settlement. The first such change was the extirpation of the North American beaver (*Castor canadensis*) from the region. The beaver would have maintained chains of beaver ponds along many of the smaller side tributaries and the main stem of East Locust Creek in the project vicinity; some of these ponds could potentially be quite substantial in size (Burchsted et al. 2010). The second such change was the removal of much of the native prairie vegetation on dryland areas in the watershed for cultivated row crops and other farming activities. This vegetation removal increased the rate of surface runoff into the streams. These two changes in land use resulted in more erosion and incising of streams in the region.

The Proposed Action would have immediate direct impacts on streams in the normal pool. Following avoidance and minimization, unavoidable impacts to streams will be mitigated according to an approved mitigation plan. Water treatment plant upgrades are anticipated to avoid additional stream impacts, although waterlines may result in temporary impacts. The relocation of existing roads and utilities could also result in temporary impacts.

The dam will alter biotic, chemical, and physical movement within East Locust Creek. Biotic life will be restricted from upstream and downstream reaches of the dam. Movement will only occur through the spillway, which would restrict many native species. Chemical and physical movement, including sediment and water, will also be altered from current, natural conditions.

4.3.3.2 Groundwater

Though there are a few registered wells located near the normal pool, the Proposed Action relies on surface water and thus would not have a cumulative impact on groundwater use in this area.

4.3.3.3 Wetlands

It has been estimated that almost 90 percent of Missouri's wetlands have been lost through a variety of man-made activities, mostly from agricultural activities, but also from other types of development (Epperson 1992). As mentioned in section 4.3.3.1 on stream cumulative impacts, the extirpation of beavers and the loss of beaver dams has been an additional substantial cause of wetland loss. According to Burchsted et al. (2010), "Under modern conditions, beaver dams create dynamic sequences of ponds and wet meadows among free-flowing segments. One beaver impoundment alone can exceed 1000 meters along the river, flood the valley laterally, and fundamentally alter biogeochemical cycles and ecological structures."

An additional change in the area that could have affected the extent of wetlands in the project vicinity was the construction of the now abandoned CB&Q rail line, which roughly paralleled the stream within the floodplain. The track embankment resulted in changes in the hydrology of the area, potentially creating more wetlands by slowing the drainage of water to the creek.

No future projects are known that would substantially affect wetlands. Future development, including construction of water transmission lines, could affect wetlands, but those projects would need to obtain permits and mitigate for impacts. Recreational development and the water treatment plant are anticipated to avoid wetland impacts. In addition, it should be noted that an existing 181-acre EWRP would be largely inundated by RW1. According to NRCS program policy, this easement must be replaced with a wetland of equal or greater ecological and economic value and result in no net loss of wetland acreage. The EWRP replacement is described in Appendix F.

The loss of wetlands because of the Proposed Action would be mitigated through compensatory mitigation. As mentioned for streams, water distribution lines associated with the potential water treatment plant could result in temporary impacts to wetlands. Future commercial or residential areas within the project vicinity could result in additional wetland impacts but none are planned or platted currently, and if any developments affect wetlands, they would be required to obtain appropriate permits and conduct compensatory mitigation, if necessary. Thus, there is no anticipated cumulative net loss of wetland functions or acreage from this or other projects.

4.3.3.4 Water Quality

Past agricultural development has resulted in degraded water quality in some parts of the region. The Proposed Action is anticipated to trap sediment and pollutants from the stream system. Developments such as the unincorporated community of Boynton and the railroad have resulted in small areas of contamination that could affect water quality in the project.

There is one foreseeable future project that is likely to affect water quality. The village of Pollock wastewater treatment facility is likely to construct sewer lines to connect to the Milan wastewater treatment plant, which is likely to reduce the number of coliform bacteria in East Locust Creek.

The Proposed Action and associated ecological flows water management plan would control the release of water to downstream sections, in turn buffering these sections from the impacts of climate change. BMPs would be followed during construction activities to mitigate project impacts to water quality.

4.3.4 Aquatic Resources

4.3.4.1 Fisheries

The Proposed Action would provide recreational fishing opportunities to the residents of Sullivan County. See the purpose and need section for the recreational demand. Lakes in Missouri provide habitat for bass, crappie, and blue gill, among other species. No other known projects would have cumulative impacts to fisheries.

4.3.4.2 Invertebrates

The Proposed Action and foreseeable future projects are not anticipated to have a cumulative effect on invertebrate species.

4.3.5 Terrestrial Vegetation

The completion of the Proposed Action and foreseeable future projects are not anticipated to have a cumulative impact on terrestrial vegetation.

4.3.6 Wildlife

The Proposed Action may provide habitat to waterfowl and shorebirds as a migratory stopover during spring and fall migration. No other known projects are likely to result in cumulative impacts to wildlife or waterfowl.

4.3.7 Threatened and Endangered Species

Land development outside the Proposed Action property boundary will not be controlled by the project proponent, and the project proponent will not be involved in land development outside the Proposed Action property boundary. The land within the East Locust Creek upstream watershed will be subject to watershed zoning regulations to protect the water quality of the reservoir. Residential development would be allowed by the zoning regulations and may occur outside the Proposed Action property boundary. The rate of development, areas that will develop, and types of development that will occur are not known.

Forested areas within Sullivan County could provide habitat for northern long-eared and Indiana bats. Development around the Proposed Action could cause the removal of potential bat habitat. The potential residential development area (Figure 4.3.7-1) was determined by drawing land outside the NCMRWC property that is within the East Locust Creek watershed and within 0.5 mile of the normal pool. Figure 4.3.7-1 shows the residential development area around the project.

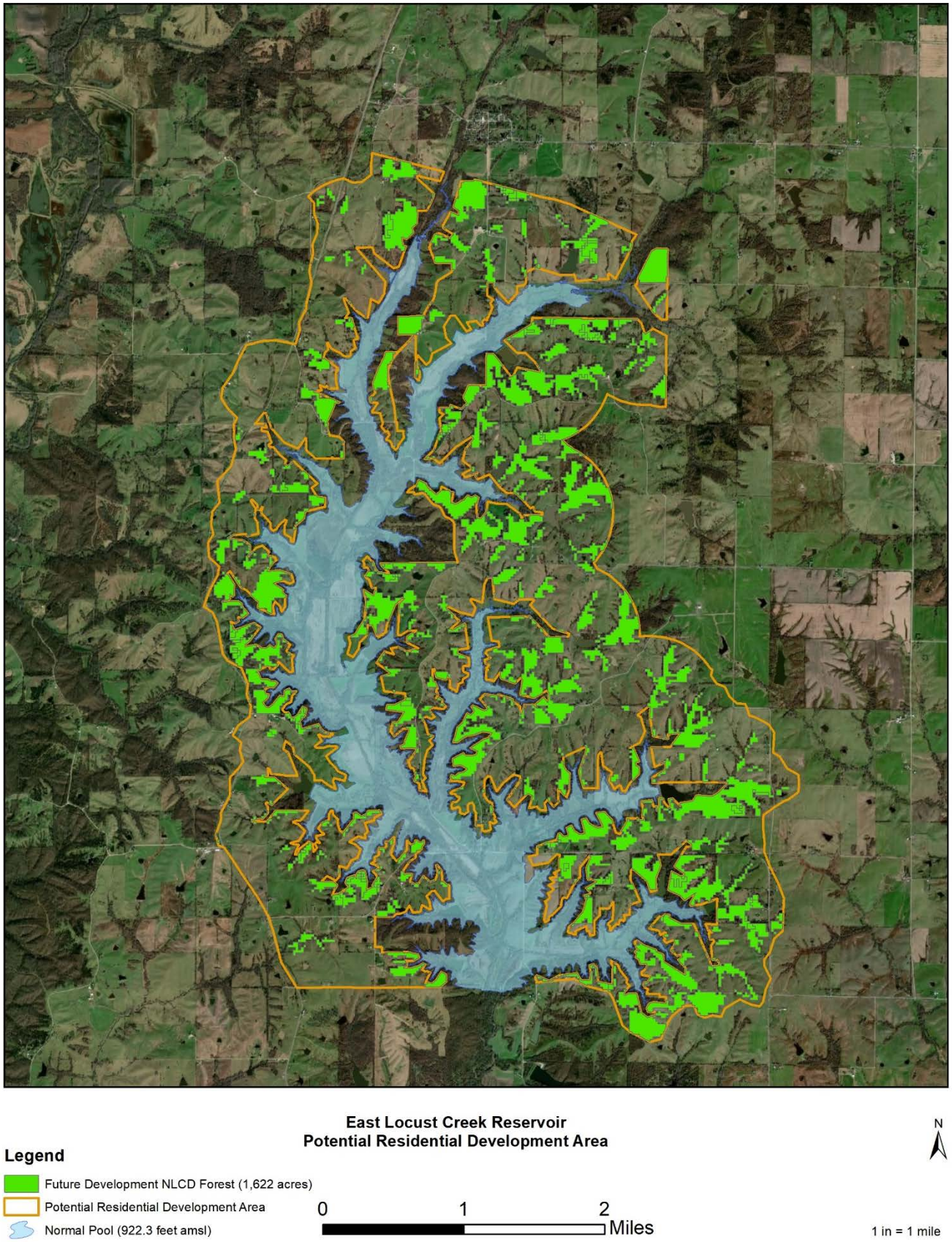


Figure 4.3.7-1. Potential Development Around the Project.

4.3.8 Economic and Social Resources

The lack of a reliable water supply in the past may have limited residential and business development in the 10-county region. The completion of the Proposed Action has the potential to increase economic vitality to the region by providing a reliable water supply. Increased business development in the region could occur with the addition of a reliable water source and recreational opportunities. No other projects are known to be planned in the project vicinity that would result in increased business opportunities.

4.3.9 Recreation and Visual Resources

The Proposed Action is anticipated to increase recreational opportunities in the future by providing an additional recreational supply. Substantial impacts outside the 10-county region are not anticipated.

There are no cumulative impacts to visual resources anticipated with the Proposed Action or foreseeable future projects.

4.3.10 Public Safety and Hazardous Materials

The completion of the Proposed Action or foreseeable future projects would not have a cumulative impact on public safety and hazardous materials.

4.3.11 Noise

Although the project would temporarily increase noise because of construction activities and permanently increase noise from potentially increased recreational traffic and motorboat usage, there are no sensitive receivers in the vicinity of the Proposed Action and no other projects are known that would result in a cumulative noise impact.

4.3.12 Geologic Resources

4.3.12.1 Geology

There would be no cumulative impacts from foreseeable future projects as a result of the Proposed Action.

4.3.12.2 Minerals

The Proposed Action would not have a cumulative impact on minerals.

4.3.12.3 Soils

With appropriate erosion control methods, the Proposed Action would not have a cumulative impact on soils. Soil loss would be minimized during construction activities by implementation of BMPs and an SWPPP.

4.3.13 Cultural Resources

The completion of the Proposed Action and foreseeable future projects may have a cumulative impact on cultural resources. Future residential and commercial development that may occur

around the proposed Project could impact cultural resources identified in the 2020 and 2006 cultural resources surveys or sites that are currently unknown.

4.4 Growth-inducing Effects

The Proposed Action would create an improved water supply to the residents and businesses in the 10-county region; helping to retain residents and businesses and potentially attracting new businesses and residents. A stable, dependable, affordable water supply could attract new businesses that would diversify the economy of the region.

In addition to increasing the water supply, the Proposed Action is anticipated to increase recreational activities that will diversify the economy because of the need to supply support to the increased visitors to the 10-county region.

Flood damage reduction downstream of the Proposed Action could increase profitability of agricultural producers through reduced insurance needs, reduced crop loss, and reduced damages to fences, terraces, and roads.

Although this project may result in some growth, there are no presently proposed, planned, or platted residential or commercial projects that would result in cumulative impacts to resources. Those projects, when developed, would need to comply with all applicable regulations.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

5.0 Comparison of Alternatives and Mitigation

5.1 Comparative Impacts of Alternatives

The comparative impacts of the No Action alternative and the Proposed Action are included in Table 5.2-1.

Table 5.2-1. Comparative Impacts.

Environmental Factors	No Action Alternative	Proposed Action	
Stream Impacts	None	49 miles	
Loss in Stream Function	None	Negative Impact (High)	
Wetland Impacts	None	362 acres	
Loss in Wetland Function	None	Negative (Moderate overall)	
		Reed Canarygrass	Negative Impact (Low)
		Farmed	Negative Impact (Low)
		Remaining	Negative Impact (High)
Federal Endangered Species	None	Negative Impact (High)	
Cultural Resources	None	Eight sites eligible for the NRHP	
Social and Economic	Negative	Positive Impact (High)	

5.2 Irreversible and Irretrievable Resource Changes

Irreversible and irretrievable environmental changes from the implementation of the Proposed Action would include loss of approximately 49 miles of streams, 362 acres of wetland, approximately 1,410 acres of riparian forest, and 11 sites eligible for the NRHP because of inundation and project-related impacts.

5.3 Unavoidable Adverse Effects

Unavoidable adverse effects would include impacts to approximately 49 miles of streams, 362 acres of wetlands, 1,410 acres of riparian forest, and 11 sites eligible for the NRHP because of inundation and project-related impacts.

5.4 Mitigation Measures

Following all avoidance and minimization efforts, compensatory mitigation measures would be developed for the unavoidable impacts. Mitigation conceptual planning assumptions are included in Appendix I.

5.4.1 Forest/Woodland Resources

Construction of the proposed reservoir would impact approximately 1,410 acres of riparian forest. See threatened and endangered species section for tree plantings and preservation.

5.4.2 Residential and Business Relocations

Acquisition of all residential and business properties was completed in compliance with the Uniform Act of 1970.

5.4.3 Utilities

Disruption of utility service would not be anticipated as a result of utility adjustments. The adjustment for these utilities would typically take place in the appropriate phase of construction. Utilities will be relocated to maintain service to existing customers. Figure 5.4.3-1 shows the proposed utility corridors.

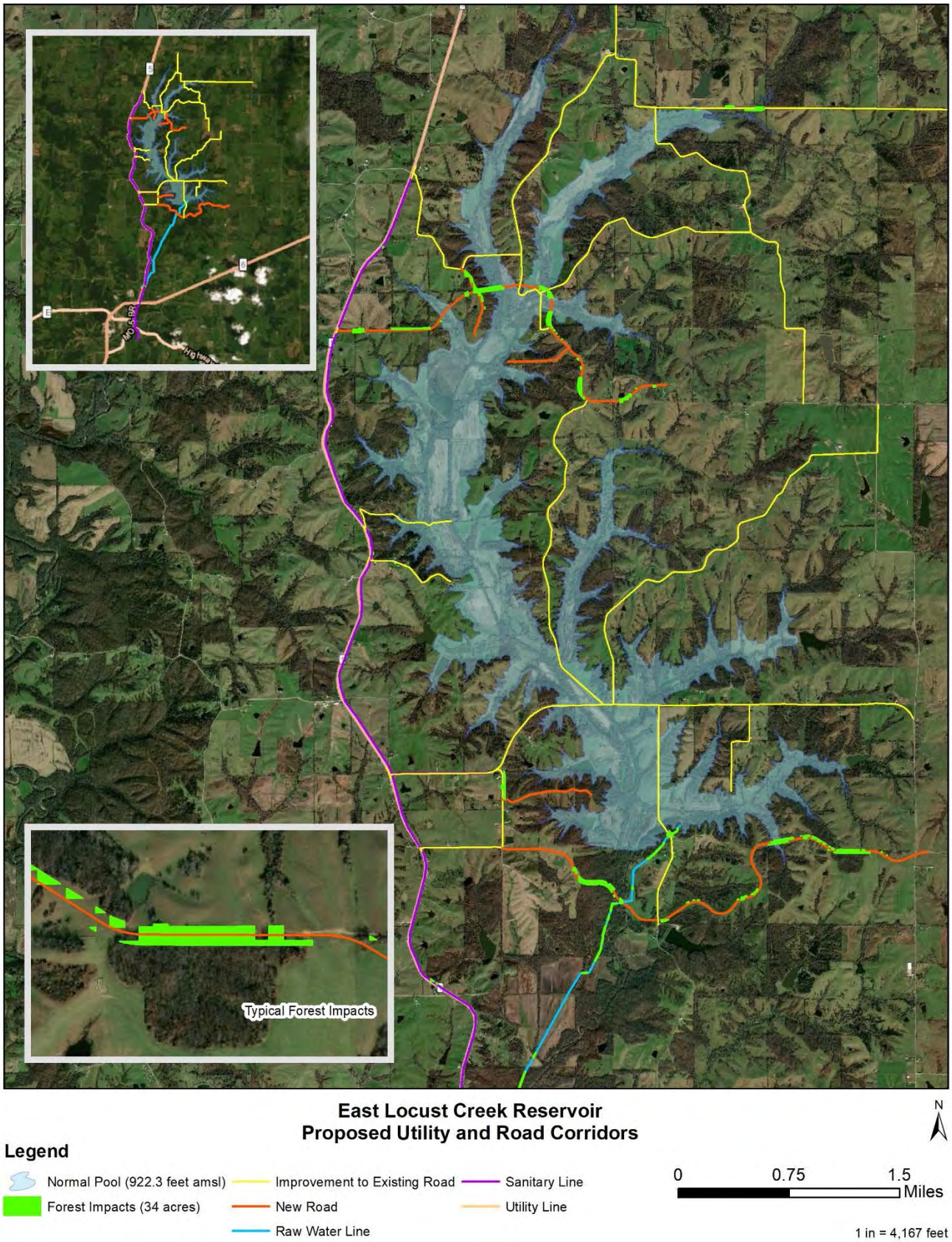


Figure 5.4.3-1. Project Utilities and Transportation Relocation.

5.4.4 Streams

Stream mitigation will follow the CWA Section 404(b)(1) guidelines. Because there are not sufficient mitigation bank stream credits or in-lieu fee provider stream credits, permittee-responsible stream mitigation would be provided. Mitigation conceptual planning assumptions are included in Appendix I.

Streams affected by the Proposed Action total 49 miles that would be lost because of inundation or dam construction. Stream mitigation would take place in the Central Plains Grand/Chariton Ecological Drainage Unit with a focus on the Lower Grand HUC 8 watershed. The goal of the mitigation efforts would be improving conditions at the Lower Grand River Conservation Opportunity Area (COA). Riverine habitats such as the Lower Locust Creek flowing through Pershing State Park and Fountain Grove Conservation Area (CA) have been described as “rare in Missouri.” The diverse aquatic fauna has served as an example of what was likely present throughout northern Missouri before channelization (Winston et al. 1998). “Every effort should be made to preserve these few remaining sections of stream with their aquatic life.” (Winston et al. 1998).

Mitigation measures would be developed in coordination with resource agencies including the USACE, USFWS, MDNR, and MDC. Potential projects include removing barriers which impede the passage of aquatic organisms, streambank stabilization, levee setback, riparian enhancement and protection, floodplain expansion, and addressing the impacts of channel avulsions affecting sensitive habitats along the lower portions of Locust and Yellow creeks.

Mitigation, both on-site and off-site, would require monitoring to ensure successful implementation and continued success of mitigation practices.

5.4.5 Groundwater

Any registered or unregistered wells within right-of-way (ROW) to be acquired would be properly abandoned according to Missouri Minimum Design Standards for Community Drinking Water Systems, paragraph 3.1.4.1.c, as well as in 10 CSR 23-3.110 – Plugging of Water Wells (MDNR 2013b; MDNR 2014a). Proper decommissioning of affected wells would not have a significant impact on groundwater quality.

5.4.6 Wetlands

Wetland mitigation will follow the CWA 404 (b)(1) guidelines. Because there are not sufficient mitigation bank wetland credits or in-lieu fee provider wetland credits, permittee-responsible wetland mitigation would be provided. Mitigation conceptual planning assumptions are included in Appendix I.

Unavoidable wetlands impacts would require compensatory mitigation following prescribed replacement to affected ratios. Preliminary jurisdictional determinations indicated approximately 362 total wetland acres affected, with 273.07 of PEM, 78.95 of PFO, and 9.74 of PSS. The preliminary jurisdictional determination also indicated 30.35 acres of open water. An existing 181-acre EWRP easement exists within RW1 and is included in the preliminary jurisdictional

determination values. According to NRCS program policy, this easement must be replaced with a wetland of equal or greater ecological value. The EWRP replacement is described in Appendix F. Wetlands were determined by NWI data associated with the utilities and road relocation and improvements. Wetland delineations and preliminary jurisdictional determinations are planned to be completed. The NWI data indicates there are 3.05 acres PEM, 9.19 acres PFO, and 0.76 acre of open water.

Appropriate mitigation sites would require adequate soils and hydrology to establish wetland vegetation. The NRCS wetlands team would provide technical assistance in restoring wetlands.

Wetland mitigation sites and extent would be determined in coordination with USACE and MDNR. Wetland mitigation locations would focus on areas upstream and downstream of the Proposed Action. Locations downstream provide similar conditions to the affected wetlands. The lake itself would provide suitable hydrologic regimes for wetland mitigation sites in areas upstream of and along the shoreline of the Proposed Action. If necessary, areas elsewhere within the HUC 8 watershed would be considered as potential wetland mitigation locations.

Permittee-responsible mitigation will require monitoring to ensure the success of the wetland mitigation areas.

5.4.7 Water Quality

To provide proper erosion control before, during, and after construction of the East Locust Creek reservoir and dam, a phased approach of erosion and sediment controls would be implemented. Prior to any construction taking place, BMPs would need to be temporarily installed and maintained throughout the construction period in locations identified on the plan sheets and SWPPP: The NPDES rules require an SWPPP on construction sites disturbing one or more acres. Potential BMPs would be needed at construction entrance(s), concrete washout areas, stockpile and staging areas, perimeter controls (sediment fence), sediment basins, sediment traps, diversion berms, diversion channels, stream crossings, and ditch checks.

During construction and mass grading, additional sediment fencing would be installed as needed. Erosion control blankets would be installed to provide permanent slope stabilization where indicated on the plans. Whenever activity has ceased for more than 14 days, disturbed areas would be temporarily seeded to provide protection to bare soils and reduce damage from sediment and runoff to downstream or off-site areas. The BMPs would be regularly inspected and maintained as indicated in the SWPPP throughout the life of the project to ensure proper erosion and sediment control protection is provided.

Once construction has been completed, removal of the temporary BMPs would require any disturbed areas to be stabilized with permanent seeding. Diversion channels are to remain in place until work in the downgradient area or natural channels is no longer required. When removed, the disturbed area shall be covered with topsoil and stabilized and seeded with mixes of appropriate native species.

In addition to protecting water quality, the BMPs include revegetation with native species and will reduce the chance of invasive or nonnative species being introduced to this area.

5.4.8 Threatened and Endangered Species

Indiana, Gray, and Northern Long-eared Bats

Voluntary measures to compensate for the loss of forested bat habitat and impacts to bats that could not be avoided and minimized include tree planting on NCMRWC property, tree preservation on NCMRWC property and within the High Hazard Zone, preservation of forested acres that will not be under a conservation easement, and wetland forest mitigation. Mitigation conceptual planning assumptions are included in Appendix I.

Forest Creation

Many areas outside the normal pool and within NCMRWC property will be planted to forest. Tree species will be selected based on the natural forest community and on favorable tree species for bat roosting habitat. Land parcels with acreage greater than one-half acre will be planted with trees to restore natural forests. A total of 553 acres of new forest will be created because of this planting.

Forested wetland impacts total 79 acres according to the USACE preliminary jurisdictional determination. The 79 forested wetland acres will be replaced with a minimum of 79 forested wetland acres. Stream impacts total 49 miles for the proposed reservoir. Riparian forest plantings and conservation easements are anticipated with a portion of the stream mitigation.

Forest Preservation

A total of 683 acres of existing forest outside the normal pool and on NCMRWC property will be preserved and will have a permanent conservation easement established. The preservation of these existing forested areas will provide permanent forested areas and bat roosting habitat. Forest management consistent with MDC forest management practices would be allowed.

An additional 361 acres of existing forest is intended to remain in perpetuity to protect water quality surrounding the reservoir. This area will be owned by the NCMRWC and will be intended to protect water quality, but in the interest of providing NCMRWC with flexibility to manage its property, will not have a permanent conservation easement established. The 361 acres was calculated by subtracting the recreational facilities, utilities and road relocation, dam construction, and potential tree clearing on NCMRWC property from the forested acres without a conservation easement.

The Lake Authority described in Section 3.8.4 Water Quality will provide 50 acres of forest preservation along stream resources within 500 feet of the NCMRWC property boundary.

Conservation Easement

A permanent conservation easement will be established on 1,236 acres for 553 acres of tree planting and 683 acres of forest preservation. The conservation easement will allow for the implementation of the Bat Habitat Compensation Plan and prohibit incompatible uses that might jeopardize the quality of bat habitat. Discussions with the Ozark Land Trust have occurred about having a certified land trust hold the conservation easement. A forest management plan is also being developed for the 1,236 acres of forest under permanent conservation easement.

A permanent conservation easement will also be established on 79 acres of forested wetlands. However, the location of the easement has not been determined.

The 50 forest acres along streams within the High Impact Zone will not have a permanent conservation easement but will be included as a zoning requirement under the Lake Authority. The zoning requirement was passed by the NCMRWC and is legally enforceable.

Plains Spotted Skunk

MDC coordination resulted in BMPs for the plains spotted skunk (MDC 2015b). No recorded sightings occurred within 10 miles of the Proposed Action.

5.4.9 Transportation Impacts

Ongoing coordination with MoDOT and Sullivan County will be done throughout the project construction period. Information on detours and road closures will be provided to emergency service providers, local residents and businesses, and the general public.

5.4.10 Hazardous Materials

Between 2012 and 2016, Targeted Brownfields Assessments found elevated arsenic concentrations in soil samples taken along the abandoned CB&Q railroad line. A study was conducted in 2017 to determine the extent of contamination by arsenic. Soil samples were collected at 20 locations along the former railroad line. All sample locations had arsenic concentrations exceeding the U.S. Environmental Protection Agency (USEPA) screening level for residential land use (0.68 mg/kg), and nine sample locations had arsenic concentrations above background concentrations as determined by the USGS for Sullivan County, Missouri (8.469 mg/kg). Results of the Tetra Tech investigation provided a range of concentrations from 4.0 to 130 mg/kg arsenic in the soil, with an average concentration of 20.3 mg/kg.

A review of the investigation results concluded that the actual maximum possible concentration of arsenic in the water of the proposed East Locust Creek reservoir would not exceed 60 percent of the USEPA drinking water standard. The investigation review is provided in Appendix B.

5.4.11 Construction Temporary Impacts

See water quality mitigation section for mitigation measures (5.5.7).

5.4.12 Cultural Resources

NRCS is currently working with SHPO to determine which impacts related to the proposed Project are adverse impacts requiring mitigation. NRCS has also reached out to the local tribes for an opportunity to comment. Mitigation will be completed for sites with adverse impacts. If discover previously unknown historic, cultural or archeological remains and artifacts are found during Project construction, the SHPO will be notified of what was found, and to the maximum extent practicable, construction activities that may affect the remains and artifacts will be avoided until the required coordination has been completed.

5.5 Relationship of Short-term Uses and Long-term Productivity

Despite loss of some acreage of farmland, flood damage reduction would provide locally controlled agricultural water management (rural water supply); fish and wildlife habitat enhancement; recreational development; and flood prevention. The short-term uses are also long-

term uses and provide benefits to the community. The Proposed Action would improve the long-term productivity for the agricultural industry in the project area because it is a dependable water supply and a means of flood prevention. In addition, the project would improve the long-term productivity for the recreation industry through the development of new recreation areas and opportunities.

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

6.0 Applicable Laws and Policies

Review and implementation of the Proposed Action requires coordination and compliance with multiple federal and state laws, regulations, executive orders, and policies. The following sections have known application to the Proposed Action.

6.1 Federal Laws, Regulations, and Policies

Bald and Golden Eagle Protection Act

Bald and golden eagles have specific protection under the BGEPA;16 USC 668-668c., which is administered by the USFWS. Protections under this act prohibit “take” of bald and golden eagles.

Clean Water Act of 1972

The CWA is the principal law governing pollution control and water quality of waters of the U.S. Section 402 of the act establishes an NPDES permitting program to regulate the point source discharge of pollutants into waters of the U.S. Missouri administers state-level NPDES programs pursuant to authority delegated by the EPA.

Section 404, administered by the USACE with oversight from the EPA, is another permitting program that regulates the placement of dredged or fill materials into waters of the U.S. USACE issues nationwide permits on a state, regional, or nationwide basis for similar activities that cause minimal adverse environmental effects, both individually and cumulatively. Individual permits may also be issued for specific activities on specific water bodies under Section 404.

An individual Missouri State Water Quality Certification (Section 401) would also be required (EPA 2017a).

Endangered Species Act

Federally listed threatened and endangered species are protected under the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.). Adverse effects on a federally listed species or its habitat would require consultation with the USFWS under Section 7 of the Endangered Species Act. Section 7, as amended, requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of proposed, endangered, or threatened species or result in the destruction or adverse modification of their critical habitat (USFWS 2015a).

Executive Order 11988 for Floodplain Management

EO 11988 requires federal agencies to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Through this criterion, the EO strives to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains for the following actions (FEMA 2015):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements

- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities

Executive Order 11990 for Protection of Wetlands

The purpose of EO 11990 is to "minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands." To meet these objectives, the EO requires federal agencies to consider alternatives to wetland sites and limit potential damage if an activity affecting a wetland cannot be avoided. The EO applies to acquisition, management, and disposition of federal lands and facilities construction and improvement projects which are undertaken, financed, or assisted by federal agencies, as well as to federal activities and programs affecting land use. This includes, but is not limited to, water and related land resources planning, regulation, and licensing activities (EPA 2016a).

Executive Order 12898 for Environmental Justice

President Clinton signed EO 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Population*, in 1994. This EO focuses the attention of federal agencies on human health and environmental conditions in minority communities and low-income communities. Environmental justice analyses are performed to identify the potential for disproportionately high and adverse impacts on minority and low-income populations from proposed actions and to identify alternatives that might mitigate these impacts. This DSEIS includes an environmental justice analysis for the 10-county region (EPA 2016c).

Executive Order 12962 for Recreational Fisheries

EO 12962, which was implemented in 1995, mandates that federal agencies, to the extent permitted by law and where practicable, improve the quality, function, and sustainable productivity and distribution of U.S. aquatic resources for increased recreational fishing opportunities. Activities to accomplish this may include developing and encouraging partnerships between governments and the private sector to advance aquatic resource conservation and enhance recreational fishing opportunities; identifying recreational fishing opportunities that are limited by water quality and habitat degradation and promoting restoration to support viable, healthy, and, where feasible, self-sustaining recreational fisheries; fostering sound aquatic conservation and restoration endeavors to benefit recreational fisheries; supporting outreach programs designed to stimulate angler participation in the conservation and restoration of aquatic systems; and implementing laws under their purview in a manner that will conserve, restore, and enhance aquatic systems that support recreational fisheries.

In addition, this order establishes the National Recreational Fisheries Coordination Council, which oversees the actions of federal agencies to ensure they accomplish the goals outlined in the EO (EPA 2016b).

Executive Order 13112 for Invasive Species

In 1999, EO 13112 was issued to prevent the introduction of invasive species and to provide for their control. It directs federal agencies to identify applicable actions and to use programs and authorities to minimize the economic, ecological, and human health impacts caused by invasive species (White House 2016). To meet the intent of this order, the Proposed Action includes environmental commitments to prevent and control the spread of invasive species.

Farmland Protection Policy Act of 1995

The purpose of the FPPA is to ensure that impacts to prime or unique farmlands are considered in federal projects. It requires federal agencies to consider alternative actions that could lessen impacts and to ensure that their actions are compatible with state and local government and private programs to protect prime and unique farmland. The NRCS is responsible for administering this act. Farmlands were considered in the Proposed Action analysis using the key indicators of changes in farm acreage and production. Prime and unique farmlands would be protected to the extent possible during implementation of the Proposed Action consistent with the act (NRCS 2012).

Fish and Wildlife Coordination Act Under Section 12 of PL83-566

PL 83-566 projects are local projects installed with Federal assistance and are exempt from the provisions of the FWCA. However, PL 85-624, which contained the 1958 amendments to the FWCA, also added section 12 to PL 83-566. Section 12 (16 U.S.C. Section 1008) applies the principles of the FWCA to the PL 83-566 program. The NRCS State Conservationist must notify the USFWS so it may provide recommendations for fish and wildlife resources, in accordance with the provisions of PL 83-566 Section 12.

Hazardous Materials Acts

The EPA and other federal and state agencies regulate hazardous materials under the Toxic Substances Control Act; Comprehensive Environmental Response Compensation and Liability Act; RCRA; Superfund Amendments and Reauthorization Act; and Emergency Planning and Community Right-to-Know Act. RCRA gives the EPA the authority to control hazardous waste from the “cradle-to-grave.” This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also sets forth a framework for the management of nonhazardous solid wastes. The 1986 amendments to RCRA enabled the EPA to address environmental problems that could result from underground storage tanks containing petroleum and other hazardous substances (EPA 2017c).

Migratory Bird Treaty Act

Under the MBTA (16 USC 703-712: Ch. 128 *as* amended), construction activities in grassland, wetland, stream, and woodland habitats and those that occur on bridges (which, for example, may affect swallow nests on bridge girders) that would otherwise result in the taking of migratory birds, eggs, young, and/or active nests should be avoided. Although the provisions of MBTA are applicable year-round, most migratory bird nesting activity in Missouri occurs during the period of April 1 to July 15. However, some migratory birds are known to nest outside the aforementioned primary nesting season period. For example, raptors (such as hawks, falcons, and owls) can be expected to nest in woodland habitats during February 1 through July 15, whereas sedge wrens, which occur in some wetland habitats, normally nest from July 15 to September 10 (USFWS 2015b).

Missouri Clean Water Commission, Water Quality Standards, 10 CSR 20-7

Water quality in Missouri is regulated by classifying water bodies according to designated beneficial uses and then assigning specific numerical water quality criteria that must be maintained to protect the assigned beneficial uses. Water bodies that are not classified fall under the General Criteria (10 CSR 20-7.031[3]) for all waters of the state. East Locust Creek, from the mouth to Missouri Highway 6, is classified by the State of Missouri (10 CSR 20-7.031) as "P," which identifies "streams that maintain permanent flow even in drought periods." From Missouri Highway 6 to Section 12, Township 64N, Range 20W near Pollock, the stream is classified as "C," which identifies "streams that may cease flow in dry periods but maintain permanent pools which support aquatic life" (10 CSR 20-7.031). The remainder of the stream is unclassified. The state-designated beneficial uses for East Locust Creek are livestock and wildlife watering and the protection of warm water aquatic life and human health – fish consumption (10 CSR 20-7.031). Whole-body contact recreation is also a designated beneficial use for East Locust Creek (MDNR 2011b).

National Historic Preservation Act of 1966

The NHPA establishes protection of historic properties as federal policy in cooperation with states, tribes, local governments, and the public. Historic properties are those buildings, structures, sites, objects, and districts or properties of traditional religious and cultural importance to Native Americans that are determined to be eligible for inclusion in the NRHP. Section 106 of the act requires federal agencies to consider the effect of proposed actions on historic properties and gives the Advisory Council on Historic Preservation an opportunity to comment. The lead federal agency is responsible for consultation with the State Historic Preservation Officer and/or Tribal Historic Preservation Offices, tribes, applicants, interested parties, and local governments regarding federal undertakings. When previously unidentified cultural resources are encountered, the project includes environmental commitments to comply with the act (NPS 1992).

National Invasive Species Act of 1996

The purpose of the National Invasive Species Act of 1996 is to: (1) prevent unintentional introduction and dispersal of nonindigenous species in the waters of the U.S. through ballast water management and other requirements; (2) to coordinate federally funded or authorized research, prevention control, information dissemination, and other activities regarding the zebra mussel and other aquatic nuisance species; (3) to develop and carry out environmentally sound control methods to prevent, monitor, and control unintentional introductions of nonindigenous species from pathways other than ballast water exchange; (4) to understand and minimize economic and ecological impacts of nonindigenous aquatic nuisance species that become established, including zebra mussel; and (5) to establish a program of research and technology development and assistance to states in the management and removal of zebra mussels (ANS Task Force 2011). To comply with the act, the Proposed Action incorporates design features to minimize invasion of nonindigenous species and monitor the distribution network for effective prevention of their spread.

Native American Graves Protection and Repatriation Act of 1990

This repatriation act "describes the rights of Native American lineal descendants, Indian tribes, and Native Hawaiian organizations with respect to the treatment, repatriation, and disposition of Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony, referred to collectively in the statute as cultural items, with which they can show a relationship of lineal descent or cultural affiliation" (NPS 1992).

Safe Drinking Water Act of 1974

This drinking water act gave the EPA the authority to set standards for drinking water quality in water delivered by public water suppliers. Analysis of water quality in the DSEIS indicates minor to no measurable changes from the existing conditions for the Proposed Action (EPA 2017b).

The Uniform Act of 1970

The Uniform Act is a federal law that "establishes minimum standards for federally funded programs and projects that require the acquisition of real property or displace persons from their homes, businesses, or farms. The Uniform Act's protections and assistance apply to the acquisition, rehabilitation, or demolition of real property for federal or federally funded projects.

Watershed Protection and Flood Prevention Act of 1954

This act, also known as PL 83-566, is a law that provides protection to watersheds from erosion, sedimentation, and flooding. Under this act, technical and financial assistance is provided to state and local governments through the NRCS to prevent erosion, floodwater, and sediment damage; to further the conservation, development, use, and disposal of water; and to further the conservation and proper use of land in authorized watersheds (NRCS n.d.).

1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

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7.0 Public Involvement

8.0 References

9.0 List of Preparers

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7.0 Public Involvement

7.1 Agency Coordination

The NRCS is the lead federal agency and the USACE, the USDA RD, and the Federal Highway Administration are cooperating agencies. EPA, MDNR, MDC, and USFWS have provided assistance and guidance though conference calls and formal meetings. The formal meetings have followed a NEPA review plan agreed on by the group that determines the review process, timeframes, document distribution, and project schedule. The review process included the following steps:

1. Document submitted with track changes as needed.
2. Regulatory agencies provide written comments within 21 days.
3. Consultants review agency comments and provide a meeting agenda.
4. Formal meeting is held to discuss how best to address agency comments.
5. Consultants prepare and distribute meeting minutes.

Table 7.1-1 summarizes information on agency meetings and other coordination and approvals.

Table 7.1-1. Administrative Record.

Date	Record Type	What
1987	Report Published	Original East Locust Creek Watershed Plan-Environmental Assessment. (Included 49 additional small floodwater retarding structures but no multipurpose reservoir.)
1995	Report Published	Rhodes Engineering Company Inc. – Preliminary Engineering Report for North Central Missouri Regional Water Supply.
08-01-2003	Report Published	Burns & McDonnell Water System Feasibility Study – evaluated groundwater, four streams, four existing suppliers, and five reservoir locations. Recommended East Locust Creek Reservoir.
11-01-2003	Report Published	Burns & McDonnell Water System Master Plan – conceptual design of reservoir and review of environmental impacts.
05-20-2004	Report Published	Water Use Study of North Central Missouri Regional Water Commission – Report from Department of Natural Resources (DNR), resulted in increased firm yield requirement from 4.5 to 8.5 MGD.
09-22-2006	Regulatory Decision	Environmental Protection Agency (EPA) publishes a statement in the Federal Register (Volume 71, Issue 184) stating, "EPA's previous concerns have been resolved; therefore, EPA does not object to the proposed action." This is regarding the original Environmental Impact Statement (EIS) and the East Locust Creek Watershed Plan.
09-27-2006	Regulatory Decision	Notice of Intent (NOI) of the Record of Decision to proceed with the installation of the East Locust Creek Watershed Revised Plan was published. This revised plan provided for a firm yield of 7.0 million gallons of raw water per day.
01-01-2007	Report Published	East Locust Creek Watershed Revised Plan and EIS completed (NRCS 2006) – Reviewed the 2003 Water System Feasibility Study, concurring with its evaluation of 22 alternatives and its further consideration of eight of the alternatives and resulting recommendation for East Locust Creek Reservoir. Then, refined the alternatives analysis with a detailed analysis of four alternatives revolving around the proposed East Locust Creek Reservoir and small floodwater retarding structures.
05-19-2010	Meeting (Permitting)	Project team met with U.S. Army Corps of Engineers (USACE) district regulatory staff including Mark Frazier and state regulatory staff.

Date	Record Type	What
10-01-2010	Meeting (Permitting)	Allstate consultants and Brad Scott met informally with Jim Ptacek and Ward Lenz to discuss project status. Stream impact factor was first identified as a big issue at this meeting.
10-14-2010	Meeting (Permitting)	Allstate consultants met with USACE state regulatory staff in Jefferson City, Missouri, to discuss preliminary mitigation numbers.
11-18-2010	Meeting (Permitting)	The Project team met with EPA for a general project update and discussion.
11-18-2010	Meeting (Permitting)	Project team met with USACE Kansas City district in Kansas City, Missouri.
12-22-2010	Regulatory Decision	USACE notified the reservoir team that the Missouri Stream Mitigation Method linear impact factor can be based on the stream segment length instead of on the cumulative total of all affected lengths
03-21-2011	Meeting (Permitting)	Project team, Natural Resources Conservation Service (NRCS), and USACE met with Colonel Hoffman and left a list of 10 requests.
08-04-2011	Regulatory Decision	Email from Mark Frazier that contained responses to questions.
01-26-2012	Meeting (Permitting)	Project team, DNR, and USACE met in Jefferson City, Missouri, to introduce the project to Shelly Carter. Included in the discussion was the need for separate alternatives analysis for each purpose.
10-25-2013	Regulatory Decision	East Locust Creek Reservoir Preliminary Engineering Report approval letter from DNR.
03-07-2014	Meeting (Permitting)	East Locust Creek Reservoir and Little Otter Creek Reservoir teams, NRCS, Green Hills Regional Planning Commission, and DNR met with Colonel Sexton and Mark Frazier in Trenton, Missouri.
11-13-2014	Regulatory Decision	USACE signed letter agreeing to be a cooperating agency.
12-08-2014	Regulatory Decision	NOI to start the Draft Supplemental Environmental Impact Statement (DSEIS) process published in the Federal Register.
12-29-2014	Report Draft Submitted to Regulators	NRCS submitted first draft jurisdictional determination document on a 167-acre subarea.
02-04-2015	Report Draft Submitted to Regulators	Draft purpose and need section submitted to regulatory agencies (USACE, EPA, U.S. Fish and Wildlife Service [USFWS], DNR, etc.).
02-25-2015	Comments Received	USACE commented on purpose and need.
02-25-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting held with regulatory agencies.
03-31-2015	Meeting (Permitting)	Jurisdictional determination guidance meeting held with USACE and EPA
05-20-2015	Meeting (Permitting)	East Locust Creek Reservoir Draft SEIS (DSEIS) meeting held with agencies (MDNR, USFWS, EPA, USACE, and NRCS)
5-26 – 5-27-2015	Meeting (Permitting)	Project team and regulatory agencies (EPA, USACE) field check one region to refine jurisdictional determination process.
07-22-2015	Report Draft Submitted to Regulators	Revised purpose and need section, screening criteria section, and list of alternatives for consideration submitted to regulatory agencies.
08-06-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting with regulatory agencies scheduled, but then cancelled to allow more time for review.
08-14-2015	Regulatory Decision	Letter from U.S. Department of Agriculture (USDA) waived $341,000 payment in original NRCS contract for inundated PL-566 structures.
09-10-2015	Comments Received	Comments from USACE on DSEIS received.
09-15-2015	Regulatory Decision	Mark Frazier sent letter to Harold Deckerd regarding the coordination of reviews of DSEIS.

Date	Record Type	What
09-22-2015	Report Draft Submitted to Regulators	Project team submitted proposed DSEIS review plan to regulatory agencies.
09-25-2015	Meeting (Permitting)	East Locust Creek Reservoir permitting meeting held with regulatory agencies to discuss coordination.
09-25-2015	Comments Received	Received comments on the purpose and need from USACE. Comments questioned population projections.
10-08-2015	Comments Received	Received comments on the purpose and need from EPA. Comments questioned future demand projections.
10-13-2015	Comments Received	Comments received from EPA on purpose and need section of DSEIS.
01-07-2016	Report Draft Submitted to Regulators	Revised purpose and need section provided to regulatory agencies.
01-26-2016	Comments Received	Received comments on the purpose and need from USACE. Included objection to including “7 MGD” in the purpose.
02-08-2016	Regulatory Decision	Letter from Director of DNR, Sara Parker Pauley, to Brad Scott affirming the state’s support of the need for 7 MGD. (Copied to Colonel Sexton.)
02-26-2016	Comments Received	Received comments on the purpose and need from EPA. EPA requested we remove a specific quantity of water supply from the purpose statement.
02-29-2016	Meeting (Regulatory)	Aaron Ball and Jim Ptacek discussion.
03-24-2016	Meeting (Permitting)	Project team and agencies hold conference call to discuss USACE and EPA comments.
09-16-2016	Meeting (Permitting)	Project teams for East Locust Creek and Little Otter Creek reservoirs and various agencies met with Colonel Guttormsen.
09-19-2016	Meeting (Permitting)	Met with the U.S. Fish and Wildlife Service.
12-02-2016	Report Draft Submitted to Regulators	Revised purpose and need section provided to regulatory agencies.
01-09-2017	Comments Received	Received comments on the purpose and need from USACE. Comments revolve around declining population and potential alternatives for water supply.
01-18-2017	Comments Received	Received comments on the purpose and need from the EPA.
01-23-2017	Regulatory Decision	Preliminary Engineering Report approval extension granted by MDNR.
02-08-2017	Meeting (Permitting)	Teleconference to discuss agency comments with agencies (USACE, EPA, USFWS, NRCS, and MDNR). Project team informed to take the comments under advisement and move forward.
03-10-2017	Response to Regulatory Comments	North Central Missouri Regional Water Commission (NCMRWC) submitted responses to USACE and EPA comments to the NRCS. I have the letter on Commission letterhead, but not a confirmation of sending.
06-05-2017	Meeting (Permitting)	NRCS met with Colonel Guttormsen to discuss schedule for East Locust Creek Reservoir and Little Otter Creek projects. Agreed to consider revised schedule and submittal of East Locust Creek Reservoir DSEIS in its entirety instead of a piece at a time.
07-26-2017	Regulatory Decision	DNR Director Carol Comer sent letter of support affirming the need to design the reservoir for 7 MGD.
10-06-2017	Meeting (Permitting)	Project team met with USFWS to discuss fence clearing.
10-24-2017	Meeting (Permitting)	Project team met with USFWS and NRCS to discuss existing Indiana bat maternity roosts on Cunningham property.
01-18-2018	Comments Received	Comments received on DSEIS from NRCS.
04-11-2018	Meeting (Permitting)	Project team met with MDNR to discuss source water protection and mitigation.

Date	Record Type	What
04-16-2018	Regulatory Decision	USDA provided draft Letter of Conditions establishing conditions for gap funding of local share of costs.
07-31-2018	Comments Received	NRCS National Water Management Center provided comments to the project team on the East Locust Creek Reservoir DSEIS
08-23-2018	Regulatory Decision	DNR approved PER for East Locust Creek Reservoir.
10-04-2018	Report Draft Submitted to Regulators	Biological assessment submitted to USFWS.
11-14-2018	Report Draft Submitted to Regulators	DSEIS to submitted to agencies.
11-26-2018	Regulatory Decision	Letter of approval of multipurpose water resources fund plan.
11-27-2018	Regulatory Decision	USDA RD – Draft Letter of Conditions – updated
11-27-2018	Regulatory Decision	Missouri Department of Natural Resources (MDNR) approves of Source Water Protection Plan
01-28-2019	Report Draft Submitted to Regulators	DSEIS submitted to NRCS – added Rathbun letter
01-31-2019	Regulatory Decision	USFWS approved clearing for fences.
02-04-2019	Report Draft Submitted to Regulators	DSEIS submitted to agencies
03-01-2019	Comments Received	Received DSEIS comments from USACE.
04-16-2019	Comments Received	Received DSEIS comments from USFWS.
07-11-2019	Comments Received	Received additional comments on the draft biological assessment from USFWS.
10-11-2019	Regulatory Decision	NCMRWC approved resolution affirming commitment to meeting USFWS obligations.
10-23-2019	Report Draft Submitted to Regulators	Biological assessment submitted to USFWS.
12-04-2019	Comments Received	USFWS commented on biological assessment.
02-14-2020	Report Draft Submitted to Regulators	Biological assessment submitted to NRCS for distribution to USFWS.
02-28-2020	Report Draft Submitted to Regulators	Biological assessment and request for formal consultation sent to USFWS.
03-27-2020	Comments Received	Received comments from USFWS on the biological assessment indicating that USFWS needed a few more things before we can enter consultation.
04-07-2020	Meeting (Permitting)	Project team met with NRCS and USFWS to discuss biological assessment and consultation.
04-09-2020	Regulatory Decision	Federal Highway Administration (FHWA) became a cooperating federal agency for the DSEIS.
05-01-2020	Report Draft Submitted to Regulators	Biological assessment submitted to NRCS for distribution and USFWS for information.
05-12-2020	Report Draft Submitted to Regulators	DSEIS from NRCS to FHWA, Missouri Department of Transportation (MoDOT), USFWS, USACE, USDA-RD, and EPA

Date	Record Type	What
05-20-2020	Report Draft Submitted to Regulators	Missing appendices from 2020-05-12 DSEIS sent to agencies.
05-27-2020	Comments Received	EPA comments received on DSEIS.
05-28-2020	Meeting (Permitting)	Met with NRCS and USACE to discuss DSEIS, mitigation, and construction access.
6-10-2020	Comments Received	Received USFWS comments on the biological assessment.
6-11-2020	Comments Received	Comments received from USACE.
6-16-2020	Meeting (Permitting)	Project team met with USACE to discuss DSEIS and alternatives analysis.
6-16-2020	Meeting (Permitting)	Project team met with USACE to discuss mitigation.
8-07-2020	Meeting (Permitting)	Project team met with with Colonel Hannan (USACE), NRCS, and Senator Roy Blunt's staff to provide Colonel Hannan an overview of the project and discuss permitting.
8-13-2020	Report Published	Final biological assessment sent to NRCS, USDA-RD, and USFWS.
8-19-2020	Report Draft Submitted to Regulators	DSEIS submitted to USACE.
08-19-2020	Report Draft Submitted to Regulators	Updated DSEIS submitted to USACE.
08-21-2020	Meeting (Permitting)	Project team met with NRCS and USACE to discuss permitting and construction access.
08-27-2020	Meeting (Permitting)	Project team met with NRCS and USACE Planning and Regulatory Division to discuss Garden of Eden mitigation project modelling.
09-07-2020	Meeting (Permitting)	Project team met with MDNR and NRCS to give an update on the mitigation plan and 401 certification.
10-01-2020	Meeting (SEIS)	Project team met with EPA to discuss their comments on the SEIS.
10-23-2020	Notice of Availability	Notice of availability published on the federal register.
10-23-2020	Final Biological Opinion	Final biological opinion received from USFWS.
11-02-2020	Comments Received	Comments received from USDA RD.
11-10-2020	Public Hearing	NRCS, USACE, NCMRWC, Olsson, and Allstate held a public hearing to address questions and receiving comments on the SEIS and 404 permit application.
11-12-2020	Meeting (SEIS)	Project team met with NRCS and USDA RD to discuss their comments on the SEIS.
11-30-2020	Comments Received	Comments received from EPA.
12-02-2020	Meeting (SEIS)	Project team met with NRCS and EPA to discuss their comments on the SEIS.

The agencies have reviewed portions of the DSEIS during development and at completion and have provided written comments and/or oral comments during formal meetings. Formal meetings began in 2015, and they included discussions on the DSEIS document, wetland delineation methodology, and endangered species.

7.2 Public Involvement

The 2006 FEIS included a public planning process, which involved public meetings, scoping meetings, formation of a steering committee comprised of local residents, print media coverage of project activities, and coordination with relevant agencies and groups. No significant unresolved issues or controversies from the public remain following this public planning process. Copies of the DSEIS are provided to federal, state, and local government agencies, environmental and

public interest groups, potentially affected landowners, other interested individuals and nongovernmental organizations, and to libraries in the project area. In addition, the DSEIS is available for public viewing on the NCMRWC website (NCMRWC 2017) and the Missouri NRCS website (NRCS 2020).

7.3 Comments on the Notice of Intent

The 2014 NOI states that "the NRCS invites full public participation to promote open communication and better decision-making. All persons and organizations with an interest in the [project] are urged to comment. Public comments are welcomed and opportunities for public participation include submitting comments to NRCS (1) during the development of the DSEIS; (2) during the review and comment period upon publishing the DSEIS; and (3) for 30 days after publication of the Final SEIS. Distribution of the comments received would be included in the Administrative Record without change and may include any personal information provided, unless the commenter indicates that the comment includes information claimed to be confidential business information.

7.4 Public Review and Comments on the Draft Supplemental Environmental Impact Statement (DSEIS)

This DSEIS is planned to be available for public review in 2020. The DSEIS will be available online and hard copies will be available in county offices and local libraries.

7.5 Intended Uses of the Draft Supplemental Environmental Impact Statement (DSEIS)

The purpose of the DSEIS is to address changes that have occurred since the NRCS prepared the East Locust Creek Watershed Revised Plan and Environmental Impact Statement in 2006 and to specifically address requirements of the CWA Section 404(b)(1) guidelines.

7.6 Document Recipients

See section 10.0 – Distribution List

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1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

8.0 References

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1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

9.0 List of Preparers

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Marshall Davis	Assistant Engineer	BS Environmental Engineering, 2014
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1.0 Introduction and Purpose and Need

2.0 Alternatives Analysis

3.0 Affected Environment and Predicted Environmental Consequences

4.0 Cumulative and Growth-Inducing Effects

5.0 Comparison of Alternatives and Mitigation

6.0 Compliance and Consultation with Applicable Laws, Policies, and Plans

7.0 Public Involvement

8.0 References

9.0 List of Preparers

10.0 Distribution List

10.0 Distribution List

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Jefferson City, Missouri 65102

Missouri Department of Transportation
P.O. Box 270
Jefferson City, MO 65101

10.3 Local Units of Government

Adair County Circuit Clerk
106 W. Washington Street, No. 2
Kirksville, Missouri 63501

Chariton County Courthouse
306 S. Cherry Street
Keytesville, Missouri 65261

Grundy County Courthouse
700 Main Street
Trenton, Missouri 64683

Linn County Clerk
108 S. High Street
Linneus, Missouri 64653

Livingston County Courthouse
700 Webster Street
Chillicothe, Missouri 64601

Macon County Clerk
101 E. Washington Street, No.1
Macon, Missouri 63552

Mercer County Circuit Clerk
802 E. Main Street
Princeton, Missouri 64673

Putnam County Circuit Court
1601 Main Street, No.101
Unionville, Missouri 63565

Schuyler County Circuit Clerk
1 Courthouse Square
Lancaster, Missouri 63548

Sullivan County
County Clerk's Office
109 N. Main Street, No. 20
Milan, Missouri 63556

10.4 Local Libraries

Sullivan County Public Library
109 E. Second Street
Milan, Missouri 63556

10.5 Elected Officials

U.S. Senator Roy Blunt
1123 Wilks Blvd Suite 320
Columbia, MO 65201

U.S. Congressman Sam Graves
411 Jules Street, Room 111
St. Joseph, MO 64501

State Senator Dan Hegeman
201 W. Capitol Avenue, Room 332
Jefferson City, MO 65101

U.S. Senator Josh Hawley
1123 Wilkes Blvd Suite 220
Columbia, MO 65201

Governor Mike Parson
Office of the Governor
P.O. Box 720
Jefferson City, MO 65102

State Rep. Danny Busick
Missouri House of Representatives
201 W. Capitol Avenue, Room 115-B
Jefferson City, MO 65101

Appendix A
Costs

Construction A1
Utility Relocation A6
Reservoir Preparation A6
Engineering Services A6
Other Professional Services and Miscellaneous A6
Recreation Cost A7
Mitigation Cost A7
Project Capital and O&M Cost Estimates A7
Creation of a New Online Channel Reservoir – East Locust Creek Reservoir (RW1) A8
Big Locust Creek Reservoir (DPA2) A10
Little East Locust Creek Reservoir (DPA3) A12
West Fork Locust Creek Reservoir (DPA4) A14
Yellow Creek Reservoir (DPA5) A16
Water Supply Combination Alternative (WA20) and Expand Existing Public Lakes (RA2) A18
Floodplain Acquisition (FA2) A23
Wetland Storage Areas (FA6) A24
Large Dry Dam – 100-year (FA7) A25

Included in this appendix is the detailed concept level cost estimates for each alternative described in the Supplemental Environmental Impact Statement (SEIS) for East Locust Creek Watershed Revised Plan. Unit prices in each detailed estimate include labor, materials, and equipment required to complete the work for each alternative and are described below.

To determine the magnitude of unit and lump sum costs for the various sites, a more detailed cost estimate was completed for the East Locust Creek location, where the North Central Missouri Regional Water Commission has developed additional data and completed preliminary design based on the conclusions in the 2006 Final Environmental Impact Statement (FEIS). For lump sum and quantified items where the estimated cost would be of a similar magnitude across different alternatives (such as a dam spillway), these lump sum items were held consistent across alternatives. Where quantified or lump sum items would be different in different alternatives because of site-specific differences (such as earth fill in a dam), the lump sum and quantity of items was increased or decreased based on the size of the proposed alternative. The list of itemized cost items in each estimate has been simplified to reflect the conceptual nature of the cost estimates. Some values are rounded.

Construction

Mobilization, Bonding, and Insurance

This item shall consist of preparatory work and operations including, but not limited to, costs for bonds, insurance, and permits; those items necessary for the movement of personnel, equipment supplies, and incidentals to the project site; the establishment of all offices, buildings, and other necessary items on the project except as provided in the contract as separate bid items; for all other work on the various items on the project site; for periodic cleanup during construction; and for cleanup upon completion of the work.

The cost for this line item is 8 percent of the total construction costs, excluding contingency and mobilization.

Clearing and Grubbing

This item consists of clearing and grubbing within a 75-foot-wide corridor along the centerline of the raw water main (37.5 feet per side), along the site for each intermediate pump station and along any other site needed for each alternative. For reservoirs, it includes clearing and grubbing for the areas of the dam and areas necessary to complete construction of the dam intake towers, spillways, and related improvements. Clearing and grubbing includes the complete removal and disposal of all buildings, timber, brush, stumps, roots, rubbish, debris, and all other obstructions resting on or protruding through the surface of the existing ground and the surface of excavated areas, and all other structures and obstructions necessary to be removed for which other items do not specify the removal thereof, including building foundations and pipes.

Clearing and grubbing is a measured quantity and is estimated at $2,500 per acre.

Structural Earth Fill

Structural earth fill consists of the work associated with preparing the foundation of the dam or other embankment by: spreading, harrowing, sprinkling, compacting, removing objectionable materials, and all other incidental work required for the construction, protection, and maintenance of the dam or other embankment. The volume of structural earth fill will be measured in cubic yards by the method of average cross-sectional end areas of in-place material needed for the dam or other embankment.

Structural earth fill is a measured quantity and is estimated at $6.8 per cubic yard (CY).

Slurry Trench / Grout Curtain

This work consists of furnishing all labor, equipment, materials, and means of performing all operations as required for installing a slurry wall and grout curtain for all new dam/lake alternatives.

Slurry trench / grout curtain is a lump-sum quantity and is estimated at $878,000.

Riprap

This item includes all labor, materials, and equipment necessary to excavate, prepare subgrade, and install rock riprap for the dam embankment or other locations. The rock riprap will be used to protect the dam embankment from wave erosion or to protect other areas from erosion created by turbulence or other forces in water conveyance.

Riprap is a measured quantity and is estimated at $80 per CY.

Instrumentation

This item includes all piezometer, settlement gages, movement markers, and other miscellaneous materials and equipment necessary to furnish and install all instrumentation needed for the intake structure.

Instrumentation is a lump-sum quantity and is estimated at $250,000.

Spillway

This line item includes the excavation, concrete, reinforcing steel, fence, and other miscellaneous materials and equipment necessary for a fully functioning spillway.

The spillway is a lump-sum quantity and is estimated at $4,451,000.

Intake Structure

This line item includes concrete, reinforcing steel, gates, wall thimbles, pipe, doors, hatches, ladders, controls, trash racks, grating, and all other miscellaneous materials and equipment needed for a fully functioning intake structure

Intake structure is a lump-sum quantity and is estimated at $1,432,000.

Access Bridge

This item includes a prefabricated access bridge, concrete, reinforcing steel, anchor bolts, and other miscellaneous materials and equipment needed for a fully functioning access bridge.

The access bridge is a lump-sum quantity and is estimated at $550,000.

Outlet Works

This item includes all concrete, reinforcing steel concrete, steel pipe, and other miscellaneous materials and equipment necessary for a fully functioning outlet works including energy dissipation to the principle spillway and transition to the downstream channel.

The outlet works is a lump-sum quantity and is estimated at $1,692,000.

Contractor Construction Staking

Contractor construction staking will be used to provide surveying services and to set the right-of-way (ROW) survey monuments consistent with surveying practices.

Contractor construction staking is a lump-sum quantity and is estimated at $150,000.

Erosion Control

Erosion control must prevent migration of sediment off the construction site throughout the duration of the project. This will include the labor, materials, and equipment necessary to establish and maintain erosion control at the construction site.

Erosion Control is a lump-sum quantity and is estimated at $150,000.

Water Treatment Plant

This item includes all labor, materials, and equipment necessary for a fully functioning water treatment plant. This cost has shown to be the same whether the water is being purchased from a provider or a new water treatment plant is constructed. The cost for this is based on $5 per gallon of treated water capacity.

The water treatment plant is a lump-sum quantity and is estimated at $35,000,000 based on a water treatment plant capacity of 7 million gallons per day (MGD). This item is not part of the project being evaluated, and thus the cost is not included as an explicit cost in the alternative cost analysis. This item is included as a related action in the analysis of alternatives.

Intermediate Booster Pump Station

The intermediate booster pump station is used to transfer water from the source to the Milan Water Treatment Plant for each option This item includes all labor, materials, and equipment necessary for a fully functioning intermediate pump station. Electrical service and telemetry costs are also included in this line item.

The number of pump stations needed for each alternative was determined by estimating the head loss through the force main used to transfer water from the source to the Milan Treatment Plant. Head loss is a factor of total force main length and elevation difference from the source and Milan Treatment Plant.

Intermediate booster pump stations are a measured quantity and are estimated at $1,100,000 each for each pump station.

30-inch Raw Water Main

This item includes all excavation, pipe material, bedding, trench checks, placing, fittings, pipe-to-pipe connections, sealing backfilling, compacting, grading, and removal of excess or unsuitable backfill material.

The diameter of the Raw Water Main (30”) was chosen because it had the high-flow carrying capability with low friction loss through the pipe wall.

The thirty-inch raw water main is a measured quantity and is estimated at $200 per linear foot (LF).

30-inch Directional Boring

This item includes all excavation, existing utility line locating, spoil removal, pipe installation, tracer wire, backfilling, compacting, grading, and removal of excess or unsuitable material.

The measurement for this line item is based on the total number of stream crossings for the raw water main. Whether a stream will require boring is based on the stream classification. Stream classifications 1 – 3 will be open cut. Stream classifications 4 – 6 will have an assumed depth of bore of 20 feet, for a total bore assumed length of 1,300 linear feet (LF) per crossing.

Thirty-inch directional boring is a measured quantity and is estimated at $500 per LF.

42-inch Directional Boring

This item includes all excavation, existing utility line locating, spoil removal, pipe installation, tracer wire, backfilling, compacting, grading, and removal of excess or unsuitable material.

The measurement for this line item is based on the total number of road crossings for the raw water main. If the road crossing is gravel, it is assumed that the road would be open cut and boring would not be necessary. Forty-two-inch boring is only calculated for paved road crossings. The total length of bore for 42-inch borings is assumed to be 200 LF.

Forty-two-inch directional boring is a measured quantity and is estimated at $600 per LF.

42-inch Steel Encasement

This item includes all excavation, bedding, trench checks, placing, fittings, boring, casing spacers, end seals, backfilling, compacting, grading and removal of excess or unsuitable material.

Steel Encasement is a measured quantity and is estimated at $300 per LF.

30-inch Valves

This bid item includes all labor and materials, equipment, excavation, backfill, and incidental items to complete the work. This also includes the cost for air release valves for the transmission main. It is assumed that one 30-inch valve will be needed for every mile of the transmission main.

Thirty-inch valves are a measured quantity and are estimated at $30,000 each.

Access Roads

The measurement for this line item assumes that 0.05 mile of a 20-foot-wide access road is needed for all intermediate pump stations and 30-inch valves. The cost includes all labor, materials, equipment, excavation, backfill, aggregate surfacing, and incidental items to complete the work.

Access roads are a measured quantity and are estimated at $75,000 per mile.

Road Repairs

The measurement for this line item is based on the amount of road crossings that are to be open cut. It is assumed that all gravel roads that are crossed will be open cut. It is also assumed that each road repair at a gravel crossing will be for a 5-foot-wide and 25-foot-long strip of gravel roadway.

Road repairs are a measured quantity and are estimated at $75 per square yard.

Cleanup, Finish Grading, Seeding, and Mulching

This item consists of cleanup, finish grading, seeding, and mulching within a 75-foot-wide corridor along the centerline of the raw water main (37.5 feet each side), the site for each intermediate pump station, and any other site needed for each alternative.

Cleanup, finish grading, seeding, and mulching is a measured quantity and is estimated at $7,500 per acre.

Miscellaneous Dam Appurtenances

This item includes abutment grouting, subsurface anomalies, subgrade stabilization/replacement, isolated French drains or blanket drains, or other isolated mitigation actions necessary to ensure long-term stability and safe operation of the dam.

Miscellaneous dam appurtenances are a lump sum quantity and are estimated at $2,000,000.

Wetland Storage

This item consists of the cost of all labor, equipment, excavation, and materials necessary for the construction of a wetland storage area.

Wetland storage is a measured quantity based on $5,000 per acre of land needed.

Box Culvert

This item includes the cost of all labor, materials, equipment, excavation, concrete, restoration, and incidental items needed for the installation of a box culvert.

The box culvert is a measured quantity and is estimated at $600 per LF of culvert installed.

Bridges

This item includes the cost of all labor, materials, equipment, excavation, steel, concrete, restoration, and miscellaneous items needed for the installation of a bridge.

Bridges are a measured quantity of $155 for each square foot of bridge installed.

Utility Relocation

The areas to be inundated for the reservoirs potentially include existing phone, electric, cable, internet, gas, or other utility facilities that may be affected by a static water surface and associated increase in groundwater level. These facilities often run along existing roadway and road ROWs, and they may also be located in a dedicated, private easement. The particular details of the allocation of costs related to relocation are part of agreements negotiated by each utility, and the details of these agreements were not reviewed (and may not be available). This cost item provides an allowance for the cost of relocation for utility facilities, either above ground or below ground, which may be affected by the reservoir. The cost of utility relocation is unknown until further detailed analysis and negotiation is completed with each individual utility company. Preliminary costs and identification of utilities present has been most fully developed on the East Locust Creek alternative, and these costs were used as a baseline to correlate lake size with potential utility relocation costs.

Reservoir Preparation

The Reservoir Preparation includes the costs and contingencies for identifying and mitigating potential contaminant sources in the reservoir as well as completing other work in the reservoir area to preserve and ensure stability of the new reservoir shoreline and adjacent features. This work includes potential construction of small pond dam structure modifications, sediment and debris basins, property and potential hazardous waste cleanup, building and other demolition, cistern/well capping, lagoon decommissioning, railroad bed cleanup, shoreline protection, road replacement, and other miscellaneous items that are needed to ensure longevity and sustainability of the reservoir area. Preliminary costs and identification of reservoir preparation has been most fully developed on the East Locust Creek alternative, and these costs were used as a baseline to correlate lake size with potential reservoir preparation costs.

Engineering Services

The engineering service cost for the project is estimated at 10 percent of the total construction cost of the project, including contingency. The engineering costs include survey, geotechnical, design, permitting, bidding, construction administration, materials testing, construction observation, and project close-out.

Other Professional Services and Miscellaneous

Appraisal / Descriptions

Appraisal costs are a measured quantity and are estimated at 10 percent of the total land acquisition costs.

Land Acquisition

This line item is based on the amount of land to be purchased for the project. This includes the land needed for the raw water main, the intermediate booster pump stations, and the reservoir (if needed). It is assumed that 50 feet of permanent easement or ROW will be needed for the entire length of the raw water main, 1 acre per intermediate booster pump station, and 1.5 times the total “normal pool” lake acreage.

Land acquisition is a measured quantity and is estimated at $3,900 per acre.

Recreation Cost

Parking Lot Drive Lane Construction

This line item includes the excavation, subgrade, concrete, asphalt, and other miscellaneous materials needed for the construction of a parking lot drive lane.

Parking lot drive lane construction is a measured quantity and is estimated at $10 per square foot.

Parking Lot

This line item includes the excavation, subgrade, concrete, asphalt, and other miscellaneous materials needed for the construction of a parking lot.

The parking lot is a measured quantity by number of parking spaces needed. This is estimated at $4,710 per parking space.

Universal Access and Other Amenities

This line item includes improvements related to universal access, piers, docks, ramps, jetties, privies, and other recreational amenities.

The universal access and other amenities are a lump sum item estimated at $1,000,000,

Mitigation Cost

Mitigation costs were estimated based on impacts to streams and wetlands. Stream and wetland impacts were determined by National Wetlands Inventory (NWI), Missouri Stream Classification, and National Hydrography Dataset (NHD). A consistent unit value cost was determined for a wetland acre ($18,000 per acre) and stream foot ($30 per foot) and multiplied by an alternative stream or wetland impact.

Project Capital and Operation and Maintenance Cost Estimates

The project capital cost estimate is the sum of construction, engineering services, other professional services, recreation, and mitigation costs needed for the project as shown in the detailed conceptual level cost estimates.

There are two separate items added together to get the present worth of the uniform series of annual operation and maintenance (O&M) value. The first is the annual electrical cost for the booster station(s) to pump the water. This cost is based on $0.10 per kilowatt hour, with a 1.1 peaking factor. The amount of water pumped was assumed to increase on a yearly basis with the total needed (7MGD) for the system reached after 50 years. The second value is the annual reservoir and transmission line labor, maintenance, and equipment cost. This cost was based on 0.4 percent of the total installation cost, less mitigation, for the alternative. Also included in this calculation was a discount rate. The discount rate that was used was 5.125 percent, consistent with the 2006 FEIS. These costs were totaled on an annual basis up to 75 years.

The cost of the project in 2018 dollars is calculated by summing the project capital cost with the present worth of the 100-year maintenance costs for the project.

Multipurpose Cost Summary

The costs described in this appendix are for individual or dual-purpose alternatives described in the alternatives section above. The table below summarizes the costs based on the multipurpose alternatives.

Multipurpose Alternative	Water Supply Costs	Water-Based Recreation Costs	Flood Damage Reduction Costs	Total Costs
RW1	$102,900,000			**$102,900,000**
MA2	$188,300,000		16,800,000	**$205,100,000**
MA3	$163,100,000		16,800,000	**$179,900,000**
MA4	$212,500,000		16,800,000	**$229,300,000**
MA5	$173,300,000		16,800,000	**$190,100,000**
MA6	Pipeline = $260,600,000 Hazel Creek = $52,100,000 Green City = $53,700,000 Elmwood = $46,900,000 Forest = $85,500,000		16,800,000	**$515,600,000**

Creation of New Online Channel Reservoir – East Locust Creek (RW1)

This alternative is described in Section 2.1.2.6. The construction of the dam would require approximately 3,400 acres of land acquisition, 200 acres of clearing and grubbing, 981,100 CY of structural earth fill, and 15,200 CY of riprap. The dam would also need instrumentation, a slurry trench / grout curtain spillway, an intake structure, an access bridge, outlet works, contractor construction staking, erosion control, and miscellaneous dam appurtenances.

A 24,700-LF raw water main would be constructed from the RW1 dam to transfer water to the water treatment plant at Milan. This will require one intermediate booster station, 200 LF of 42-inch directional boring and 42-inch steel encasement, five 30-inch valves, 0.8 mile of access road, 14 square yards of road repairs, and 42 acres of cleanup, finish grading, seeding, and mulching.

This alternative provides a water supply that requires a water treatment plant (7.0 MGD). This alternative also provides recreation and has 224 parking spaces and 9,630 square feet of parking lot construction.

Water Supply, Recreation and Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Proposed Action – East Locust Creek Reservoir (RW1)					
1.00	**Construction**	**Quantity**	**Unit***	**Unit Cost**	**Total**
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 2,048,000	$ 2,048,000
1.02	Clearing and Grubbing	200	Acres	$ 2,500	$ 500,000
1.03	Structural Earth Fill	922,100	CY	$ 6.80	$ 6,270,300
1.04	Chimney and Blanket Drain Aggregate	59,000	CY	$ 70.00	$ 4,130,000
1.05	Slurry Trench/Grout Curtain	1	L.S.	$ 878,000	$ 878,000
1.06	Riprap	15,200	CY	$ 80	$ 1,216,000
1.07	Instrumentation	1	L.S.	$ 250,000	$ 250,000
1.08	Spillway	1	L.S.	$ 4,451,000	$ 4,451,000
1.09	Intake Structure	1	Each	$ 1,432,000	$ 1,432,000
1.10	Access Bridge	1	L.S.	$ 550,000	$ 550,000
1.11	Outlet Works	1	L.S.	$ 1,692,000	$ 1,692,000
1.12	Contractor Construction Staking	1	L.S.	$ 150,000	$ 150,000
1.13	Erosion Control	1	L.S.	$ 150,000	$ 150,000
1.14	30-inch Raw Water Main	24,700	LF	$ 200	$ 4,940,000
1.15	42-inch Directional Boring	200	LF	$ 600	$ 120,000
1.16	42-inch Steel Encasement	200	LF	$ 300	$ 60,000
1.17	30-inch Valves	5	Each	$ 30,000	$ 150,000
1.18	Access Roads	0.8	Mi	$ 75,000	$ 60,000
1.19	Road Repairs	14	Sq. Yd.	$ 75	$ 1,100
1.20	Clean Up, Finish Grading, Seeding, Mulch	43	Acres	$ 7,500	$ 322,500
1.21	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$ 2,000,000
				Subtotal	**$ 31,370,900**
1.22	Contingencies (30%)				$9,411,300
				Construction Subtotal	**$ 40,800,000**

2.00	**Utility Relocation**	**2,328**	**Acres**	**$ 2,280**	**$ 5,300,000**
				Utility Relocation Subtotal	**$ 5,300,000**

3.00	**Reservoir Preparation**	**2,328**	**Acres**	**$ 7,500**	**$ 17,500,000**
				Reservoir Preparation Subtotal	**$ 17,500,000**

4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$ 6,400,000**
				Engineering Subtotal	**$ 6,400,000**

5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$ 1,774,500
5.02	Land Acquisition	4,550	Acres	$ 3,900	$ 17,745,000
				Other Subtotal	**$ 19,500,000**
6.00	**Recreation Construction Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$ 10	$ 96,300
6.02	Parking Lot	224	Spaces	$ 4,710	$ 1,055,100
6.03	Universal Access and Other Amenities	1	L.S.	$ 1,000,000	$ 1,000,000
				Recreation Subtotal	**$ 2,200,000**

7.00	**Mitigation**	**$ 7,300,000**
	Mitigation Subtotal	**$ 7,300,000**
	Project Capital Cost	**$ 99,000,000**
	Project O&M PV	**$ 4,000,000**
	Project Cost	**$ 102,900,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 98,208 feet
Wetland Impacts = 242 acres

Big Locust Creek Reservoir (DPA 2)

This alternative is described in Section 2. The construction of the dam would require approximately 8,900 acres of land acquisition, 600 acres of clearing and grubbing, 1,340,900 CY of structural earth fill, and 20,800 CY of riprap. The dam would also need instrumentation, a slurry trench / grout curtain spillway, **an intake structure, an access bridge, outlet works, contractor construction staking, erosion control, and miscellaneous dam appurtenances.**

A 23,500-LF raw water main would be constructed from the DPA 2 dam to transfer water to the water treatment plant at Milan. This will require two intermediate booster stations, 800 LF of 42-inch directional boring and 42-inch steel encasement, five 30-inch valves, 1.1 miles of access roads, 38 square yards (SY) of road repairs, and 41 acres of cleanup, finish grading, seeding, and mulching.

This alternative provides a water supply that requires a water treatment plant (7.0 MGD). This alternative also provides recreation and has 585 parking spaces and 9,630 square feet of parking lot construction.

Water Supply, Recreation and Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Big Locust Creek Reservoir (DPA 2)					
1.00	**Construction**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 2,560,000	$ 2,560,000
1.02	Clearing and Grubbing	600	Acres	$ 2,500	$ 1,500,000
1.03	Structural Earth Fill	1,184,300	CY	$ 6.80	$ 8,053,300
1.04	Chimney and Blanket Drain Aggregate	76,000	CY	$ 70.00	$ 5,320,000
1.05	Slurry Trench/Grout Curtain	1	L.S.	$ 878,000	$ 878,000
1.06	Riprap	20,800	CY	$ 80	$ 1,664,000
1.07	Instrumentation	1	L.S.	$ 250,000	$ 250,000
1.08	Spillway	1	L.S.	$ 4,451,000	$ 4,451,000
1.09	Intake Structure	1	Each	$ 1,432,000	$ 1,432,000
1.10	Access Bridge	1	L.S.	$ 550,000	$ 550,000
1.11	Outlet Works	1	L.S.	$ 1,692,000	$ 1,692,000
1.12	Contractor Construction Staking	1	L.S.	$ 150,000	$ 150,000
1.13	Erosion Control	1	L.S.	$ 150,000	$ 150,000
1.14	Intermediate Booster Pump Station	2	Each	$ 1,100,000	$ 2,200,000
1.15	30-inch Raw Water Main	23,500	LF	$ 200	$ 4,700,000
1.16	42-inch Directional Boring	800	LF	$ 600	$ 480,000
1.17	42-inch Steel Encasement	800	LF	$ 300	$ 240,000
1.18	30-inch Valves	5	Each	$ 30,000	$ 150,000
1.19	Access Roads	1.1	Mi	$ 75,000	$ 82,500
1.20	Road Repairs	38	Sq. Yd.	$ 75	$ 2,900
1.21	Clean Up, Finish Grading, Seeding, Mulch	41	Acres	$ 7,500	$ 307,500
1.22	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$ 2,000,000
				Subtotal	**$ 38,813,200**

1.23	Contingencies (30%)				$ 11,644,000
				Construction Subtotal	**$ 50,500,000**
2.00	**Utility Relocation**	**5,850**	**Acres**	**$ 2,280**	**$ 13,300,000**
				Utility Relocation Subtotal	**$ 13,300,000**
3.00	**Reservoir Preparation**	**5,850**	**Acres**	**$ 7,500**	**$ 43,875,000**
				Reservoir Preparation Subtotal	**$ 43,875,000**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$ 10,800,000**
				Engineering Subtotal	**$ 10,800,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$ 4,485,000
5.02	Land Acquisition	11,500	Acres	$ 3,900	$ 44,850,000
				Other Subtotal	**$ 49,300,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$ 10	$ 96,300
6.02	Parking Lot	585	Spaces	$ 4,710	$ 2,755,400
6.03	Universal Access and Amenities	1	L.S.	$ 1,000,000	$ 1,000,000
				Recreation Subtotal	**$ 3,900,000**
7.00	**Mitigation**				**$ 30,600,000**
				Mitigation Subtotal	**$ 30,600,000**
				Project Capital Cost	**$ 202,300,000**
				Project O&M PV	**$ 10,200,000**
				Project Cost	**$ 212,500,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 167,904 feet
Wetland Impacts = 1,422 acres

Little East Locust Creek Reservoir (DPA 3)

This alternative is described in Section 2. The construction of the dam would require approximately 5,600 acres of land acquisition, 500 acres of clearing and grubbing, 1,602,300 CY of structural earth fill, and 20,900 CY of riprap. The dam would also need instrumentation, a slurry trench / grout curtain spillway, an intake structure, an access bridge, outlet works, contractor construction staking, erosion control, and miscellaneous dam appurtenances.

A 75,000-LF raw water main would be constructed from the DPA 3 dam to transfer water to the water treatment plant at Milan. This will require two intermediate booster stations, 1,300 LF of 30-inch directional boring, 1,400 LF of 42-inch directional boring with 42-inch steel encasement, 15 30-inch valves, 1.6 miles of access roads, 125 SY of road repairs, and 120 acres of cleanup, finish grading, seeding, and mulching.

This alternative provides a water supply that requires a water treatment plant (7.0 MGD). This alternative also provides recreation and has 365 parking spaces and 9,630 square feet of parking lot construction.

Water Supply, Recreation and Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Little East Locust Creek Reservoir (DPA 3)					
1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 3,683,000	$ 3,683,000
1.02	Clearing and Grubbing	500	Acres	$ 2,500	$ 1,250,000
1.03	Structural Earth Fill	1,415,900	CY	$ 6.80	$ 9,628,200
1.04	Chimney and Blanket Drain Aggregate	90,000	CY	$ 70.00	$ 6,300,000
1.05	Slurry Trench/Grout Curtain	1	L.S.	$ 878,000	$ 878,000
1.06	Riprap	20,900	CY	$ 80	$ 1,672,000
1.07	Instrumentation	1	L.S.	$ 250,000	$ 250,000
1.08	Spillway	1	L.S.	$ 4,451,000	$ 4,451,000
1.09	Intake Structure	1	Each	$ 1,432,000	$ 1,432,000
1.10	Access Bridge	1	L.S.	$ 550,000	$ 550,000
1.11	Outlet Works	1	L.S.	$ 1,692,000	$ 1,692,000
1.12	Contractor Construction Staking	1	L.S.	$ 150,000	$ 150,000
1.13	Erosion Control	1	L.S.	$ 150,000	$ 150,000
1.14	Intermediate Booster Pump Station	2	Each	$ 1,100,000	$ 2,200,000
1.15	30-inch Raw Water Main	75,000	LF	$ 200	$ 15,000,000
1.16	30-inch Directional Boring	1,300	LF	$ 500	$ 650,000
1.17	42-inch Directional Boring	1,400	LF	$ 600	$ 840,000
1.18	42-inch Steel Encasement	1,400	LF	$ 300	$ 420,000
1.19	30-inch Valves	15	Each	$ 30,000	$ 450,000
1.20	Access Roads	1.6	Mi	$ 75,000	$ 120,000
1.21	Road Repairs	125	Sq. Yd.	$ 75	$ 9,400
1.22	Clean Up, Finish Grading, Seeding, Mulch	130	Acres	$ 7,500	$ 975,000
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$ 2,000,000
				Subtotal	**$ 54,750,600**
1.24	Contingencies (30%)				$ 16,425,200

				Construction Subtotal	$ 71,200,000
2.00	Utility Relocation	3,650	Acres	$ 2,280	$ 8,300,000
				Utility Relocation Subtotal	$ 8,300,000
3.00	Reservoir Preparation	3,650	Acres	$ 7,500	$ 27,375,000
				Reservoir Preparation Subtotal	$ 27,375,000
4.00	Engineering Services (10% of Items 1, 2, and 3 Subtotals)				$ 10,700,000
				Engineering Subtotal	$ 10,700,000
5.00	Other Professional Services & Miscellaneous				
5.01	Appraisals / Descriptions				$ 2,808,000
5.02	Land Acquisition	7,200	Acres	$ 3,900	$ 28,080,000
				Other Subtotal	$ 30,900,000
6.00	Recreation Cost				
6.02	Parking Lot Drive Lane Construction	9,630	SF	$ 10	$ 96,300
6.03	Parking Lot	365	Spaces	$ 4,710	$ 1,719,200
6.044	Universal Access and Other Amenities	1	L.S.	$ 1,000,000	$ 1,000,000
				Recreation Subtotal	$ 2,800,000
7.00	Mitigation				$ 8,700,000
				Mitigation Subtotal	$ 8,700,000
				Project Capital Cost	$ 160,000,000
				Project O&M PV	$ 13,300,000
				Project Cost	$ 173,300,000

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 127,248 feet
Wetland Impacts = 269 acres

West Fork Locust Creek Reservoir (DPA 4)

This alternative is described in Section 2. The construction of the dam would require approximately 5,900 acres of land acquisition, 400 acres of clearing and grubbing, 1,694,5008 CY of structural earth fill, and 13,400 CY of riprap. The dam would also need instrumentation, a slurry trench / grout curtain spillway, an intake structure, an access bridge, outlet works, contractor construction staking, erosion control, and miscellaneous dam appurtenances.

A 38,000-LF raw water main would be constructed from the DPA 3 dam to transfer water to the water treatment plant at Milan. This will require two intermediate booster stations, 2,600 LF of 30-inch directional boring, 1,200 LF of 42-inch directional boring with 42-inch steel encasement, 8 30-inch valves, 0.9 mile of access road, 102 SY of road repairs, and 66 acres of cleanup, finish grading, seeding, and mulching.

This alternative provides a water supply that requires a water treatment plant (7.0 MGD). This alternative also provides recreation and has 386 parking spaces and 9,630 square feet of parking lot construction.

Water Supply, Recreation and Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
West Fork Locust Creek Reservoir (DPA4)					
1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 2,964,000	$ 2,964,000
1.02	Clearing and Grubbing	400	Acres	$ 2,500	$ 1,000,000
1.03	Structural Earth Fill	1,496,600	CY	$ 6.80	$ 10,176,900
1.04	Chimney and Blanket Drain Aggregate	96,000	CY	$ 70	$ 6,720,000
1.05	Slurry Trench/Grout Curtain	1	L.S.	$ 878,000	$ 878,000
1.06	Riprap	13,400	CY	$ 80	$ 1,072,000
1.07	Instrumentation	1	L.S.	$ 250,000	$ 250,000
1.08	Spillway	1	L.S.	$ 4,451,000	$ 4,451,000
1.09	Intake Structure	1	Each	$ 1,432,000	$ 1,432,000
1.10	Access Bridge	1	L.S.	$ 550,000	$ 550,000
1.11	Outlet Works	1	L.S.	$ 1,692,000	$ 1,692,000
1.12	Contractor Construction Staking	1	L.S.	$ 150,000	$ 150,000
1.13	Erosion Control	1	L.S.	$ 150,000	$ 150,000
1.14	Intermediate Booster Pump Station	1	Each	$ 1,100,000	$ 1,100,000
1.15	30-inch Raw Water Main	38,000	LF	$ 200	$ 7,600,000
1.16	30-inch Directional Boring	2,600	LF	$ 500	$ 1,300,000
1.17	42-inch Directional Boring	1,200	LF	$ 600	$ 720,000
1.18	42-inch Steel Encasement	1,200	LF	$ 300	$ 360,000
1.19	30-inch Valves	8	Each	$ 30,000	$ 240,000
1.20	Access Roads	0.9	Mi	$ 75,000	$ 67,500
1.21	Road Repairs	102	Sq. Yd.	$ 75	$ 7,700
1.22	Clean Up, Finish Grading, Seeding, Mulch	66	Acres	$ 7,500	$ 495,000
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$ 2,000,000
				Subtotal	**$ 45,376,100**
1.24	Contingencies (30%)				$ 13,612,900
				Construction Subtotal	**$ 59,000,000**

2.00	**Utility Relocation**	**3,860**	**Acres**	**$ 2,280**	**$ 8,800,000**
				Utility Relocation Subtotal	**$ 8,800,000**
3.00	**Reservoir Preparation**	**3,860**	**Acres**	**$ 7,500**	**$ 28,950,000**
				Reservoir Preparation Subtotal	**$ 28,950,000**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$ 9,700,000**
				Engineering Subtotal	**$ 9,700,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$ 2,964,000
5.02	Land Acquisition	7,600	Acres	$ 3,900	$ 29,640,000
				Other Subtotal	**$ 32,600,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$ 10	$ 96,300
6.02	Parking Lot	386	Spaces	$ 4,710	$ 1,818,100
6.03	Universal Access and Other Amenities	1	L.S.	$ 1,000,000	$ 1,000,000
				Recreation Subtotal	**$ 2,900,000**
7.00	**Mitigation**				**$ 10,400,000**
				Mitigation Subtotal	**$ 10,400,000**
				Project Capital Cost	**$ 152,400,000**
				Project O&M PV	**$ 10,700,000**
				Project Cost	**$ 163,100,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 124,608 feet
Wetland Impacts = 372 acres

Yellow Creek Reservoir (DPA 5)

This alternative is described in Section 2. The construction of the dam would require approximately 5,000 acres of land acquisition, 500 acres of clearing and grubbing, 1,409,100 CY of structural earth fill, and 14,900 CY of riprap. The dam would also need instrumentation, a slurry trench / grout curtain spillway, an intake structure, an access bridge, outlet works, contractor construction staking, erosion control, and miscellaneous dam appurtenances.

A 133,900-LF raw water main would be constructed from the DPA 3 dam to transfer water to the water treatment plant at Milan. This will require two intermediate booster stations, 3,900 LF of 30-inch directional boring, 2,200 LF of 42-inch directional boring with 42-inch steel encasement, 27 30-inch valves, 2.0 miles of access roads, 200 SY of road repairs, and 231 acres of cleanup, finish grading, seeding, and mulching.

This alternative provides a water supply that requires a water treatment plant (7.0 MGD). This alternative also provides recreation and has 321 parking spaces and 9,630 square feet of parking lot construction.

Water Supply, Recreation and Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Yellow Creek Reservoir (DPA 5)					
1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 4,824,000	$ 4,824,000
1.02	Clearing and Grubbing	500	Acres	$ 2,500	$ 1,250,000
1.03	Structural Earth Fill	1,245,400	CY	$ 6.80	$ 8,468,800
1.04	Chimney and Blanket Drain Aggregate	79,000	CY	$ 70	$ 5,530,000
1.05	Slurry Trench/Grout Curtain	1	L.S.	$ 878,000	$ 878,000
1.06	Riprap	14,900	CY	$ 80	$ 1,192,000
1.07	Instrumentation	1	L.S.	$ 250,000	$ 250,000
1.08	Spillway	1	L.S.	$ 4,451,000	$ 4,451,000
1.09	Intake Structure	1	Each	$ 1,432,000	$ 1,432,000
1.10	Access Bridge	1	L.S.	$ 550,000	$ 550,000
1.11	Outlet Works	1	L.S.	$ 1,692,000	$ 1,692,000
1.12	Contractor Construction Staking	1	L.S.	$ 150,000	$ 150,000
1.13	Erosion Control	1	L.S.	$ 150,000	$ 150,000
1.14	Intermediate Booster Pump Station	3	Each	$ 1,100,000	$ 3,300,000
1.15	30-inch Raw Water Main	133,900	LF	$ 200	$ 26,780,000
1.16	30-inch Directional Boring	3,900	LF	$ 500	$ 1,950,000
1.17	42-inch Directional Boring	2,200	LF	$ 600	$ 1,320,000
1.18	42-inch Steel Encasement	2,200	LF	$ 300	$ 660,000
1.19	30-inch Valves	27	Each	$ 30,000	$ 810,000
1.20	Access Roads	2	Mi	$ 75,000	$ 150,000
1.21	Road Repairs	200	Sq. Yd.	$ 75	$ 15,000
1.22	Clean Up, Finish Grading, Seeding, Mulch	231	Acres	$ 7,500	$ 1,732,500
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$ 2,000,000
				Subtotal	**$ 69,535,300**
1.24	Contingencies (30%)				$ 20,860,600
					$ 90,400,000

2.00	**Utility Relocation**	**3,210**	**Acres**	**$ 2,280**	**$**	**7,300,000**
				Utility Relocation Subtotal	**$**	**7,300,000**
3.00	**Reservoir Preparation**	**3,210**	**Acres**	**$ 7,500**	**$**	**24,075,000**
				Reservoir Preparation Subtotal	**$**	**24,075,000**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$**	**12,200,000**
				Engineering Subtotal	**$**	**12,200,000**
5.00	**Other Professional Services & Miscellaneous**					
5.01	Appraisals / Descriptions				$	2,457,000
5.02	Land Acquisition	6,300	Acres	$ 3,900	$	24,570,000
				Other Subtotal	**$**	**27,000,000**
6.00	**Recreation Cost**					
6.01	Parking Lot Drive Lane Construction	9,630	SF	$ 10	$	96,300
6.02	Parking Lot	321	Spaces	$ 4,710	$	1,512,000
6.03	Universal Access and Other Amenities	1	L.S.	$ 1,000,000	$	1,000,000
				Recreation Subtotal	**$**	**2,600,000**
7.00	**Mitigation**				**$**	**7,300,000**
				Mitigation Subtotal	**$**	**7,300,000**
				Project Capital Cost	**$**	**170,900,000**
				Project O&M PV	**$**	**17,400,000**
				Project Cost	**$**	**188,300,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 137,280 feet
Wetland Impacts = 179.1 acres

Water Supply Combination Alternative (WA20) and Expand Existing Public Lakes (RA2)

The Water Supply Combination (WA20) and Expand Existing Public Lakes (RA2) alternatives both include replacing the dams for Forest Lake and Green City Lake. These alternatives are combined for a multipurpose alternative and thus their associated costs are included together below. The costs associated with the flood damage reduction alternative are not included.

The Water Supply Combination alternative includes 300 miles of pipeline from the existing water systems to Milan.

Water Supply Combination Alternative (Pipeline Costs)

	Livingston County PWSD No. 4	MMU	Missouri American Brunswick	Salisbury	Chillicothe Municipal Utilities
Pipe Diameter (inches)	6	6	12	6	12
Unit Cost (miles)	100	100	150	100	150
Pipeline Length (miles)	49.5	68.5	64.5	76.7	39.3
Pipe Costs	**$26,162,137**	**$36,171,132**	**$51,066,054**	**$40,510,840**	**$31,123,276**
Intermediate Pump Stations	2	3	3	4	2
Unit Pump Station Cost	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000
Pump Costs	**$2,200,000**	**$3,300,000**	**$3,300,000**	**$4,400,000**	**$2,200,000**
Subtotal	**$28,362,137**	**$39,471,132**	**$54,366,054**	**$44,910,840**	**$33,323,276**
Contingency	$8,508,641	$11,841,340	$16,309,816	$13,473,252	$9,996,983
Individual Water System Total	**$36,870,778**	**$51,312,472**	**$70,675,870**	**$58,384,092**	**$43,320,259**
				Project Total Pipeline Costs	**$260,600,000**

Note: All stream and wetland impacts are temporary and no mitigation is calculated.

Hazel Creek Lake

1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$2,100,000	$2,100,000
1.02	Clearing and Grubbing	100	Acres	$2,500	$250,000
1.03	Dam Decommissioning and Silt Removal	1	L.S.	$5,000,000	$5,000,000
1.04	Structural Earth Fill	725,600	CY	$6.80	$4,934,100
1.05	Chimney and Blanket Drain Aggregate	49,700	CY	$70.00	$3,479,000
1.06	Slurry Trench/Grout Curtain	1	L.S.	$878,000	$878,000
1.07	Riprap	12,800	CY	$80	$1,024,000
1.08	Instrumentation	1	L.S.	$250,000	$250,000
1.09	Spillway	1	L.S.	$4,451,000	$4,451,000
1.10	Intake Structure	1	Each	$1,432,000	$1,432,000
1.11	Access Bridge	1	L.S.	$550,000	$550,000
1.12	Outlet Works	1	L.S.	$1,692,000	$1,692,000
1.13	Contractor Construction Staking	1	L.S.	$150,000	$150,000
1.14	Erosion Control	1	L.S.	$150,000	$150,000
1.20	Access Roads	0.5	Mi	$75,000	$37,500
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$ 2,000,000	$2,000,000
				Subtotal	**$28,377,600**
1.23	Contingencies (30%)				$8,513,300
				Construction Subtotal	**$36,900,000**
2.00	**Utility Relocation**	**427**	**Acres**	**$2,280**	**$1,000,000**
				Utility Relocation Subtotal	**$1,000,000**
3.00	**Reservoir Preparation**	**427**	**Acres**	**$7,500**	**$3,202,500**
				Reservoir Preparation Subtotal	**$3,202,500**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$4,100,000**
				Engineering Subtotal	**$4,100,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$351,000
5.02	Land Acquisition	900	Acres	$3,900	$3,510,000
				Other Subtotal	**$3,900,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$10	$96,300
6.02	Parking Lot	43	Spaces	$4,710	$202,600
6.03	Universal Access and Other Amenities	1	L.S.	$1,000,000	$1,000,000
				Recreation Subtotal	**$1,300,000**
7.00	**Mitigation**				**$1,210,000**

Mitigation Subtotal	**$1,210,000**
Project Capital Cost	**$51,600,000**
Project O&M PV	**$500,000**
Project Cost	**$52,100,000**

L.S. = Lump Sum; CY = Cubic Yards; SF = Square Feet; Mi = Miles

Note: Stream Impacts = 26,928 feet
Wetland Impacts = 22.2 acres

Green City Lake

1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$2,100,000	$2,100,000
1.02	Clearing and Grubbing	100	Acres	$2,500	$250,000
1.03	Dam Decommissioning and Silt Removal	1	L.S.	$5,000,000	$5,000,000
1.04	Structural Earth Fill	661,700	CY	$6.80	$4,499,600
1.05	Chimney and Blanket Drain Aggregate	45,300	CY	$70.00	$3,171,000
1.06	Slurry Trench/Grout Curtain	1	L.S.	$878,000	$878,000
1.07	Riprap	11,700	CY	$80	$936,000
1.08	Instrumentation	1	L.S.	$250,000	$250,000
1.09	Spillway	1	L.S.	$4,451,000	$4,451,000
1.10	Intake Structure	1	Each	$1,432,000	$1,432,000
1.11	Access Bridge	1	L.S.	$550,000	$550,000
1.12	Outlet Works	1	L.S.	$1,692,000	$1,692,000
1.13	Contractor Construction Staking	1	L.S.	$150,000	$150,000
1.14	Erosion Control	1	L.S.	$150,000	$150,000
1.16	6-inch Raw Water Main	61,800	L.F.	$85	$5,253,000
1.17	18-inch Directional Boring	1,000	L.F.	$600	$400,000
1.18	18-inch Steel Encasement	1,000	L.F.	$300	$200,000
1.19	6-inch Valves	12	Each	$4,000	$48,000
1.20	Access Roads	1.0	Mi	$75,000	$75,000
1.21	Road Repairs	186	Sq. Yd.	$100	$18,600
1.22	Clean Up, Finish Grading, Seeding, Mulch	107	Acres	$7,500	$802,500
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$2,000,000	$2,000,000
				Subtotal	**$34,306,700**
1.23	Contingencies (30%)				$10,292,100
				Construction Subtotal	**$44,600,000**
2.00	**Utility Relocation**	**127**	**Acres**	**$2,280**	**$300,000**
				Utility Relocation Subtotal	**$300,000**

3.00	**Reservoir Preparation**	**127**	**Acres**	**$7,500**	**$952,500**
				Reservoir Preparation Subtotal	**$952,500**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$4,600,000**
				Engineering Subtotal	**$4,600,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$117,000
5.02	Land Acquisition	300	Acres	$3,900	$1,170,000
				Other Subtotal	**$1,300,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$10	$96,300
6.02	Parking Lot	13	Spaces	$4,710	$61,300
6.03	Universal Access and Other Amenities	1	L.S.	$1,000,000	$1,000,000
				Recreation Subtotal	**$1,200,000**
7.00	**Mitigation**				**$270,000**
				Mitigation Subtotal	**$270,000**
				Project Capital Cost	**$53,200,000**
				Project O&M PV	**$500,000**
				Project Cost	**$ 53,700,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 4,330 feet
Wetland Impacts = 7.3 acres

Elmwood Lake

1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$1,980,000	$1,980,000
1.02	Clearing and Grubbing	100	Acres	$2,500	$250,000
1.03	Dam Decommissioning and Silt Removal	1	L.S.	$5,000,000	$5,000,000
1.04	Structural Earth Fill	607,300	CY	$6.80	$4,129,700
1.05	Chimney and Blanket Drain Aggregate	41,600	CY	$70.00	$2,912,000
1.06	Slurry Trench/Grout Curtain	1	L.S.	$878,000	$878,000
1.07	Riprap	10,700	CY	$80	$856,000
1.08	Instrumentation	1	L.S.	$250,000	$250,000
1.09	Spillway	1	L.S.	$4,451,000	$4,451,000
1.10	Intake Structure	1	Each	$1,432,000	$1,432,000
1.11	Access Bridge	1	L.S.	$550,000	$550,000
1.12	Outlet Works	1	L.S.	$1,692,000	$1,692,000
1.13	Contractor Construction Staking	1	L.S.	$150,000	$150,000

1.14	Erosion Control	1	L.S.	$150,000	$150,000
1.20	Access Roads	0.4	Mi	$75,000	$30,000
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$2,000,000	$2,000,000
				Subtotal	**$26,710,700**
1.23	Contingencies (30%)				$8,013,300
				Construction Subtotal	**$34,700,000**
2.00	**Utility Relocation**	**294**	**Acres**	**$2,280**	**$700,000**
				Utility Relocation Subtotal	**$700,000**
3.00	**Reservoir Preparation**	**294**	**Acres**	**$7,500**	**$2,205,000**
				Reservoir Preparation Subtotal	**$2,205,000**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$3,800,000**
				Engineering Subtotal	**$3,800,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$234,000
5.02	Land Acquisition	600	Acres	$3,900	$2,340,000
				Other Subtotal	**$2,600,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$10	$96,300
6.02	Parking Lot	30	Spaces	$4,710	$141,300
6.03	Universal Access and Other Amenities	1	L.S.	$1,000,000	$1,000,000
				Recreation Subtotal	**$1,200,000**
7.00	**Mitigation**				**$1,180,000**
				Mitigation Subtotal	**$1,180,000**
				Project Capital Cost	**$46,400,000**
				Project O&M PV	**$500,000**
				Project Cost	**$46,900,000**

L.S. = Lump Sum; CY = Cubic Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 22,704 feet
Wetland Impacts = 27.5 acres

Forest Lake

1.00	Construction	Quantity	Unit	Unit Cost	Total
1.01	Mobilization, Bonding, Insurance	1	L.S.	$2,100,000	$2,100,000
1.02	Clearing and Grubbing	300	Acres	$2,500	$750,000
1.03	Dam Decommissioning and Silt Removal	1	L.S.	$5,000,000	$5,000,000
1.04	Structural Earth Fill	716,100	CY	$6.80	$4,869,500
1.05	Chimney and Blanket Drain Aggregate	49,000	CY	$70.00	$3,430,000
1.06	Slurry Trench/Grout Curtain	1	L.S.	$878,000	$878,000
1.07	Riprap	12,700	CY	$80	$1,016,000
1.08	Instrumentation	1	L.S.	$250,000	$250,000
1.09	Spillway	1	L.S.	$4,451,000	$4,451,000
1.10	Intake Structure	1	Each	$1,432,000	$1,432,000
1.11	Access Bridge	1	L.S.	$550,000	$550,000
1.12	Outlet Works	1	L.S.	$1,692,000	$1,692,000
1.13	Contractor Construction Staking	1	L.S.	$150,000	$150,000
1.14	Erosion Control	1	L.S.	$150,000	$150,000
1.15	Intermediate Booster Pump Station	1	Each	$1,100,000	$1,100,000
1.16	12-inch Raw Water Main	153,200	L.F.	$125	$19,150,000
1.17	24-inch Directional Boring	2,600	L.F.	$500	$1,300,000
1.18	24-inch Steel Encasement	2,600	L.F.	$250	$650,000
1.19	12-inch Valves	30	Each	$5,000	$150,000
1.20	Access Roads	2.0	Mi	$75,000	$150,000
1.21	Road Repairs	510	Sq. Yd.	$100	$51,000
1.22	Clean Up, Finish Grading, Seeding, Mulch	265	Acres	$7,500	$1,987,500
1.23	Miscellaneous Dam Appurtenances	1	L.S.	$2,000,000	$2,000,000
				Subtotal	**$53,257,000**
1.23	Contingencies (30%)				$15,977,100
				Construction Subtotal	**$69,200,000**
2.00	**Utility Relocation**	**349**	**Acres**	**$2,280**	**$800,000**
				Utility Relocation Subtotal	**$800,000**
3.00	**Reservoir Preparation**	**349**	**Acres**	**$7,500**	**$2,617,500**
				Reservoir Preparation Subtotal	**$2,617,500**
4.00	**Engineering Services (10% of Items 1, 2, and 3 Subtotals)**				**$7,300,000**
				Engineering Subtotal	**$7,300,000**
5.00	**Other Professional Services & Miscellaneous**				
5.01	Appraisals / Descriptions				$273,000
5.02	Land Acquisition	700	Acres	$3,900	$2,730,000
				Other Subtotal	**$3,000,000**
6.00	**Recreation Cost**				
6.01	Parking Lot Drive Lane Construction	9,630	SF	$10	$96,300
6.02	Parking Lot	35	Spaces	$4,710	$164,900

6.03	Universal Access and Other Amenities	1	L.S.	$1,000,000	$1,000,000
				Recreation Subtotal	**$1,300,000**
7.00	**Mitigation**				**$780,000**
				Mitigation Subtotal	**$780,000**
				Project Capital Cost	**$85,000,000**
				Project O&M PV	**$500,000**
				Project Cost	**$85,500,000**

L.S. = Lump Sum; CY = Cubic Yards; Sq. Yd. = Square Yards; SF = Square Feet; LF = Linear Feet; Mi = Miles

Note: Stream Impacts = 19,536 feet
Wetland Impacts = 10.5 acres

Floodplain Acquisition (FA 2)

This alternative is described in Section 2. This alternative will require land acquisition of approximately 3,700 acres.

Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Floodplain Acquisition (FA 2)					
1.00	**Other Professional Services & Miscellaneous**				
1.01	Appraisals / Descriptions				$ 1,443,000
1.02	Land Acquisition	3,700	Acres	$ 3,900	$ 14,430,000
				Subtotal	**$ 15,900,000**
				Project Capital Cost	**$ 15,900,000**
				Project O&M Cost	**$ 900,000**
				Project Cost	**$ 16,800,000**

Note: Stream Impacts = 0 feet
Wetland Impacts = 0 acres

Wetland Storage Areas (FA 6)

This alternative is described in Section 2 of this report. This alternative will require 6,141 acres of wetland storage and 9,212 acres of land acquisition.

1.00	Other Professional Services & Miscellaneous				
1.01	Appraisals / Descriptions				$ 3,592,700
1.02	Wetland Storage	6,141	Acres	$ 5,000	$ 30,705,000
1.03	Land Acquisition	9,212	Acres	$ 3,900	$ 35,926,800
				Other Subtotal	**$ 70,200,000**
4.00	**Mitigation**				**$ 6,870,000**
				Mitigation Subtotal	**$ 6,870,000**
				Project Capital Cost	**$ 77,100,000**
				Project O&M Cost	**$ 4,600,000**
				Project Cost	**$ 81,700,000**

Note: Stream Impacts = 229,152 feet
Wetland Impacts = 0 acres

Large Dry Dam – 100-year (FA 7)

This alternative is described in Section 2 of this report. This alternative will require clearing and grubbing of 16 acres, 133,300 CY of structural earth fill, 1,700 CY of riprap, 550 LF of box culvert, and 9 acres of cleanup, finish grading, seeding and mulching. This alternative will also require land acquisition of 1,060 acres.

Flood Damage Reduction Alternative					
Opinion of Probable Project Cost					
Large Dry Dam – 100-year Storage (FA 7)					
1.00	**Construction**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1.01	Mobilization, Bonding, Insurance	1	L.S.	$ 119,000	$ 119,000
1.02	Clearing and Grubbing	16	CY	$ 2,500	$ 40,000
1.03	Structural Earth Fill	133,300	CY	$ 6.8	$ 906,500
1.04	Riprap	1,700	CY	$ 80	$ 136,000
1.05	Box Culvert (5 feet x 5 feet)	550	LF	$ 600	$ 330,000
1.06	Seeding, Fertilizer, Mulch	9	Acres	$ 7,500	$ 67,500
				Subtotal	**$ 1,599,000**
1.07	Contingencies (30% of Construction Total)				$ 479,700
				Construction Subtotal	**$ 2,100,000**

2.00	**Engineering Services (20% of Construction Subtotal)**			**Subtotal**	**$**	**200,000**
				Engineering Subtotal	**$**	**200,000**
3.00	**Other Professional Services & Miscellaneous**					
3.01	Appraisals / Descriptions				$	413,400
3.02	Land Acquisition	1,060	Acres	$ 3,900.00	$	4,134,000
				Other Subtotal	**$**	**4,500,000**
4.00	**Mitigation**				**$**	**50,000**
				Mitigation Subtotal	**$**	**50,000**
				Project Capital Cost	**$**	**6,900,000**
				Project O&M Cost	**$**	**400,000**
				Project Cost	**$**	**7,300,000**

L.S. = Lump Sum; CY = Cubic Yards; LF = Linear Feet

Note: Stream Impacts = 211 feet
Wetland Impacts = 4 acres

Appendix B

Supporting Documentation

- Ady 2015 Letter B1
- Akyuz 2000 Letter B2
- Arsenic Memorandum B4
- Caldwell County Commission B7
- Sullivan County Commission B9
- Carol Comer Letter B10
- City of Brookfield B12
- City of Chillicothe B13
- City of Kirksville B14
- City of Lancaster B15
- City of Marceline B16
- City of Milan B17
- City of Princeton B18
- City of Trenton B19
- City of Unionville B20
- Consolidated Public Water Supply District (CPWSD) Number 1 – Linn County B21
- CPWSD Number 1 – Schuyler County B22
- Glenn 2019 Letter B23
- Macon Municipal Utilities (MMU) B24
- Michael Wells Letter B25
- Public Water Supply District (PWSD) Number 1 – Adair County B27
- PWSD Number 1 – Macon County B28
- PWSD Number 1 – Mercer County B29
- PWSD Number 1 – Putnam County B30
- PWSD Number 2 – Chariton County B31
- PWSD Number 3 – Linn-Livingston Counties B32
- PWSD Number 3 – Chariton and Linn Counties B33
- Sara Parker Pauley Letter (2011) B34
- Sara Parker Pauley Letter (2016) B35
- Stephen Mahfood Letter B37
- Sullivan County Farm Bureau B39
- Under Secretary for Natural Resources and Environment, Robert Bonnie, USDA B40
- University of Missouri
    - Missouri Climate Center B42
    - Water Resources Research Center B44
- U.S. Senator Claire McCaskill B45
- City of Kirksville Personal Email Correspondence. Ken Dunlap. August 31, 2016 ..... B46
- U.S. Senator Roy Blunt B47
- USDA Letter to Colonel Guttormsen B49
- Governor Michael Parson B51

Ady Advantage

Mr. Randy Railsback
Executive Director
Green Hills Regional Planning Commission
1104 Main Street
Trenton, Missouri 64683

Dear Randy:

I had the pleasure of presenting the keynote address at this year's Missouri Economic Development Association annual meeting in Columbia. I spoke about "Capacity Readiness" as a means of competitive advantage for economic development organizations, focusing on infrastructure, partnerships, and internal capacities of various sorts. The presentation prompted follow up discussions between me and leadership from Allstate Consultants, LLC, about the importance of water and wastewater treatment in industrial development.

My business focuses in part on translating the needs of relocating and expanding companies into implications for economic development organizations trying to capture the investment and jobs that come from these activities. Allstate asked me to summarize for you key drivers related to water and wastewater treatment.

- Water and the treatment of wastewater, is increasing in importance as a site selection criterion.
- It is of critical importance to those companies that need water for their process or for cooling.
- Many site searches today are screened based not only on current capacity and demand for both water and wastewater treatment, but also forecasts for many years out. They want to understand plans for future capacity, and if these future uses have already been permitted and approved.
- Companies also want to understand the source of the water (groundwater or surface), its chemical characteristics, and the community's ability to treat various levels of BODs in the water.
- We have heard anecdotally that companies in areas where water is a concern, especially California, are actively looking for new locations with better long-term water supplies.

In my opinion, water is a strategic economic development asset. The long-term availability and quality of water will continue to grow in importance for those industrial companies that require water for their operations. Communities and regions with ample water and wastewater treatment capacities will have an advantage, all else being equal.

Sincerely,

Janet Ady
President

Voltedge, Inc. dba **Ady Advantage** | 613 Williamson St, Suite 201 | Madison, WI 53703 | 608.663.9218 | **AdyAdvantage.com**

1

Missouri Climate Center
The School of Natural Resources
Department of Soil and Atmospheric Sciences
www.mcc.missouri.edu

University of Missouri-Columbia

100 Gentry Hall
Columbia, MO 65211
Phone: (573) 882 - 8599
Fax: (573) 884 - 5133

October 30, 2000

The Honorable Donald W. Summers
State Representative
State Capitol Building, Room 101-B
Jefferson City, MO 65101

Dear Representative Summers:

I am writing this letter in response to your request to support constructing a new lake in Sullivan County as a supplemental water source during future droughts such as the drought of 1999-2000 when the shortage threatened public drinking water facilities.

Unlike Southern Missouri where ground water supplies are resourceful and annual average rainfall totals range from 44" to 52", Northern Missouri mostly relies on surface water supply, which is fed by an annual total rainfall ranging from 31" to 40". On average, 37.28 inches of rainfall occurs annually according to 30-yr National Climatic Data Center records in the City of Milan, Sullivan County. In 1999, 28.42 inches of rainfall (8.86" below normal) was observed in Milan. As of October 30, Milan weather station recorded 29.85 inches of precipitation since the beginning of 2000 while the 30-yr average rainfall amount suggests that this period's total should have been 2.78 inches more. The precipitation deficit becomes more significant (11.04" below normal) when the actual total rainfall since July 1999 (41.24") is compared with the 30-yr average (52.28") for the period from July 1, 1999 to October 30, 2000. Furthermore, the long-term forecast does not suggest above normal precipitation for the next 3 months to make up the difference. Even if 11.04 inches (equivalent to the total rainfall deficit since July 1999) above normal precipitation fell in November 2000, hydrological drought would prevail since most water would be lost by surface runoff unless adequate facilities exist to regulate the excessive water.

Climatology of Missouri shows that the probability of severe summer drought in Missouri is 20% or once every 5 years. Thus, Northern Missouri is more susceptible to drought than the rest of the state. In fact, it has been noted during each Drought Assessment Committee, formed by the request of the honorable Mel Carnahan, that the public water system in Sullivan County has been problematic since July 1999 when the current drought first began.

Because of the issues mentioned above, I endorse any action to construct a new water supply lake in Sullivan County to serve as a regional public water supply source.

The Missouri Climate Center is a part of the Department of Soil and Atmospheric Sciences, in the School of Natural Resources of the University of Missouri-Columbia.

Please do not hesitate to contact me if you have any questions regarding climates of the area. I wish you good luck in your mission and congratulate you for your dedication.

Sincerely,

F. Adnan Akyüz, Ph.D.
Missouri State Climatologist
E-mail: AkyuzF@missouri.edu

c: J. Staake, DNR
S. McIntosh, WRP
D. Hammer, UMC
A. Vogt, UMC

The Missouri Climate Center is a part of the Department of Soil and Atmospheric Sciences, in the School of Natural Resources of the University of Missouri-Columbia.

Arsenic Memorandum

To: File

From: Ted Hartsig, CPSS

Date: November 20, 2017

Re: Review of Tetra Tech Phase II Targeted Brownfields Assessment
Former CB&Q Railroad Tracks, East Locust Creek

In 2015, Olsson Associates (Olsson) reviewed 21 separate Phase I and Phase II Environmental Site Assessments (ESAs) that had been previously performed on properties potentially included within the project area for the proposed East Locust Creek Reservoir. The purpose of Olsson's review was to determine whether contamination is present within the inundation zone of the proposed East Locust Creek Reservoir that may cause an unacceptable impact for use of the reservoir for drinking water. A summary of Olsson's review was presented in a letter report to Allstate Engineering, dated November 10, 2015.

This review concluded that, based on the reports reviewed, arsenic appeared to be the only contaminant of potential concern (COPC) for properties within the proposed reservoir inundation zone. The source of the arsenic appears to be the former Chicago, Burlington, and Quincy (CB&Q) railroad corridor, which extends for 6.3 miles through the proposed reservoir inundation zone. Olsson's 2015 report stated that the source of arsenic found in samples collected along the former railroad corridor is possibly from railroad ties treated with chromated copper arsenate (CCA), or from herbicides that may have been used in the past to control vegetation along the tracks. As the railroad ties have degraded over time since abandonment of the railroad line, it is possible that arsenic may have leached into the soil.

Based on this review, Olsson recommended that additional sampling should be conducted along the former CB&Q railroad corridor to more fully evaluate potential arsenic contamination. Subsequently, a Phase II Targeted Brownfields Assessment (TBA) of potential soil contamination was conducted along the former CB&Q line. The Phase II TBA was completed by Tetra Tech Inc., and the findings were detailed in a report dated September 6, 2017. In October 2017, Olsson reviewed this report to compare the results of the TBA investigation with Olsson's previous assessment of contaminants as summarized in the 2015 letter report.

Soil samples collected in site investigations completed before 2017, (as summarized in Olsson's November 2015 report) showed that arsenic concentrations in 13 sample locations along the former railroad line ranged from 6.7 to 110 milligrams per kilogram (mg/kg) of soil, with an average concentration of 46.75 mg/kg. Review of the Tetra Tech Phase II TBA report shows that of 20 soil samples collected along the former railroad line, all sample locations had arsenic concentrations exceeding the U.S. Environmental Protection Agency (USEPA) screening level for residential land use (0.68 mg/kg), and nine sample locations had arsenic concentrations above background concentrations as determined by the U.S. Geological Survey for Sullivan County, Missouri (8.469 mg/kg). Results of the Tetra Tech investigation provided a range of

concentrations from 4.0 to 130 mg/kg arsenic in the soil, with an average concentration of 20.3 mg/kg.

The Tetra Tech Phase II TBA investigation provided results regarding arsenic concentrations in soil that are consistent with previous investigations of the area. The photographic log of the Tetra Tech investigation was provided in the September 6, 2017, report; the photos show that the former railroad line is now an unpaved and unmaintained, narrow path. It is possible that former railroad ties and ballast are buried below a soil layer, or may have been removed.

Olsson's November 2015 report included a brief explanation of arsenic chemistry in soil, and the potential for releases of arsenic into the aquatic environment of the proposed future East Locust Reservoir. Essentially, arsenic chemistry in soils is very complex. Arsenic is typically found in two ionic forms: arsenite (As-III), or the reduced form of arsenic, arsenate (As-V), which is the oxidized form of arsenic in soils. Under most environmental conditions, arsenate is the more common species of arsenic found. In this form, arsenic is generally not mobile, as it adsorbs tightly to soil particles and to iron and aluminum oxides. When arsenate is reduced to arsenite, however, it becomes more prone to migration. The reduction and oxidation reactions of arsenite/arsenate present a challenging environment, because the transition between the species can be relatively rapid. Arsenite, which may be mobile in liquid environments, can oxidize back to arsenate when encountering oxygen (including in oxygenated water), then re-precipitate back into a solid form in association with iron and aluminum oxides. The reduction and oxidation of arsenic species is further complicated by the presence of other metals in the soil, and therefore it is difficult to predict what species will be present in a wet environment.

As part of its review of the 2017 Tetra Tech TBA report, Olsson calculated the potential environmental impact of the arsenic concentrations detected along the former CB&Q railroad line. These calculations, which represent a worst-case scenario for release of arsenic contamination into the waters of the proposed East Locust Creek Reservoir, are attached, and are briefly summarized in the following paragraphs.

The CB&Q railroad line within the East Locust Creek inundation zone is 6.3 miles long; a conservative assumption is that the railroad corridor averages approximately 8 feet wide. Average arsenic concentrations along this railroad corridor, as measured in the Tetra Tech BTA study conducted in 2017, are 20.3 mg/kg.

Olsson further assumed, for purposes of this calculation, that all arsenic present in the soil would be released into the water of the proposed reservoir simultaneously immediately upon inundation. This is, again, a very conservative assumption, because the reduction and oxidation of arsenic in the soil environment, as described above, would be expected to result in a release of only a small portion of arsenic into the aquatic environment at any given time.

Based on these assumptions, Olsson has calculated that the maximum possible arsenic concentration in the lake water would be approximately 0.0066 milligrams per liter (mg/L). The US Environmental Protection Agency (USEPA) drinking water risk-based threshold for arsenic in drinking water is 0.01 mg/L.

Therefore, it is concluded that the actual maximum possible concentration of arsenic in the water of the proposed East Locust Creek reservoir cannot possibly exceed 60 percent of the USEPA drinking water standard, even under very unlikely worst-case scenarios.

CALCULATION
EAST LOCUST CREEK WORST-CASE ARSENIC CONCENTRATION
CB&Q RAILROAD CORRIDOR

Assume:

- 6.3 miles (33,264 linear feet) of former railroad line
- 8 feet average width
- 2 feet depth of arsenic contamination
    - Yields 532,224 cubic feet (ft3) of soil

- Soil @ approximately 90 pounds (lbs) or 40.9 kilograms (kg) per ft3
    - 532,224 ft3 x 40.9 kg/ft3 = 21,767,962 kg of soil

- Average concentration of arsenic in soil is 20.3 mg/kg
- 20.3 mg/kg x 21,767,962 kg soil = 441,889,629 mg arsenic (total load)

- Reservoir volume = 54,000 acre-feet
- One acre-foot = 43,560 ft3 of water
    - 54,000 x 43,560 ft3/acre-foot = 2,352,240,000 ft3 of water
- One ft3 of water = 28.3 liters (L) of water
    - 2,352,240,000 ft3 x 28.3 L/ft3 = 66,568,392,000 L

So:

If all the arsenic load of the former CB&Q railroad corridor were released at one time, then:

$$\frac{441{,}889{,}629 \text{ mg of arsenic}}{66{,}568{,}392{,}000 \text{ L water}} = 0.0066 \text{ mg/L}$$

C.R. BUD MOTSINGER
Presiding Commissioner
Hamilton, MO 64644

DONNIE COX
Eastern District Commissioner
Braymer, MO 64624

GERALD McBRAYER
Western District Commissioner

Regular Terms of
Commission Meeting:
First Monday in February,
May, August and November

Beverly J Bryant
Clerk to the Commission

Regular Meeting: Each Monday

CALDWELL COUNTY COMMISSION

49 East Main, PO Box 67
Kingston, Missouri 64650
816.586.2571
816.586.3001 (fax)

January 29, 2016

Bradley M. Scott
General Manager, North Central
Missouri Regional Water Commission
201 N. Market
Milan, MO
63556

Dear Brad
Throughout the State of Missouri there are pressing needs related to water supply, transmission and distribution caused by population shifts, aging water infrastructure and increasingly stringent water quality standards. Large parts of Missouri are facing or will face water supply and distribution challenges that will only increase over time. In our own County of Caldwell, the County Commission has led the effort for the construction of the Little Otter Creek Water Supply Reservoir to address an acute and persistent water shortage. That project is ready for construction, merely awaiting permitting and final funding so that construction can begin.

In EPA's 2013 Drinking Water Infrastructure Needs Survey and Assessment (based on a 2011 survey) it is estimated that the nation needs a total of $384.2 Billion in water system infrastructure capital improvements over a 20 year period. This study includes only infrastructure needs that are eligible for the state revolving loan fund, so it excludes dams, reservoirs, projects related primarily to population growth, and operation and maintenance costs. $8.5 Billion (2.2%) of this need is attributed to Missouri. The numbers in Missouri are particularly dire for small systems (serving 10,000 or fewer persons) with 50.2% of the total need going to such systems. Only 4 states have a higher percentage.

There are currently efforts underway to "stand-up" a statute that is in existence known as the "Multipurpose Water Resource Program Renewable Water Program Fund" (Multipurpose Fund) (Sections 256.435-256.445, RSMo). The program and models associated with the Multipurpose Fund hold great promise for the creation of a tool that can unleash millions of dollars of water infrastructure development, maximize federal funds to the State and replenish itself or pay back the State of Missouri for its investment. This very tool may be employed at Little Otter Creek Water Supply Reservoir to finish the lake or be used by the Little Otter Lake Wholesale Water Commission to build necessary infrastructure. Regardless, the County Commission is in support of developing more funding tools for the State to use on water projects.

The Caldwell County Commission endorses efforts to activate the Multipurpose Fund statute and encourages the members of the Legislative and Executive Branches to work diligently to put in place a flexible tool that could be utilized to accomplish multiple projects.

Sincerely,

C.R. Bud Motsinger

C/R. Bud Motsinger
Caldwell County Presiding Commissioner

January 25, 2016

Bradley M. Scott
General Manager, North Central
Missouri Regional Water Commission
201 N. Market
Milan, MO
63556

Dear Brad

Throughout the State of Missouri there are pressing needs related to water supply, transmission and distribution caused by population shifts, aging water infrastructure and increasingly stringent water quality standards. Large parts of Missouri are facing or will face water supply and distribution challenges that will only increase over time. In our own County of Caldwell, the County Commission has led the effort for the construction of the Little Otter Creek Water Supply Reservoir to address an acute and persistent water shortage. That project is ready for construction, merely awaiting permitting and final funding so that construction can begin.

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The Caldwell County Commission endorses efforts to activate the Multipurpose Fund statute and encourages the members of the Legislative and Executive Branches to work diligently to put in place a flexible tool that could be utilized to accomplish multiple projects.

Sincerely,

January 25, 2016

Bradley M. Scott
General Manager, North Central
Missouri Regional Water Commission
201 N. Market
Milan, MO
63556

Dear Brad

Throughout the State of Missouri there are pressing needs related to water supply, transmission and distribution caused by population shifts, aging water infrastructure and increasingly stringent water quality standards. Large parts of Missouri are facing or will face water supply and distribution challenges that will only increase over time. In our own County of Sullivan, the County Commission has supported the efforts for construction of the East Locust Creek Water Supply Reservoir to address an acute and persistent water shortage. That project is nearly ready for construction, merely awaiting the acquisition of 9 remaining parcels (out of 81), permitting and final funding so that construction can begin. The Reservoir will be a regional water supply serving 10 counties and 54,000 customers in North Central Missouri. To date, over $32 million has been spent or obligated for the project.

In EPA's 2013 Drinking Water Infrastructure Needs Survey and Assessment (based on a 2011 survey) it is estimated that the nation needs a total of $384.2 Billion in water system infrastructure capital improvements over a 20 year period. This study includes only infrastructure needs that are eligible for the state revolving loan fund, so it excludes dams, reservoirs, projects related primarily to population growth, and operation and maintenance costs. $8.5 Billion (2.2%) of this need is attributed to Missouri. The numbers in Missouri are particularly dire for small systems (serving 10,000 or fewer persons) with 50.2% of the total need going to such systems. Only 4 states have a higher percentage.

There are currently efforts underway to "stand-up" a statute that is in existence known as the "Multipurpose Water Resource Program Renewable Water Program Fund" (Multipurpose Fund) (Sections 256.435-256.445,RSMo). The program and models associated with the Multipurpose Fund hold great promise for the creation of a tool that can unleash millions of dollars of water infrastructure development, maximize federal funds to the State and replenish itself or pay back the State of Missouri for its investment. This very tool may be employed at both East Locust Creek Water Supply Reservoir and at Little Otter Creek Water Supply Reservoir to finish the lake or run transmission mains to our prospective customer for them to run distribution lines to their customers. Regardless, the County Commission is in support of developing more tools for use on water projects.

The Sullivan County Commission endorses efforts to activate the Multipurpose Fund statute and encourages the members of the Legislative and Executive Branches to work diligently to put in place a flexible tool that could be utilized to accomplish multiple projects in Missouri, including the one in Sullivan County.

Sincerely,

Sullivan Co. Presiding Commissioner
Chris May

Missouri Department of NATURAL RESOURCES dnr.mo.gov

Eric R. Greitens, Governor Carol S. Comer, Director

JUL 26 2017

Mr. Bradley M. Scott
General Manager
North Central Missouri Regional Water Commission
201 N. Market Street
Milan, MO 63556

Re: East Locust Creek Reservoir

Dear Mr. Scott:

I am writing you today to convey the Missouri Department of Natural Resources' (Department) continued support for the East Locust Creek Reservoir project. I commend you, your staff, and the North Central Missouri Regional Water Commission (Commission) on your efforts and commitment to developing a long-term solution to the water supply needs of North Central Missouri.

As you are aware, surface water supplies in the 10-county region of North Central Missouri are vulnerable to drought, and the use of groundwater in northern Missouri is limited, not only because of a lack of quantity, but also because of its poor quality. The 2,352 acre East Locust Creek Reservoir would provide a much needed reliable, long-term water supply in northern Missouri.

The Department's Water Resource Center independent analysis, using the USDA Agricultural Research service model "RESOP", demonstrated a firm yield of 6.8 million gallons per day for East Locust Creek Reservoir. Based on the Department's current evaluation of the project and after reviewing the draft Project Purpose and Need Statement (January 7, 2016) the Department agrees that the current design yield of 7.0 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir.

In support of the Commission's efforts and the East Locust Creek Reservoir project, the State of Missouri has invested more than $7 million towards securing this much needed regional water supply project. It is the Department's understanding that the Commission has nearly completed land acquisition, has begun preparing the lake bed and is awaiting full completion of the permit process.

Once the permit process is complete, the Commission has indicated that it intends to apply for a USDA Rural Development loan to pay for a majority of the remaining project costs; however, the loan cannot be secured until all permitting is fully complete.

Recycled paper

Letter to Mr. Bradley M. Scott
Page Two

In closing, the Department looks forward to the full completion of the permit process and remains committed to supporting the East Locust Creek Reservoir project.

Sincerely,

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Carol S. Comer
Director

cc: Mr. Mark Frasier, USACE, KC District
Colonel Douglas B. Guttormsen, USACE, KC District

City Of Brookfield

116 W. BROOKS • BROOKFIELD, MO 64628-0328 • (660) 258-3377

February 4, 2002

North Central Missouri Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson:

Mr. Don Summers was present at the January 22 Brookfield City Council Meeting and presented proposed plans for building a new lake in northern Missouri.

I am writing to express the interest of the Council in your efforts to establish a regional water supply source in our area. Although we currently have an adequate primary source of water for the foreseeable future, we are interested in the idea of having a back up, secondary source of water.

We support any effort to improve the quality of life in North Central Missouri and will discuss the merits of our opportunity to become an associate member. We wish you much success while you work to improve the quality of life and quantity of water in our region of the state.

Sincerely,

William J. Dorsey
Mayor

City of Chillicothe

Office of Mayor & CEO
Phone 660-646-2267

December 13, 2001

Pat Wilson
North Central Missouri Regional Water Commission
PO Box 266
Unionville, MO 63565

Dear Mr. Wilson:

We are writing to express our interest and support for your efforts to secure a regional water supply and the network to deliver it to systems of need in our region.

The completion of Interstate 72 will bring prospective employers to our area. Being able to assure them that there is abundant, affordable water available is a must. Although the City of Chillicothe will not likely purchase water from the NCMEWC, it will help the development of the region and attract jobs through potential new industrial users.

We wish you the best in your endeavors to secure a regional water source.

Sincerely,

Mayor Jeffery Curtis Foli

715 N. Washington • Chillicothe, MO 64601 • Fax 660-646-6811

KIRKSVILLE
M I S S O U R I

201 S. Franklin
Kirksville, Missouri 63501

(660) 627-1224
Fax: (660) 665-0940

October 31, 2001

Pat Wilson, President
North Central Missouri Regional Water Commission
Post Office Box 266
Unionville, MO 63565

Dear Mr. Wilson:

We are writing to express our support of your efforts to secure a regional water supply and the network to deliver it to systems of need in our region.

To attract jobs to our area and maintain a high quality of life for our residents, (there must be) a plentiful, pure and affordable source of water. We commend you on your mission statement focusing on the supply and affordability of water for this region.

Although the City of Kirksville will not likely purchase water from the NCMRWC, it could serve as a secondary source to the Adair County Rural Water District. This will also help the development of the region. We understand that the Adair County Rural Water District and the City of Kirksville may be associate members with the opportunity to monitor your progress and eventually secure an option for full membership at the associate's choice in the future.

Whether a water provider needs to procure a secondary source of supply or needs all of their water supplied as some do, it makes sense to cooperate with your commission and take the opportunity to have a say in our region's future.

Please consider us a supporter of your efforts to improve the quality of life in North Central Missouri.

Sincerely,

William R. Murray
Mayor

vlb

January 29, 2002

To: North Central Missouri Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson:

In response to the information given to the Lancaster City Council by Mr. Don Summers recently, I would like to offer our support and encouragement to your Commission in your efforts to provide an additional water supply in our area.

As we are all aware, having a plentiful, affordable, and local source of safe drinking water, as well as water for other uses, is vital for our future. We do commend you in this cause.

Please accept my personal apology for the delay in getting this letter of support to you. I had intended to put it in the mail a month ago, and somehow let it slip by without getting done.

As with any project of this size, there is a lot of hard work ahead. Good luck with your plans.

Sincerely yours,

Linda Bruner

Linda Bruner
Mayor of Lancaster, MO

pbc: file

City of Marceline

February 28, 2002

North Central Missouri Regional Water Commission
Pat Wilson, President
PO Box 266
Unionville MO 63565

Dear Mr. Wilson:

I am writing to express our interest and support for your efforts to secure a regional water supply and the network to deliver it to systems of need in Northern Missouri.

As we are all aware, having a plentiful, affordable, and local source of safe drinking water, as well as water for other uses, is vital for our future. We do commend you in this cause. Although we currently have an adequate primary source of water for the foreseeable future, we are interested in the idea of having a back up, secondary source of water.

We support any effort to improve the quality of life in North Central Missouri and wish you much success while you work to improve the quality of life and quantity of water in our region of the state.

Sincerely,

Elizabeth Cupp
City Manager

116 Main Street USA Marceline, MO 64658
Boyhood Home of Walt Disney
660-376-3528

THE CITY OF MILAN

201 NORTH MARKET, MILAN, MISSOURI 63556 (660) 265-4491

August 21, 2000

Mr. Don Summers
R.R. #4, Box 209
Unionville, MO 63565

Dear Don:

This letter expresses the City of Milan's complete support for the planning and construction of a reservoir large enough to serve not only the future of the city of Milan and Sullivan County, but also the North Central Missouri region. It is our understanding that numerous communities and water districts in the area have inadequate reserves to withstand either prolonged drought, or future growth.

While we endeavor to meet our current needs with numerous methods, the only answer for the long term future and success of our community hinges on the construction of such an impoundment.

If the city of Milan can be of further assistance, please feel free to contact me at 660-265-4420.

Sincerely,

David T. Wilson
Mayor

"MILAN MO IS ON THE GO"

CITY OF PRINCETON
Office of City Clerk
Princeton, Missouri 64673

February 14, 2002

North Central Missouri
Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson:

Mr. Don Summers attended our February 5th Council Meeting to discuss the proposed plan to secure a regional water supply in North Central Missouri.

To attract jobs to our area and maintain a high quality of life for residents, there must be a plentiful and affordable source of water. We applaud your efforts to develop an abundant source of low cost water supply for the residents of North Central Missouri.

Although the City of Princeton would not likely purchase water from the NCMRWC, we recognize your project is important to economic development in the region. We will discuss at a later date the benefits of an associate membership.

Please consider us a supporter of your efforts to improve the quality of life in North Central Missouri. Feel free to contact us if we can be of further assistance.

Sincerely,

Michael Greenlee
Mayor

CITY OF TRENTON MISSOURI

Discover your heart . . .
in the Green Hills

October 18, 2001

Pat Wilson
North Central Missouri Regional Water Commission
PO Box 266
Unionville MO 63565

Dear Mr. Wilson:

We are writing to express our interest and support for your efforts to secure a regional water supply and the network to deliver it to systems of need in our region.

Our ability to attract jobs to our area as well as maintaining the quality of life for our residents depends on a plentiful, affordable source of water. We commend you on your mission statement focusing on the supply and affordability of water for our region.

We understand that members of your commission represent retail water systems that obtain part or all of the water they need from NCMRWC, and yet retain their sovereignty. We also commend your allowing associate members the opportunity to monitor your progress as well as securing an option for full membership at the associate's choice in the future.

Whether a water provider needs to procure a secondary source of supply or needs all of their water supplied as some do, it makes sense to cooperate with your commission and take the opportunity to have a say in our region's future.

Please consider us a supporter of your efforts to improve the quality of life in North Central Missouri.

Sincerely,

Tim Whitaker
Mayor

TW:rdm

1100 Main Street • P.O. Box 188
Trenton, MO 64683
(660) 359-4310

FAX (660) 359-2284

Trenton Municipal Utilities
P.O. Box 108 • Trenton, MO 64683
(660) 359-2281

City of Unionville
1611 Grant • P.O. Box 255 • Unionville, MO 63565

November 1, 2001

North Central Missouri Regional Water Commission
Pat Wilson, Pres.
P. O. Box 266
Unionville, MO 63565

Dear Mr. Wilson

We are writing to express our interest and support for your efforts to secure a regional water supply and the network to deliver it to systems of need in our region.

Our ability to attract jobs to our area as well as maintaining the quality of life for our residents depends on a plentiful, affordable source of water. We commend you on your mission statement focusing on the supply and affordability of water for our region.

We understand that members of your commission represent retail water systems that obtain part or all of the water they need from NCMRWC, and yet retain their sovereignty. We also commend your allowing associate member the opportunity to monitor your progress as well securing an option for full membership at the associate's choice in the future.

Whether a water provide need to procure a secondary source of supply or needs al of their water supplied as some, it makes sense to cooperated with your commission and take the opportunity to have a say in our region's future.

Please consider Unionville as a support of your efforts to improve the quality of life in North Central Missouri.

Sincerely

Ralph Halferty

Ralph Halferty
Mayor Pro Tem

Consolidated Public Water Supply District #1
of Linn County Missouri
P.O. Box 111
Purdin, Missouri 64674

Kay Fowler
Clerk

Office: 660-244-7345
Home: 660-244-7585

November 15, 2001

North Central Missouri Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson,

We are writing to inform you of our support for your 2700 acre water supply lake. It is a project we feel will benefit the whole region of North Central Missouri.

While we at C.P.W.S.D. #1 of Linn County do not anticipate any need for surface water in the foreseeable future, having adequate reserves in the region to use as a backup seems prudent.

We appreciate also your commitment to keep the water you produce affordable for those who need it.

We wish you the best in your endeavors to secure a regional water source.

Sincerely,

C P W S D #1 of LINN CO.

C.P.W.S.D.#1 of Linn Co.

kf

CONSOLIDATED PUBLIC WATER SUPPLY
District #1 of Schuyler County, Mo 63561
P.O. Box 295
Queen City, MO. 63561
Phone & Fax 660-766-2497

December 4, 2001

North Central Missouri Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO. 63565

Dear Mr. Wilson:

Mr. Don Summers was at our November 6 Board meeting to discuss the proposed plans for building a new lake with the Water District Board members.

We are writing to express our interest in your efforts to secure a source of regional water supply in our region. Although we do not need a primary source of water in the foreseeable future, we like the idea of having a back up, secondary source of water.

Please consider us a supporter of your efforts to improve the quality of life in North Central Missouri. We will discuss and decide later about our opportunity to become associate members. We wish you much success while you work to improve the quality of life in our region of the state.

Sincerely,

James Werner
President of the Board

RRWA

RATHBUN REGIONAL WATER ASSOCIATION, INC.
16166 Hwy. J29 - Centerville, Iowa 52544

January 15, 2019

Brad Scott
General Manager
North Central Missouri Regional Water Commission
201 North Market Street
Milan, MO 63556

Dear Mr. Scott:

Thank you for your inquiry regarding Rathbun Regional Water Association (RRWA) providing a portion of our water supply storage allocation in Rathbun Lake to the North Central Missouri Regional Water Commission or, in the alternative, RRWA providing potable water to the Commission.

At the present time, RRWA anticipates the need to preserve all of the available water supply storage allocation in Rathbun Lake to meet the demand for potable water by our customers. This allocation includes the 6,680 acre-feet of storage that RRWA has acquired contractually from the US Army Corps of Engineers as well as the remaining 8,320 acre-feet of storage to which RRWA has been provided the right of first refusal by the US Congress. Presently, RRWA is actively engaged in the process of acquiring the 8,320 acre-feet of storage.

At this time, RRWA does not believe that the available water supply storage allocation in Rathbun Lake will allow us to provide potable water to customers outside of our association's current service territory. RRWA makes this determination based on meeting these customers' expected demand for potable water with an acceptable level of reliability.

Given the above, RRWA is not able to make any commitment to supply raw or potable water to the Commission.

Thank you again for your inquiry regarding RRWA's water supply storage allocation in Rathbun Lake and our association's potable water supply capabilities. Please contact me with any questions or for additional information.

Sincerely,

John Glenn
Chief Executive Officer
Chief Operating Officer

641-647-2416 1-800-233-8849 FAX 641-647-2217 Email: rrwainc@rrwa.net

BOARD OF PUBLIC WORKS

TIM WATTS, President
DON KINKHORST, Vice President
GARY McELWAIN
GARY HOLMAN
KIM WILLIAMS, Secretary

MACON MUNICIPAL UTILITIES

Since 1890

106 West Bourke
P.O. Box 569
Macon, Missouri 63552-0569

Telephone (660) 385-3173
Fax (660) 385-6554

March 2, 2002

Pat Wilson
North Central Missouri Regional Water Commission
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson:

We are writing to express our support for your efforts to secure a regional water supply and the network to deliver it to systems in the North Central Missouri region.

The completion of Interstate 72 will bring prospective employers to the area, which will contribute to the economic growth and development of the North Central Missouri region. Having a safe, abundant supply of affordable water is a key element of attracting businesses to the area. Although the City of Macon will not be a likely purchaser of water from the North Central Missouri Regional Water Commission, we support your efforts to help the development of the overall region.

We wish you the best in your efforts to improve the quality of life in our part of the great state of Missouri.

Sincerely,

Vern Kincheloe
General Manager, Macon Municipal Utilities

STATE OF MISSOURI

Jeremiah W. (Jay) Nixon, Governor • Mark N. Templeton, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

FEB 19 2010

Mr. Bobby Williams, Chairman
North Central Missouri Regional Water Commission
P.O. Box 164
Milan, MO 63556

Dear Mr. Williams:

I am writing to offer the Department of Natural Resources' continued support of your efforts to develop a long-term sustainable water supply source in Sullivan County. The department has and will continue to support a regional water supply system for North Central Missouri. Since the early stages of this project, the department has provided financial and technical assistance to this effort. Due to the fact that in most instances regional water systems provide for a more efficient and cost effective method of providing high quality water, the department will continue to give priority for assistance to regional water supply systems over small disparate systems.

Based on numerous stream and groundwater evaluations conducted by both department staff and private engineering firms, a surface water reservoir has been identified as the most feasible alternative to securing a long-term sustainable water source for North Central Missouri. The department endorses the recommendations of the "Water System Feasibility Study" prepared by Burns & McDonnell in 2003, which concluded that a reservoir on East Fork of Locust Creek is the most cost effective solution to the region's water supply needs.

The citizens of Sullivan County are to be commended for taking the leadership and initiative in forming North Central Missouri Regional Water Commission to develop a long-term sustainable water system for the region. While many of the communities in the region have addressed their short-term water shortage needs in recent years, studies have shown that these short-term solutions are not sustainable through extended periods of drought nor will they support long-term economic growth in the region. The department continues to support a centrally located reservoir capable of sustaining the region's future water supply demands.

Recycled Paper

13

Mr. Bobby Williams, Chairman
Page Two

During periods of extended drought in Missouri, the Missouri Drought Assessment Committee, which I chair, has recognized that communities in and near Sullivan County often have the most critical water supply shortages in the state. This information further emphasizes the need for a more sustainable water supply system in this region. Please let me know if the department can be of assistance to the Commission as you continue to work towards this most worthwhile project.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Michael D. Wells
Deputy Director for Water Resources

14

Adair County Public Water Supply District No. 1

1120 North Green
Post Office Box O
Kirksville, Missouri 63501
Phone (660) 665-8378

November 13, 2001

North Central Missouri Regional Water Commission
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson:

Our Board of Directors voted recently to express our interest and support of your efforts to work toward getting a regional water supply for the northern portion of Missouri. We further support the network that you have developed to deliver the water to those who need that water.

It is clear that the purposes that you propose, in addition to water for the region, such as the ability to attract jobs through potential new industrial users are meaningful. An abundant source of low-cost, pure, quality water for all in North Central Missouri is vital.

Allowing those who presently have their own water source, and those who intend to supplement their source with water from the new water supply, to participate while maintaining their own identity on the commission is important. The organization is such that neighboring districts such as ours could participate as associate members for support. This fact is also important.

We support your desire to secure a reliable, low cost, pure, quality water source for North Central Missouri. Our region's future depends upon forward thinking persons such as your commission.

Sincerely, Brent Lee Motter

Brent Motter
Board of Directors, President

DH/GM

Board of Directors
Brent Motter, President Jeff Crist, Vice President Tom Primmer, Member
Dwight Hart, Member Bill Sanders, Member

Public Water Supply District No. 1 of Macon County

P.O. BOX 386
MACON, MO 63552-0386

December 27, 2001

North Central Missouri Regional Water Commission
Pat Wilson, President
P.O. Box 266
Unionville, MO 63565

Dear Mr. Wilson

We are writing to express our support and interest in your Organizations effort to secure a regional water supply in North Missouri. The regional concept is one that brings many benefits to the members of the supply and to the citizens that they serve. There has been a demonstrated advantage both in reduced cost and increased water quality when water purveyors join together to build and operate a single large treatment facility instead of many smaller ones. The rapidly approaching time for the implementation of numerous new water quality regulations by the U.S. EPA will only increase these savings.

Recent water shortages in North Missouri serve to demonstrate that a new and permanent water supply must be found to preserve the quality of life and health in our rural communities. The Board of Directors of the Macon County Public Water Supply District supports your efforts to address these pressing needs and wishes to maintain close communications with your organization as you bring this project forward. We are interested in exploring the benefits of an associate membership when you have progressed to the point when that would be appropriate.

Please feel free to call on us again for any support that we can provide, as you seek to complete your project.

Sincerely,

David G. Waller
General Manager

660-385-6457 1-800-748-7888 Fax 660-385-6008

Public Water Supply District #1
of Mercer County, Missouri
P O Box 676
Mercer, Mo. 64661
(660) 382-4776

Mr. Pat Wilson
North Central Missouri Regional Water Commission
P O Box 266
Unionville, MO. 63565

Dear Mr. Wilson:

We are writing to express our support of your efforts to promote a regional water supply for the northern area of Missouri.

Mr. Don Summers was present at our January board meeting to explain and inform us of the proposed 2700 acre lake and the plan to be able to serve water to the systems in need in our area.

We have an adequate water supply at this time, however we are always looking for another good second source of water which we feel would supply our district should the need arise.

Yours Truly,

Jack S. Goodin, President
Board of Directors
Public Water Supply District #1
Mercer County, Missouri

PUBLIC WATER SUPPLY DISTRICT NO. 1
OF PUTNAM COUNTY

RT. 3 BOX 402 · UNIONVILLE, MISSOURI 63565-9802 · 660-947-3616

February 14, 2002

North Central Missouri Regional Water Commission
Pat Wilson, President
P. O. Box 266
Unionville, MO 63565

Dear Mr. Wilson

The Pubic Water Supply District #1 of Putnam County Board of Directors is writing this letter to express our support of your organization's efforts to secure a regional water supply system. An affordable, plentiful source of water is an absolute necessity not only to the citizens residing in the area but also to the economic development of the future. Recent water shortages in the north Missouri region have demonstrated the express need for this type of system.

While our rural water district does not anticipate use of the regional water supply system at this time, we appreciate your willingness to include outlying systems in the process of procurement. We would be interested in receiving information on exploring the benefits of an associate membership after which the Board would make a decision on the feasibility of becoming an associate member.

Please feel free to call on us for any support we can provide.

Sincerely,

Bobby K Jones

Bobby K. Jones
President, Board of Directors

PUBLIC WATER SUPPLY DISTRICT NO. 2
R.R. 2, Box 30
Brunswick, MO 65236
660/548-3565

February 25, 2002

Mr. Don Summers
North Central Missouri Regional Water Commission
P.O. Box 266
Unionville, MO 63565

Dear Mr. Summers:

Thank you for your presentation to the board of directors February 14, 2002. This letter is to inform you of our support of your plans for a water reservoir to supply the needs of the north central region of Missouri.

This project is vital to the future endeavors of industry and growth in this region. We are becoming increasingly aware of water as a precious resource. We need to look ahead and plan for the future to assure quality and adequate supply. This project is a step toward this goal.

Public Water Supply District #2 is currently looking at other sources of water. It is reassuring to know that if the need arises, your project is a potential supplier of our water district in the future.

We want to convey our best wishes in your efforts toward this regional water source.

Sincerely,

Robert Kistler
Superintendent

vb

Chief Plant Operator
660-659-2476

Angela Baldwin
Office Manager
660-659-2266

Don Edwards
Chief Distribution System Operator
660-659-2266

Clean Clear Water Provided By

LINN-LIVINGSTON PWSD #3

P.O. Box 109
Wheeling, MO 64688

March 13, 2002

North Central Missouri
Regional Water Commission
Pat Wilson, President
PO Box 266
Unionville, MO 63565

Dear Mr. Wilson:

We are writing to express our interest and support for your efforts to secure a regional water supply and the network to deliver it to the systems of need in the North Central Missouri region.

Whether a system needs a backup source of supply, or needs all their water supplied, it makes sense to look at the region's needs and resources in order to maintain the quality of life for residents who depend on a plentiful, affordable source of water in North Central Missouri.

We recognize that your project is an important step in the North Central Missouri Region but feel at this time; we do not need your services in the present and near future.

Please consider us a supporter of your efforts to improve the quality of life in North Central Missouri.

Sincerely,

Tom Burtch

Tom Burtch, President
Linn-Livingston PWSD #3

PUBLIC WATER SUPPLY DISTRICT NO. 3
of CHARITON & LINN COUNTY, MISSOURI
814 W. Helm • 660-258-5606
Brookfield, Missouri 64628

To: North Central Missouri Water Commission
Pat Wilson, President
PO Box 266
Unionville, MO. 63565

Dear Mr. Wilson

We are writing to tell you of our interest and support for your plans to build and maintain a regional water supply in North Central Missouri. We also wish you well in your vision of a affordable water supply to systems in need in the North Central Missouri region.

Whether a system needs a backup source of supply, or a quote to serve a potential industrial user, it makes sence to look at our region's needs and resources. We hope to monitor your progress as you work toward your goal.

While we do not need your services at the present time, We may in the future. We recognize that your project is important to our region's growth.

Please write or call if we can be of futher assistance.

Sincerely,

Dan Downey
Chairton-Linn PWSD#3

STATE OF MISSOURI

Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

June 3, 2011

The Honorable Tom Vilsack
Secretary, U.S. Department of Agriculture
1400 Independence Ave., S.W., Room 200 A
Washington, DC 20250

Dear Secretary Vilsack:

Sullivan County and the north central Missouri region often experience the most critical water supply shortages in the state. While many communities in the region have addressed their short-term water needs, these solutions are not sustainable through extended periods of drought, nor will they support long-term economic growth in the region. Therefore, I am writing to urge your continued support for the East Locust Creek Reservoir project, which is identified as the most feasible and cost effective solution to meet the region's water supply needs.

The citizens of Sullivan County have demonstrated their commitment to this project and should be commended for their leadership and initiative in forming the North Central Missouri Regional Water Commission. For nearly a decade the Commission has partnered with the Natural Resources Conservation Service (NRCS) and has completed numerous plans and studies necessary to develop a regional drinking water reservoir. In addition, Sullivan County voters overwhelmingly passed a ½ cent sales tax in April 2010 and increased wholesale water rates in order to meet their matching requirements for land acquisition, relocation, engineering and project construction. Unfortunately, with recent federal budget cuts it is uncertain if the NRCS will provide future financial and technical support to continue this much needed project.

The East Locust Creek Reservoir is vitally important to the health and prosperity of the citizens in north central Missouri and it is critical that support from the NRCS and United States Department of Agriculture – Rural Development be continued to help address this serious shortage of water resources.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Sara Parker Pauley
Director

Recycled Paper

15

STATE OF MISSOURI

Jeremiah W. (Jay) Nixon, Governor • Sara Parker Pauley, Director

DEPARTMENT OF NATURAL RESOURCES

www.dnr.mo.gov

FEB - 8 2016

Mr. Bradley M. Scott
General Manager
North Central Missouri Regional Water Commission
201 N. Market Street
Milan, MO 63556

Re: East Locust Creek Reservoir – Purpose and Need Statements

Dear Mr. Scott:

I am writing to express the Missouri Department of Natural Resources' (Department) support of the full design capacity of East Locust Creek Reservoir. Based on our current evaluation of the project and after reviewing the draft Project Purpose and Need Statement (January 7, 2016) the Department agrees that the current design yield of 7.0 million gallons per day is appropriate and should be utilized as the final design capacity for the reservoir.

The Department's Water Resources Center independent analysis, using the USDA Agricultural Research Service model "RESOP", demonstrated a firm yield of 6.8 million gallons per day for East Locust Creek Reservoir, which is anticipated to meet the water supply needs of North Central Missouri region.

In 2005, the Department and the Natural Resources Conservation Service published evaluations of the Regional Economic Demand and the National Economic Demand for the project showing that the benefits of the proposed reservoir outweighed the project costs. In July 2015, the Department's Water Resources Center completed the "East Locust Creek Reservoir Economic Impacts" report. This study found that the reservoir's benefit to cost ratio is 1.20 for federal investment and 2.58 for state and local investment, demonstrating that the project is a positive economic investment.

The 2002 Missouri Drought Plan identifies the region near the city of Milan as highly susceptible to drought. This region has previously been given a recommendation for a drought emergency by the Missouri Climate and Weather sub-committee of the Governor's Drought Assessment Committee. Current long range projections indicate higher variability in weather patterns with more frequent extreme drought and flood events. Such future scenarios do not bode well for the numerous stream diversions that currently support the water supply needs of the region.

Recycled Paper

28

Letter to Mr. Bradley M. Scott
Page 2

The Department supports the need for additional water supplies in the region, and has provided assistance in establishing the Locust Creek Stream diversions to supplement Elmwood Reservoir, and the emergency water line from Trenton. These measures were never considered permanent solutions. Engineering reports have verified that a centrally located reservoir in North Central Missouri is the most cost effective solution to solve long term water deficits that are expected during drought conditions.

For these reasons, the Department remains committed to the optimization of the East Locust Creek Reservoir site and fully supports the need of the project to provide the future water supply of the region.

Sincerely,

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Sara Parker Pauley
Director

SPP:mv

c: Mr. Mark Frasier, U.S. Army Corps of Engineers, Kansas City District
Colonel Andrew Sexton, U.S. Army Corps of Engineers, Kansas City District

29

STATE OF MISSOURI

Mel Carnahan, Governor • Stephen M. Mahfood, Director

DEPARTMENT OF NATURAL RESOURCES

OFFICE OF THE DIRECTOR

P.O. Box 176 Jefferson City, MO 65102-0176

OCT 5 2000

The Honorable Donald W. Summers
State Representative
State Capitol Building, Room 101-B
Jefferson City, MO 65101

Dear Representative Summers:

This is in response to your request for a letter of support for a new water supply lake in Sullivan County to serve as a possible regional water supply source. The Department of Natural Resources supports the development of a long-term reliable drinking water source for this area as a means to improve the health and quality of life of the citizens of north central Missouri.

Several of the existing public water systems within the area are prone to water shortages during the recurring droughts of the area. Also, small surface water systems of the area face significant technical, managerial, and financial challenges in meeting more stringent drinking water standards now being proposed. Studies have shown that Milan's water supply lakes and Green City's water supply lake do not provide adequate capacity to meet even current water demands during extreme periods of drought such as occurred in the years 1953-1958. Because of drought conditions over the past 18 months in Sullivan County, the city of Milan, Green City, and the Sullivan Co. PWSD #1 are curtailing normal water uses. Each of the public water systems is seeking temporary alternative sources to prevent outages. However, these alternatives are temporary at best.

A reliable high quality source of drinking water is long overdue for north central Missouri. Construction of a new lake to serve as a regional water supply source would be one long-term option to eliminate the water shortage problems in the future. A new regional water supply source would also allow the area water systems to meet increased water demands associated with anticipated and needed future economic growth in the area. Without an additional water supply source, any economic growth will be hampered.

The evaluation of alternative long-term sources of drinking water for the area is necessary for the citizens of the area to receive the best water quality possible at affordable prices. The effort of regional cooperation in north central Missouri is encouraged and supported by the department.

The Honorable Donald W. Summers
Page 2

Thank you for your dedication to providing safe and adequate drinking water to the citizens of Missouri.

If you need additional information, please contact Ms. Deana Cash of the Public Drinking Water Program at (573) 751-5331.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Stephen Mahfood
Director

SM:dcj

c: Everett Baker, NERO
Steve McIntosh, WRP
Jerry Lane, PDWP

Never hesitate to contact Jeff or if you need to. Thanks

2

SULLIVAN COUNTY
FARM BUREAU

October 17, 2017

Representative Nate Walker
201 West Capitol Avenue
Rm 316
Jefferson City, MO 65101

Dear Representative Walker,

On Behalf of the Sullivan County Farm Bureau, we are writing to *thank you* for your ongoing support of the East Locust Creek Reservoir in Sullivan County and to encourage your continued support. The North Central Missouri Regional Water Commission recently announced that 4,550 acres of land that will be home to the 2,352 acre water supply reservoir has been acquired. While this is an incredible milestone, much work remains.
We encourage your continued support as the Commission focuses on the remaining critical path elements including:

- Permitting with the Corps of Engineers
- USDA-Rural Development Loan and Grant funding
- State Participation in Debt Service
- Federal Construction Cost-share
- Wetland and Stream Mitigation

Each of these elements requires significant Federal/State collaboration, cooperation and coordination. You are in a key position to foster and encourage action by the various entities that will, necessarily, be a party to moving the desperately needed East Locust Creek Reservoir to completion.

The East Locust Creek Reservoir is designed to serve some 10 counties in North Central Missouri, removing the dire and chronic threat of water shortage. The reservoir will become an economic engine in North Central Missouri that will give rise to economic development and job opportunities to future generations.

Again, we thank you for your past leadership and support and we encourage your renewed focus on the East Locust Creek Reservoir.

Sincerely,

Charles E. Emberton
President, Sullivan County Farm Bureau

USDA

United States Department of Agriculture

Office of the Secretary
Washington, D.C. 20250

AUG 14 2015

The Honorable Roy Blunt
United States Senate
260 Russell Senate Office Building
Washington, D.C. 20510-2508

Dear Senator Blunt:

Thank you for your letter of March 15, 2015, to Thomas J. Vilsack, on behalf of the North Central Missouri Regional Water Commission (Water Commission), the sponsor of the East Locust Creek multiple-purpose reservoir. The Water Commission has asked for consideration of three financial requests to address existing challenges in advancing the completion of the reservoir. I apologize for the delay in this response.

The U.S. Department of Agriculture (USDA) supports the efforts being made by the Water Commission and the significant positive impact that the completion of the reservoir will have for Missouri. This important reservoir is a priority for the USDA's Natural Resources Conservation Service (NRCS), and we continue to support project implementation. The project has evolved over time, moving from single-purpose water control structures to a complex, regional water supply project covering a larger drainage area and producing many more benefits.

NRCS thoroughly evaluated the Water Commission's request for a waiver of $341,000, as requested. This payment reflects the amount owed for the construction of the single-purpose structures. Given that the newly planned reservoir will enhance the original flood prevention and water quality benefits, and that the single-purpose structures will continue to function as sediment traps, NRCS agrees with the sponsor's request and will waive the requirement to repay this amount. In addition, NRCS was confirmed that the requested $350,000 in funding for matching land acquisition costs will be made for this project. However, NRCS is unable to assist with the Water Commission's land acquisition funding obligations due to statutory requirements. I was glad to learn that the State of Missouri is able to provide this funding and that the project will move forward.

An Equal Opportunity Employer

The Honorable Roy Blunt
Page 2

I am pleased that USDA can provide additional assistance to the Water Commission and the people of Missouri in this effort to secure a reliable, high quality water supply.

Again, thank you for writing and for your support of conservation in Missouri.

Sincerely,

Robert Bonnie
Under Secretary
Natural Resources and Environment

26

Missouri Climate Center
The School of Natural Resources
Department of Soil and Atmospheric Sciences
www.mcc.missouri.edu

University of Missouri-Columbia

100 Gentry Hall
Columbia, MO 65211
Phone: (573) 882 - 8599
Fax: (573) 884 - 5133

October 30, 2000

The Honorable Donald W. Summers
State Representative
State Capitol Building, Room 101-B
Jefferson City, MO 65101

Dear Representative Summers:

I am writing this letter in response to your request to support constructing a new lake in Sullivan County as a supplemental water source during future droughts such as the drought of 1999-2000 when the shortage threatened public drinking water facilities.

Unlike Southern Missouri where ground water supplies are resourceful and annual average rainfall totals range from 44" to 52", Northern Missouri mostly relies on surface water supply, which is fed by an annual total rainfall ranging from 31" to 40". On average, 37.28 inches of rainfall occurs annually according to 30-yr National Climatic Data Center records in the City of Milan, Sullivan County. In 1999, 28.42 inches of rainfall (8.86" below normal) was observed in Milan. As of October 30, Milan weather station recorded 29.85 inches of precipitation since the beginning of 2000 while the 30-yr average rainfall amount suggests that this period's total should have been 2.78 inches more. The precipitation deficit becomes more significant (11.04" below normal) when the actual total rainfall since July 1999 (41.24") is compared with the 30-yr average (52.28") for the period from July 1, 1999 to October 30, 2000. Furthermore, the long-term forecast does not suggest above normal precipitation for the next 3 months to make up the difference. Even if 11.04 inches (equivalent to the total rainfall deficit since July 1999) above normal precipitation fell in November 2000, hydrological drought would prevail since most water would be lost by surface runoff unless adequate facilities exist to regulate the excessive water.

Climatology of Missouri shows that the probability of severe summer drought in Missouri is 20% or once every 5 years. Thus, Northern Missouri is more susceptible to drought than the rest of the state. In fact, it has been noted during each Drought Assessment Committee, formed by the request of the honorable Mel Carnahan, that the public water system in Sullivan County has been problematic since July 1999 when the current drought first began.

Because of the issues mentioned above, I endorse any action to construct a new water supply lake in Sullivan County to serve as a regional public water supply source.

The Missouri Climate Center is a part of the Department of Soil and Atmospheric Sciences, in the School of Natural Resources of the University of Missouri-Columbia.

3

Please do not hesitate to contact me if you have any questions regarding climates of the area. I wish you good luck in your mission and congratulate you for your dedication.

Sincerely,

F. Adnan Akyüz, Ph.D.
Missouri State Climatologist
E-mail: AkyuzF@missouri.edu

c: J. Staake, DNR
S. McIntosh, WRP
D. Hammer, UMC
A. Vogt, UMC

The Missouri Climate Center is a part of the Department of Soil and Atmospheric Sciences, in the School of Natural Resources of the University of Missouri-Columbia.

4

Water Resources Research Center

University of Missouri-Columbia

E2509 Lafferre Hall
Columbia, MO 65211
Phone (573) 882-4638
Fax [573] 884-2766

July 23, 2015

Mr. John Holmes
Allstate Consultants
3312 LeMone Industrial Blvd.
Columbia, MO 65201

Dear John,

The East Locust Creek Reservoir (ELCR) offers a unique opportunity to create a model for future lakes and can be used to develop better methods to protect this lake and the public from potential contaminants. We are interested in working with you (the North Central Missouri Regional Water Commission and Allstate Consultants) in establishing a study area to address potential environmental concerns. By being able to study the reservoir before and after construction, one can determine any variations and the causes. Results from this research would benefit not only this reservoir but can be applied statewide and have national implications. Possible topics include enhanced data acquisition for streams and flows, including nutrients, pathogens, toxins and chemical contaminants, carbon life cycle analysis of this lake water compared to the other options and alternatives evaluated in the Preliminary Engineering Report, and for the Army Corp of Engineers permits and Supplemental Environmental Impact Statement, etc.

It is understood that there is only "one" water and it will have multiple uses in its life cycle. All of those need to be considered as we make decisions. This includes energy, food and water needs and their interactions. It is critical that the "Smart Lake Approach", that the project team has been using, be expanded to include the generation of the type of data necessary to properly implement the Lake Authority Legislation controls granted by the state on this water and to further evaluate their impacts on the lake and the potential benefits its brings to the watershed health and downstream environment.

We hope that MU's Missouri Water Resources Research Center will be able to work with the North Central Missouri Regional Water Commission and Allstate Consultants on this project. You have a wealth of talented engineers and teaming with MU's Missouri Water Resources Research Center will provide us with the expertise necessary to provide unique data for the reservoir, state and nation.

Sincerely,

Tom Clevenger
Professor Emeritus
Missouri Water Resources Research Center

Baolin Deng
Director
Missouri Water Resources Research Center

27

CLAIRE McCASKILL
MISSOURI

United States Senate

WASHINGTON, DC 20510

IN REPLY PLEASE REFER TO
OFFICE INDICATED:

555 INDEPENDENCE
ROOM 1600
☐ CAPE GIRARDEAU, MO 63703
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FAX: (573) 334-4278

28 NORTH 8TH STREET
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5850 DELMAR BOULEVARD
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324 PARK CENTRAL WEST
SUITE 101
☐ SPRINGFIELD, MO 65806
(417) 868-8745
FAX: (417) 831-1349

http://mccaskill.senate.gov

December 10, 2015

Mr. Mark Hague
Regional Administrator
U.S. Environmental Protection Agency Region 7
1120I Renner Blvd
Lenexa, KS 66219-9601

Dear Administrator Hague,

I am writing in support of the North Central Missouri Regional Water Commission's application for Brownfields grants through the Environmental Protection Agency.

The North Central Missouri Regional Water Commission is responsible for constructing a water supply reservoir to address an acute and chronic water supply shortage for a ten county region. The commission was successful in their application to receive funds last year and have since acquired numerous additional properties in need of cleanup. The Brownfields grant this year would assist in the continued cleanup of these sites therefore contributing to the creation of a safe and adequate water supply for at least ten counties in North Central Missouri. Additionally, providing funding for this cleanup will also contribute to future economic development in the area and much needed job creation.

It is for these reasons, I support their efforts and I hope you will give full and fair consideration to this application. Please keep me informed on the progress of this request.

Again, thank you for contacting me. Please do not hesitate to contact me in the future if I can be of further assistance to you on this or any other issue.

Sincerely,

Claire McCaskill
United States Senator

From: Ken Dunlap [mailto:kdunlap@kirksvillecity.com]
Sent: Thursday, September 1, 2016 9:54 AM
To: Aaron Jones <AJones@allstateconsultants.net>
Subject: RE: Kirksville Water Usage

Hi Arron.....The lab guys are saying we average 3 mgd a day.....in 2015 kraft averaged 279,836 a day new projected usage is 665,280 a day so id guess a ball park number would be 350,000 increase we will only know foor sure once it has started back up...kenny

From: Aaron Jones [mailto:AJones@allstateconsultants.net]
Sent: Wednesday, August 31, 2016 3:40 PM
To: Ken Dunlap <kdunlap@kirksvillecity.com>
Subject: Kirksville Water Usage

Thanks again for your assistance, it has been very helpful in understanding Kirksville's water situation. Below is a list of questions that would help clarify our data.

Total gallons produced in 2015

Average daily demand from Adair Foods prior to closure (please include the approximate date of closure if it was in calendar year 2015.)

Projected average daily demand from Adair Foods upon reopening

Thanks again Mr. Dunlap.

ROY BLUNT
MISSOURI

VICE CHAIRMAN, SENATE REPUBLICAN CONFERENCE

260 RUSSELL SENATE OFFICE BUILDING
WASHINGTON, DC 20510–2508
202–224–5721

United States Senate
WASHINGTON, DC 20510

COMMITTEES:
APPROPRIATIONS

COMMERCE, SCIENCE AND TRANSPORTATION

CHAIRMAN, RULES AND ADMINISTRATION

SELECT COMMITTEE ON INTELLIGENCE

June 23, 2016

The Honorable Thomas Vilsack
Secretary, U.S. Department of Agriculture
1400 Independence Ave., S.W., Room 200 A
Washington, DC 20250

Dear Mr. Secretary:

I want to share that the Natural Resource Conservation Service (NRCS) has provided tremendous support and leadership on a P.L. 566 Program reservoir in Missouri known as the East Locust Creek Reservoir. I appreciate their past and continued involvement.

This desperately needed 10 county water supply reservoir is progressing nicely with approximately $37 million having been spent or programmed to be spent. It is anticipated that the total cost of the reservoir will be approximately $98 million split between federal and local/state match. The North Central Missouri Regional Water Commission (Commission), the local sponsor, has done an excellent job in securing state support, including drafting legislation to allow the State of Missouri to contribute annually to retiring a loan.

Currently, the plan is to utilize a USDA Rural Development (RD) loan to the Commission to consolidate two bonds and provide for the local match share to meet the local obligations that remain to complete the project. This approximate $37 million will be serviced by the Commission and the State of Missouri in a proportionate cost share arrangement. Due to its size, the RD loan will have to be reviewed and considered for approval at USDA Rural Development headquarters.

The East Locust Creek Reservoir team has informed me that they have received tremendous support and guidance for their funding consolidation plan from the Missouri USDA Rural Development office, specifically from Anita (Janie) Dunning and Clark Thomas. Engineers on the project also met, briefly, with Ben Shuman, PE, Senior Environmental Engineer with USDA Rural Development. Finally, the East Locust Creek Reservoir Team leaders also met with Jacki Ponti-Lazarak, USDA Assistant Administrator for Water and Environmental Program Rural Utilities Service. Ms. Ponti-Lazaruk was in Missouri and afforded the East Locust Creek Reservoir team an opportunity to meet with her on this vital project. According to the team, she provided tremendous counsel and guidance. All of these individuals will play an important role in the loan request review and approval.

Because of the size of the loan, the East Locust Creek Reservoir team was told that the application cannot be transmitted to headquarters for review and approval until all permitting is

www.facebook.com/senatorblunt www.blunt.senate.gov www.twitter.com/royblunt

fully complete. This seems to be a departure from prior practice, but the team is not contesting that decision. However, the change means that the team will face a challenge in timing the State's annual appropriation with the loan payment targeted for July of 2017.

The East Locust Creek Reservoir project is in its 17th month of the permitting process with a Corps of Engineers staff that is overseeing two large water supply lake projects, which also compounds the challenge and concern over timing. In September of 2006 the East Locust Creek project's Final Environmental Impact Statement (EIS), developed in coordination with NRCS, received an EPA Record of Decision. However, the Corps is requiring a Supplemental EIS be produced, adding to the lengthy process.

The East Locust Creek Reservoir Team have nothing but praise for USDA Rural Development and NRCS officials. In an attempt to expedite loan approval, the team hopes to fully answer any and all questions that might arise in its consideration.

As you know, I have been supportive, as you have, of this important project. I will be requesting that East Locust Creek Reservoir team members fly to Washington to brief my staff and will invite staff of Senator McCaskill and Congressman Graves to join. It is my hope that this briefing will occur the last week of July or in early August. While the team are here, I request that you allow Ms. Ponti and Mr. Shuman to meet with them and my team. Issues to discuss include the following:

1) An understanding of the resource needs of USDA Rural Development as it relates to the loan program the East Locust team will be applying.
2) An understanding of some possible challenging portions of the loan application so the East Locust team might be able to work those issues in advance of the application submission.
3) An informal review of the application prior to permitting completion since the NRCS already completed the EIS in 2006 as recorded in the Federal Register by the EPA.

Like you, I understand busy schedules. However, I hope that you will encourage Ms. Ponti-Lazaruk and Mr. Shuman to make themselves available for this discussion. My staff, and the East Locust team, are happy to accommodate their schedules. I remain grateful for your support, and the support of your team, on this critical water supply reservoir in Missouri. Please have Ms. Ponti-Lazaruk and Mr. Shuman contact my legislative director, Tracy Henke, at 202-224-5721 regarding their availability.

Sincere Regards,

Roy Blunt
United States Senator

CC:
Ms. Jacki Ponti-Lazaruk
Mr. Ben Shuman
Ms. Anita Dunning
Mr. Clark Thomas

USDA
United States Department of Agriculture

May 21, 2018

Colonel Douglas Guttormsen
Kansas City District Commander
U.S. Army Corps of Engineers
601 E. 12th Street
Kansas City, MO 64106

Dear Colonel Guttormsen:

This letter is for the purpose of indicating the support of the Missouri State Food and Agricultural Council (FAC), the three Missouri USDA Agencies, Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA), and Rural Development (RD), for the East Locust Creek Reservoir (ELCR) project located in Sullivan County, Missouri. The project encompasses approximately 4550 acres of land that was acquired to host the 2352 acre reservoir.

NRCS has identified approximately $46 million in cost share for the project and RD has issued a draft letter of conditions regarding the injection of $37,600,000 loan funds and $6,000,000 in grant funds towards the project. FSA continues to recognize the agricultural production importance of a dependable water supply for this part of the state and what it means in stimulating the local economy. This 10 county region is the highest agri-business producer per-capita in the state, providing an economic impact of nearly $2.2 billion.

The local sponsor, the North Central Missouri Regional Water Commission (NCMRWC) has spent or has money programmed to spend almost $50 million. Local expenditures account for 37%; state expenditures 16%; and federal expenditures 47%. Much to the sponsor's credit working with 81 landowners, the land was acquired without the use of eminent domain. Agencies at the local level have shown their support by increasing water rates on the existing water users to strengthen their cash flow position and passing a sales tax to support the project. Additionally, the Missouri delegation of Senators Blunt, Senator McCaskill, Congressman Graves and the State of Missouri and are in full support, as they recognized the critical importance of having a reliable domestic water supply in the North Central part of the state. The State of Missouri is showing their strong commitment by their injection of initial planning funds, and in proposing to use the Multipurpose Water Resource Fund to cover any loan deficiency payments that may occur.

In the coming weeks you and your team will have the opportunity to review the NRCS Supplemental Environmental Impact Statement (SEIS) for the East Locust Creek Reservoir in Sullivan County. This document represents a critical and key step toward the construction of the reservoir.

All three of USDA's Missouri agencies have been intimately involved in and supportive of ELCR. The responsibility of USACE is of vital importance at a critical time. We are at your service to provide any information that you might require.

Sincerely,

Jeff Case
Missouri State Director,
Missouri State FAC Chair
USDA-Rural Development

J.R. Flores
State Conservationist, NRCS
USDA-NRCS

Richard Fordyce
Missouri State Exec Director,
USDA-Farm Service Agency

Rural Development • Missouri State Office
601 Business Loop 70 West, Parkade Center, Suite 235 • Columbia, Missouri 65203
Voice (573) 876-0976 • Fax (855) 830-0685 • TDD (573) 876-9480

USDA is an equal opportunity provider, employer, and lender.

CC: Senator Claire McCaskill
Senator Roy Blunt
Congressman Sam Graves
Brad Scott, North Central Missouri Regional Water Commission
Jeff Case, USDA Rural Development
J.R. Flores, USDA NRCS
Richard Fordyce, USDA Farm Service Agency

STATE CAPITOL
201 W. CAPITOL AVENUE, ROOM 216
JEFFERSON CITY, MISSOURI 65101

(573) 751-3222
WWW.GOVERNOR.MO.GOV

Michael L. Parson
GOVERNOR
STATE OF MISSOURI

October 15, 2018

Mr. Jeff Case
State Director
United States Department of Agriculture
601 Business Loop 70 West
Parkade Center, Suite 235
Columbia, MO 65203

Dear Mr. Case,

This letter relating to the East Locust Creek Reservoir (ELCR) is in regard to the United States Department of Agriculture – Rural Development Office (USDA-RD). I want to extend my gratitude for the USDA-RD's support for advancing this important and necessary water supply reservoir.

The planning for construction of the ELCR has taken place over the past 30 years. With support from the North Central Missouri Regional Water Commission (NCMRWC), the State of Missouri, and Senator Roy Blunt, real commitment on this project has materialized during the past nine years.

The ELCR is a part of Missouri's Strategic Regionalization Strategy. Missouri's recent drought has heightened interest in water supply. I've instructed my staff to work with the NCMRWC on processes that may potentially enable the State to utilize various resource funds, including the Missouri Multipurpose Resource Program Fund, to advance this project's efforts.

It is worth noting that all necessary land has been acquired without using eminent domain, a county-wide retail sales tax was passed by 81.25% of county residents to advance this project, and a water rate increase has been implemented to service initials bonds needed for a local match of federal dollars. Planning and engineering is making progress with $64 million of the $110 million project having been already spent or allocated.

My administration is committed to resolving any problems that disrupt the firmly established pathway to securing any remaining federal dollars necessary to finish construction of this project. Thank you for your consideration on this project. Please do not hesitate to reach out to me or my staff with any questions you have.

Sincerely,

Governor Michael L. Parson
State of Missouri

Appendix C

North Central Missouri Regional Water Source Evaluation

Northcentral Missouri
Regional Water Source Evaluation

for the counties of

Adair, Chariton, Grundy, Linn, Livingston,

Macon, Mercer, Putnam, Schuyler, and Sullivan

November 2016

Aaron S. Jones, PE

Cary D. Sayre, PE

John Holmes, PE

Produced with support from Olsson Associates

ALLSTATE CONSULTANTS

OLSSON ASSOCIATES

Table of Contents

Preface 1
Introduction to Region and Water Suppliers 3
History of Water in Rural North-central Missouri 4
Overview of Surface Water Cluster Evaluations 8
RESOP Method 8
7 Q10 Method 10
Surface Water Cluster Reports SW-1 to SW-6 11
Summary of Surface Water Cluster Evaluations 36
Overview of Groundwater Cluster Evaluations 37
Groundwater Cluster Reports GW-1 to GW-9 40
Summary of Ground Water Cluster Evaluations 71
Overview of Out-of-Region Cluster Evaluations 73
Out-of-Region Reports OR-1 to OR-3 74
Summary of Out-of-Region Cluster Evaluations 80
Summary of Findings 81
Conclusion 86
Bibliography 87
Appendicies 89

Preface

The goal of the following analysis is to determine the ability for existing drinking water source(s) to provide sufficient, dependable raw water for the 10-county region of north-central Missouri. By grouping Public Water Systems (PWS's) utilizing the same raw water source(s), into clusters, the regional availability of water can be displayed more accurately. The 18 clusters are split into 3 groups for analysis: groundwater, surface water, and out-of-region clusters. These groupings are detailed below. This approach allows planners to identify instances when a supply source in one cluster has excess capacity during the drought of record (DOR) and another cluster has deficient supply. The first step is understanding the local need for water and identifying whether that need is being met. The second step is evaluating whether those systems with adequate water supply are capable of providing those with inadequate water supply. For the purposes of this evaluation the focus will remain on the first step.

The analysis to determine adequacy of a water source to serve a cluster is based on the following assumptions:

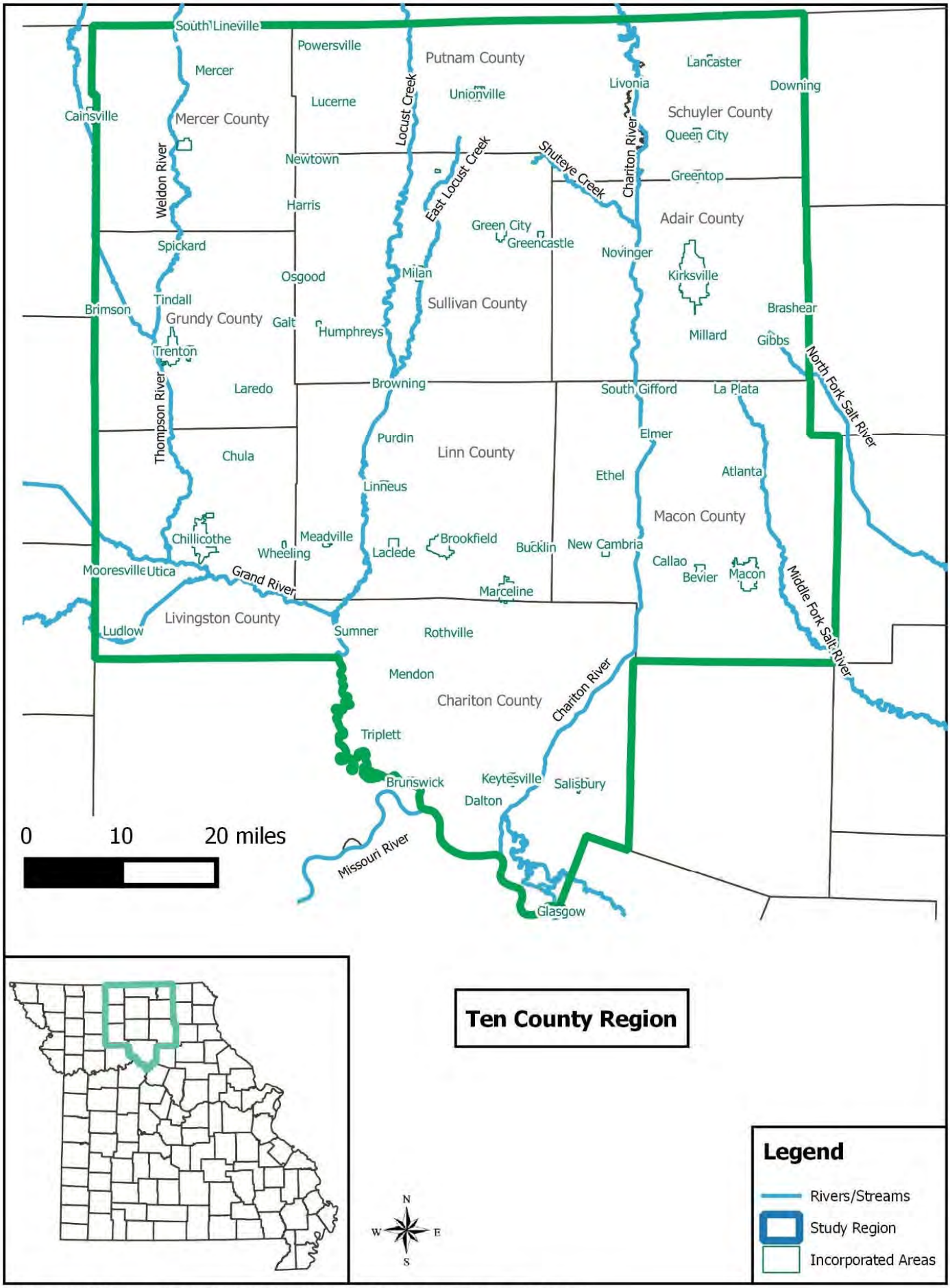
- Current daily raw water demands remain constant
- DOR recharge conditions
- Fifty years of sediment loading for surface water systems
- Water sources are sized according to current Missouri Dept. of Natural Resources design requirements
- Geologic and hydrogeological evidence
- Local history and information specific to water supply

Based on these assumptions, if a source is unable to supply the current daily demand, the cluster will be labeled as an inadequate source. Conversely, if a source is able to supply the current daily demand the cluster will be labeled as adequate.

This study was conducted using information from U.S. Geological Survey (USGS), Missouri Department of Natural Resources (MDNR), individual system interview data and the U.S. Department of Agriculture- National Resource Conservation Service (NRCS).

Staff from the engineering firms of Allstate Consultants and Olsson Associates collaborated on the production of this document. For more information, contact Aaron S. Jones, PE at ajones@allstateconsultants.net or Chad Johnson, PE at cjohnson@olssonassociates.com.

Cluster ID	PWS Providing Water for Cluster
SW-1	North Central Missouri Regional Water Commission
SW-2	City of Brookfield & City Marceline
SW-3	City of Unionville
SW-4	Trenton Municipal Utilities
SW-5	City of Kirksville
SW-6	Macon Municipal Utilities
GW-1	City of Keytesville
GW-2	MO American Brunswick
GW-3	Chillicothe Municipal Utilities
GW-4	Livingston County PWSD #2
GW-5	Linn County Consolidated PWSD #1
GW-6	Linn-Livingston PWSD #3
GW-7	City of Meadville
GW-8	City of Princeton
GW-9	City of Salisbury
OR-1	Rathbun Regional Water Association (surface water)
OR-2	Clarence Cannon Wholesale Water Commission (surface water)
OR-3	Livingston County PWSD #4 (groundwater)



QGIS Version: 2.14.5-Essen Path: //Allstate/GIS Data/CARES/Quantum Projects/Missouri Water Supply 2.8noF.qgs

Figure 1: Location Map for Region of Study.

Introduction to Region and Water Suppliers

The 10-county region of north-central Missouri includes the following counties: Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan. The residents and businesses of these counties are dependent upon the 19 water suppliers, within 18 clusters, to provide treated water daily. Figure 1, above, displays the region and communities within it.

Each cluster has a primary PWS that treats water from the source(s) and then transmits the treated water to other public water systems within the cluster. In some instances, a single PWS may be a part of two or more clusters. This is because the water system has multiple isolated systems for which the water is purchased from different providers. Note that Cluster SW-2 has two PWS's (City of Brookfield and City of Marceline) supplying individually treated water from different sources within the cluster. In this case, there is some interconnection between suppliers.

Generally speaking, the infrastructure needed to transport meaningful amounts of water between clusters is non-existent and development of the infrastructure is not viable for the limited amount of excess capacity that may exist within pockets in the region. The inability of current infrastructure to transport large volumes between adjacent systems, across cluster boundaries, is because of the original sizing of water mains and hydraulics. The existing water mains were sized by engineers based on maintaining adequate flow, water quality standards, and minimum pressures for individual systems.

There are six surface water clusters (SW-1-through SW-6), nine groundwater clusters (GW-1-through GW-9) and three out-of-region clusters (OR-1-through OR-3) that provide finished water in the 10 county region in North Missouri. In Figure 2, below, each segment of the pie corresponds to a producer suppling treated water within the 10 county region. The size of each segment is proportionate to the average daily demand produced by each system. A total of 13.723 million gallons per day (MGD) of treated water was produced in 2015, according to data provided by PWS's. This treated water demand data, is referenced through this evaluation. This graphic brings understanding to how regionalized the study region has become.

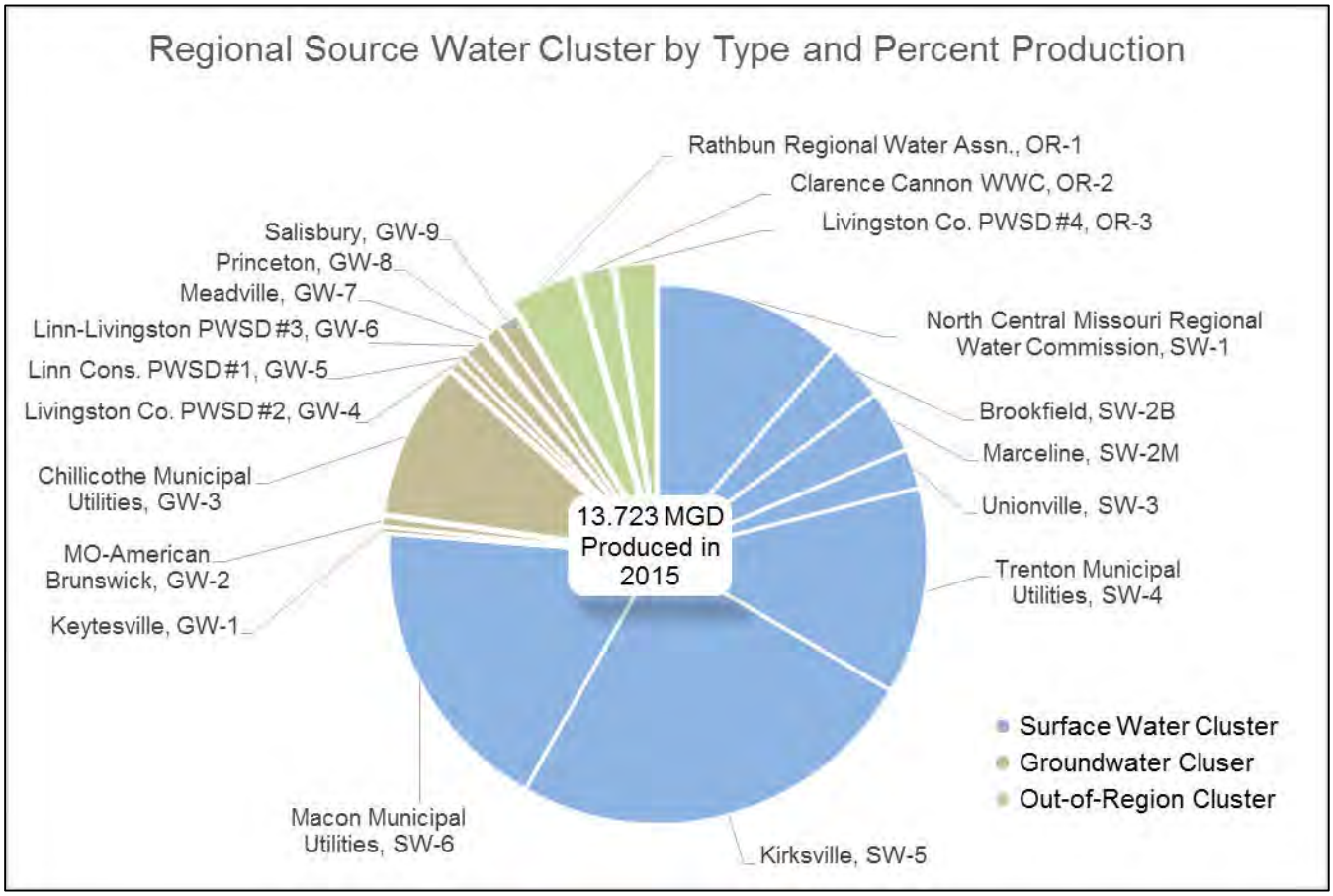


Figure 2: Regional Source Water Clusters by Type and Percent Production

History of Water in Rural North Central Missouri

Water is not a new product or commodity, but the way it is accessed for consumption has change dramatically, in rural north central Missouri. Similarly, the impact of indoor potable water on the United States has been so profound the United States government included questions pertaining to residential plumbing facilities in decennial US Census Housing data, collected from 1940 to 1990 (U.S. Census 2016). Figure 3, below, reveals how rapid the evolution of residential plumbing occurred. The left axis depicts the percentage of residences lacking complete plumbing facilities. Although the intent of the graph is to show data for Missouri, the entire US is included for reference. Coupled with the number of Missouri residences with complete plumbing facilities, the graph captures not only the number of homes modified but also new construction residences with plumbing during a given period. The data shows that over 900,000 homes were built or modified to include complete plumbing facilities between 1950 and 1970. Complete plumbing facilities are defined as hot and cold piped water, a bath- tub or shower, and a flush toilet. (U.S. Census 2016)

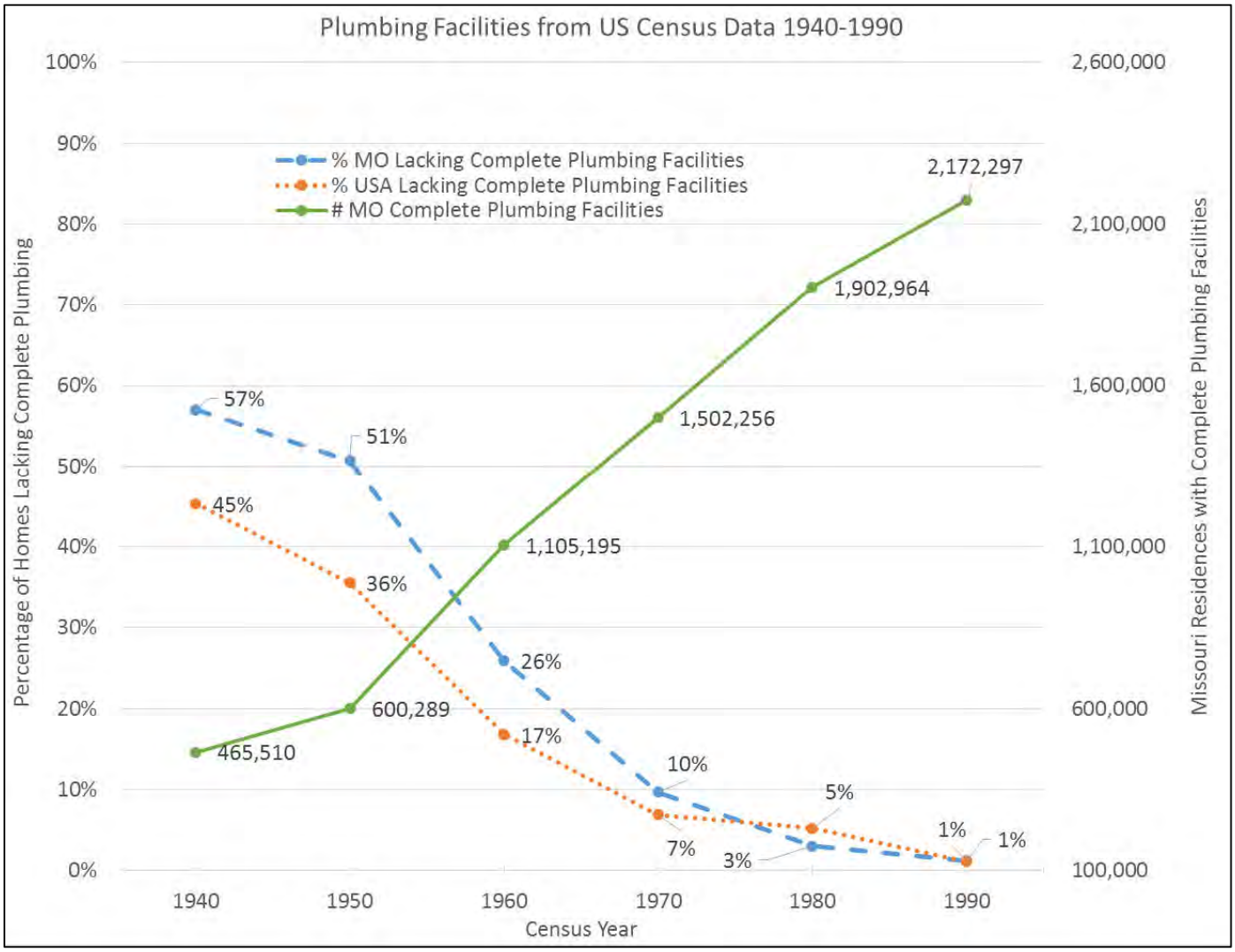


Figure 3: Plumbing Facilities in Missouri and US from U.S. Census data 1940-1990. (U.S. Census Bureau 2016)

The indoor plumbing trend was not exclusive to urban residents, many small rural communities provided available water to residents near town when possible. Many rural homes operated cisterns and had a pump and pressure tank that was utilized to force water into the home's bathroom and kitchen. At that time homes did not have automatic dishwashers and automatic clothes washers, as a general rule, as they used too much water and they would run the cistern dry. Families typically used a bathtub full of water for multiple family members for bathing and residential bathroom showers were a rare thing. When the water level in the cistern became depleted, pumps located in cellars or a home basement would lose prime. Periodically, the homeowner would

clean the cistern and dump bleach in it. Impurities in the cistern would enter the cistern from barn roof gutter drains, house roof gutter drains, surface water conduits, and pond water being pumped in to the cistern. Items that might be cleaned from a cistern could include silt; bird feces; bird feathers; dead animals such as rabbits, rats, cats, birds, snakes, etc.; algae from the ponds; grass clippings; and other such items. Farmers were constantly cleaning out bird nests from gutters and down spouts to keep impurities out of the home's water supply. Some of the better cistern set ups included roof gutter drains dumping into barrels or cylinders filled full of sand that would provide some filtering prior to entering the cistern.

Prior to rural water districts expansions in the late 1960's, residential water in north central Missouri was limited to cisterns and shallow wells. Many of the old cisterns and residential wells were located for ease of access which was typically as close to the home and barn as possible. Many of the old hand dug wells and cisterns have been abandoned and/or collapsed. Remnants of the old cisterns and hand dug wells with windmills can still be seen scattered across north Missouri but many of the old windmills have been torn down.

Surface runoff and livestock waste above and around the well or cistern allowed surface water to enter the water supply. Water quality testing performed by agencies such as University of Missouri Extension, Missouri Department of Health, MDNR, and USDA-NRCS concluded that many of the shallow wells and cisterns were high in nitrates. Elevated nitrate levels utilized for human and livestock water posed health risks such as Blue Baby Syndrome, stillborn calves and stillborn pigs. This water quality testing further increased the need and desire for safe potable water systems to be provided to rural areas (Sievers and Fulhage 1992).

"Groundwater contamination is possible, and numerous cases of groundwater pollution have been documented. However, most are local problems caused by private septic systems, agricultural runoff from livestock confinements, fertilizer, and other agricultural chemicals, such as, pesticides and herbicides" (Miller and Vandike 1997).

Rural water districts in Missouri started in the mid-1960's in the counties surrounding the urban areas of Kansas City and St. Louis. Districts began when people formed steering committees and groups to push for rural water. These systems would allow the rural residents to discontinue using pond water, cistern water, and individual wells for drinking water purposes. The first rural water districts were formed prior to organized design criteria, with private funds by individuals wanting potable water; Plastic and poly vinyl chloride (PVC) pipe allowed the distribution system construction to be more economical than cast iron or ductile iron pipe.

The first rural water districts utilized small-diameter water mains ranging from 3/4-inch to 2 1/2 – inches to fill up cisterns with a yard hydrant. Design criteria for the sizing pipes for rural water systems was initially non-existent in the early to middle 1960's. PVC pipe allowed cheaper pipe to be installed, but many of the larger engineering companies would not specify or allow its use. Agencies such as the State of Missouri worked with Engineers and communities to develop PVC water pipe design criteria such as early glue joint pipe and now slip joint pipe. Engineers within the Missouri Department of Health (currently MDNR) reviewed plans and specifications for the PWS's and began researching the amount of rural water users compared with the gallons of water utilized. From this research and data, it was determined that a near straight line could be plotted on semi-log paper thus the formula for rural water systems was developed in about 1970:

$$Q = 12C^{0.515}$$

Where: Q = water demand in gallons per minute

C = number of residential users

This formula was utilized for years in hand calculations for rural water districts all over the state of Missouri and beyond. The formula calculates water supply for residential household use only and does not account for fire flows (MDNR 2013).

These new public entities (i.e. water districts) allowed people to pass bond issues to fund initial phases of the water district. The next expansion phases of the water district development required people to take on more debt to help out their neighbors in obtaining potable water from a rural water district. This was accomplished through funding by USDA- Rural Development (formerly USDA-FmHA), MDNR, and Community Development Block Grant (CDBG) as districts began to materialize by utilizing low-interest loans and grants. PVC pipe, pumping stations, and elevated finished water storage reservoirs began to be constructed in the rural areas as a pathway to successful rural water districts. This method of rural people helping out each other through the acceptance of debt allowed the rural water districts began to grow and expand.

In part, research from the University Extension indicated farmers' livestock utilizing safe potable water for livestock can result in greater livestock production and profit. Often times, utilizing the rural water district water supply was more dependable and required less maintenance than the farmers operating and maintaining their own wells, cisterns, pump and pressure tanks, pond float and pump system, or any other type of water supply system. Many farmers currently utilize rural water for at least a portion of their livestock watering needs.

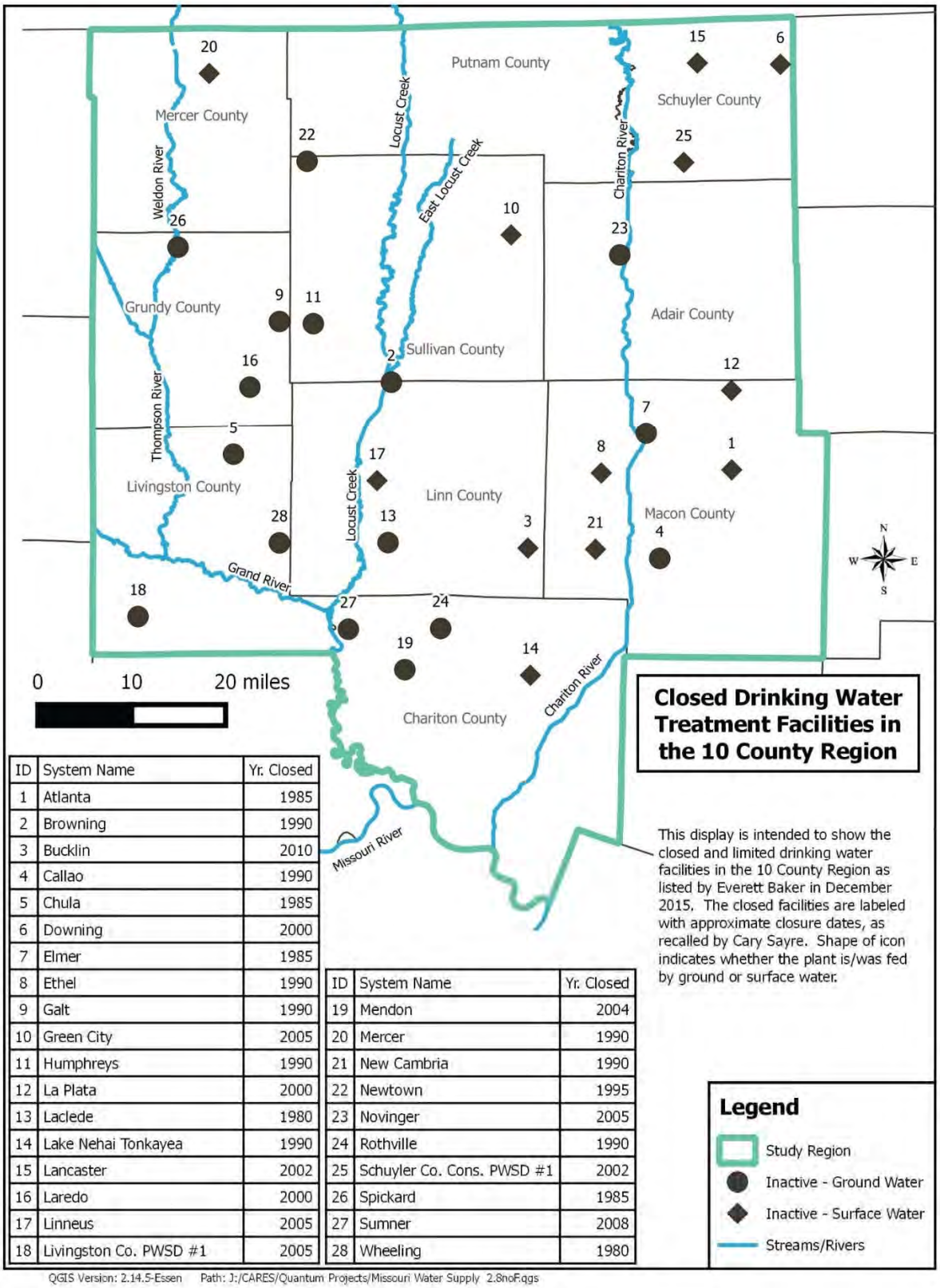
Through time, the drinking water standards and criteria have become more stringent. Trihalomethanes, disinfection, turbidity, security and other such drinking water standards have caused many PWS's to consolidate with larger systems. The closure or consolidation of the 28 treatment facilities since 1980 is one of the most compelling data trends for rural water systems in the region. The complete listing with a summary of factors for closure, including both surface and groundwater sources, is found in Appendix C. Figure 4, below, depicts the location of the systems now purchasing water from an adjacent system after moving away from their own water source and closing their treatment plants. The aggregation of water systems, or development of unintended regional water supplies, to suppliers with larger capacity has impacted the ability of remaining sources to ensure adequate, reliable raw water for all customers. The impacts of unintended regional water supplies has not been sufficiently evaluated within the 10-county area. The analysis contained herein will evaluate existing water sources and evaluate the need for a regional solution for providing adequate, reliable water. In many cases throughout north Missouri, the raw water supply source capacity was not increased at the same order of magnitude that the drinking water demands increased through the addition of rural water expansion and consolidation.

The first example, the City of Bucklin's lake was constructed in the mid-1930's to be a raw water supply reservoir for the City and to fill steam engines for the adjacent railroad. Bucklin began selling treated water to the local rural water district during the early 1980's. The reservoir silted in through the years and the more current U.S. Environmental Protection Agency's (EPA) drinking water standards became too stringent for the City to comply without a tremendous cost. The City of Bucklin closed their water plant in 2010, no longer sell water to the water district, and now both the city and rural users obtain their water from the City of Marceline via Chariton-Linn PWSD #3. This consolidation created additional strain on City of Marceline's water supply system, from raw water source availability, to the treatment, operation, and maintenance capacities.

The second example references the letter in Appendix B, shows an example of a supply system, Linn County Consolidated PWSD #1, in search of another well site after their existing well had been influenced by high iron. The drillers' letter states after 11 test wells that "We don't feel a suitable formation for a well to produce at least 50 GPM has been encountered." This was in an area adjacent to Locust Creek.

In summary, rural public water supplies and even indoor plumbing has only been prevalent in Missouri since around the 1950's. Originally, rural water suppliers were formed to improve health conditions. As those benefits were realized systems rapidly outgrew water source supply capacity. With the public dependent upon a single supply, a need for quality standards was introduced in the Safe Drinking Water Act. These standards became more than some communities could achieve or afford, so reliance upon adjacent supplies began. Figure 4, below, identifies the 28 closed systems in the region since 1980. In an area where source water is scarce, regionalization

has led to the current conditions of widespread dependency on a few sources. Only three of the 18 clusters provide water to their one district or community; the remainder provide wholesale water.



ID	System Name	Yr. Closed
1	Atlanta	1985
2	Browning	1990
3	Bucklin	2010
4	Callao	1990
5	Chula	1985
6	Downing	2000
7	Elmer	1985
8	Ethel	1990
9	Galt	1990
10	Green City	2005
11	Humphreys	1990
12	La Plata	2000
13	Laclede	1980
14	Lake Nehai Tonkayea	1990
15	Lancaster	2002
16	Laredo	2000
17	Linneus	2005
18	Livingston Co. PWSD #1	2005

ID	System Name	Yr. Closed
19	Mendon	2004
20	Mercer	1990
21	New Cambria	1990
22	Newtown	1995
23	Novinger	2005
24	Rothville	1990
25	Schuyler Co. Cons. PWSD #1	2002
26	Spickard	1985
27	Sumner	2008
28	Wheeling	1980

Figure 4: Closed Drinking Water Treatment Facilities in the 10 County Region, based on (MDNR- Baker)

Overview of Surface Water Cluster Evaluations

Water supply systems in north central Missouri rely on a variety of surface water sources, including in-stream reservoirs, off-stream reservoirs, and streamflows. Evaluation of these surface water sources, requires analysis of either the Reservoir Operation Study Computer Program (RESOP) for instream reservoirs, or the 7 day average low flow rate that occurs once in 10 years on average (7 Q10) of streamflows combined with capacities of off-stream reservoirs. These methods were analyzed against the available rain gauge data from this period, 1952-1959, as the DOR, which is the longest duration and most intense drought in Missouri on file.

RESOP Method

The MDNR approved method for instream reservoir analysis is the NRCS's RESOP, which is used to calculate "optimized demand" as described in NRCS Technical Release 19.

> Optimize Demand -- indicates that the lowest storage will be checked against the lower limit and the demand modified until the maximum demand is reached and no deficiency occurs. (NRCS 1987)

To avoid confusion with the word demand, in this evaluation optimized demand will be referred to as reservoir yield capacity and defined as:

> <u>Reservoir Yield Capacity</u> is the calculated volume of raw water that can be withdrawn daily from a reservoir to maintain a minimum volume in the reservoir to meet other purposes, and meet water source design guidelines.

The term Normal Demand will be defined as:

> <u>Normal Demand</u> is the average daily quantity of water used by customers, based on an annual period.

The RESOP calculates the reservoir yield capacity by using initial volume, water supply volume, rainfall, runoff, and evaporation parameters. If daily water supply withdrawals (normal demand) are greater than reservoir yield, the results will be a shortage of water during a DOR. The evaluation contained herein will characterize system clusters with a normal demand greater than the calculated water source yield capacity, as an inadequate source. The system clusters with a normal demand less than its calculated yield capacity will be characterized as an adequate source.

> Normal Demand (raw water) < Reservoir Yield Capacity → Adequate Source

> Normal Demand (raw water) > Reservoir Yield Capacity → Inadequate Source

Some of the evaluated reservoirs serve multiple purposes such as recreational, drinking water supply, and flood control. In the case of a water supply and recreational use reservoir, a minimum volume, or lower limit, must be established to maintain aquatic habitat and recreational uses. Other examples of lower limit volumes include physical intake inlet elevations and water quality thresholds. Note that these limitations and thresholds are different for each source. These lower limits were not included in the Missouri Water Supply Study of 2013 (MDNR 2013), so that analysis assumes that quality drinking water can be withdrawn from the lake until the lake is dry. The Missouri Water Supply Study provided the background data and base RESOP models for this evaluation, but this new, more detailed analysis was completed to better quantify water availability in the 10-County region by accounting for added sediment over the next 50 years, and reasonable limits on acceptable lake levels.

Given the sensitivity and security of information regarding specific design details of public water supply inlet structures, systems interviewed asked for those details to be omitted from this evaluation. Some systems within the study region shared their inlet elevations and discussed which inlets were typically used. One system referenced water analysis conducted on the entire water column and noted water from the lowest inlet elevation was "oxygen deprived and therefore highly reactive during jar testing." By conducting routine jar testing the systems staff determined that they could use less chemical to treat water 4 to 6 feet below the water surface.

Water inlet elevations vary by source, as well as by water quality horizons. This evaluation could not reasonably consider all variables that affect each supply in the region and, therefore the assumption of the lower one-third reservoir elevation was made to account for inaccessible water and water quality limitations, and is based on the knowledge of systems within the study region. Note the one-third elevation, from the spillway to the lowest pool elevation, is not equal to one-third of the reservoir volume. Bathymetric evaluations by USGS from the Missouri Water Supply Study of 2013 were used for calculations.

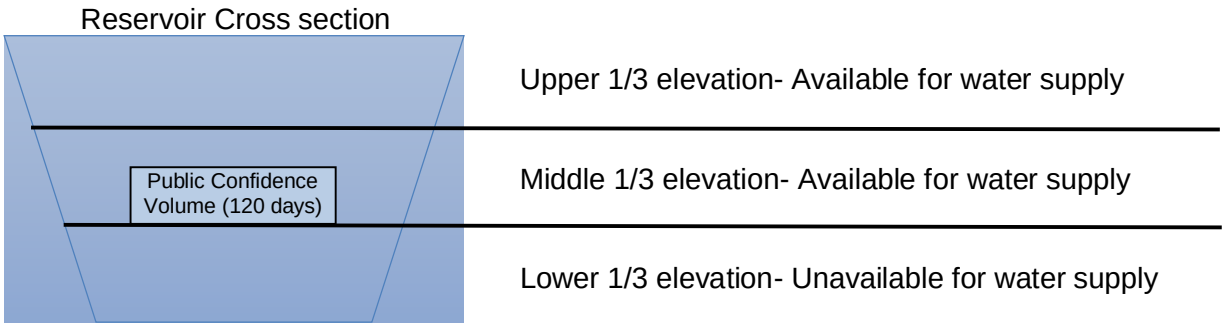


Figure 5: Reservoir Cross section (not to scale)

When evaluating a source for quantity and reliability the Minimum Design Standards for Missouri Community Water Systems states the following in Chapter 3 Section1.1a:

> "Reservoir storage volume shall provide a reasonable surplus for reserve storage. A reasonable amount of surplus reserve storage should be considered in order to maintain public confidence in the reliability of supply at predicted depletion levels during a prolonged severe drought. A minimum of 120 days surplus reserve storage should be considered."

This public confidence volume should be accounted for in the portion available for water supply, as shown in the Middle 1/3 elevation in Figure 5. This volume is calculated by multiplying the normal demand by 120 days. This quantity of million gallons must then be converted to acre-feet and added to the lower limit of RESOP analysis when calculating reservoir yield capacity. An example of the impact of public confidence is included in the following Cluster SW-5 report.

In order to provide a thorough investigation of the water supply dependability in the 10-county region, the RESOP analyses were updated for differing assumptions. RESOP input parameters for lake volumes were also modified for sediment to reflect the volume of reservoir capacity reduced by the accumulation of sediment over the next 50 years. Some of the RESOP graphs show this as adjustment for sediment, which is the reservoir levels assuming normal demand stays constant, but shifted to account for the reduced reservoir volume due to sedimentation over 50 years.

To accurately model extreme conditions the scenarios considered must reflect conditions when no pumping will be allowed. These no pumping conditions have been observed in actual pumping data sets. As an example the largest streamflow in the region is the Thompson River which provides water for Cluster SW-4. The USGS recorded the daily flows in the Thompson River observation station at Trenton, MO. The data shows a four consecutive-month period (November 1955 to February 1956) when average monthly flows (from daily flow calculations) in the Thompson River were below the base flow of 9 cfs, therefore no pumping could be allowed during this time. See Cluster Report SW-4 for more information. Through observed data and because other streamflows smaller than that of the Thompson River are used to supplement in-stream reservoirs, (which prohibited pumping during the DOR), the capacity from pumping will not be considered as a dependable source of water.

An important note about RESOP analysis is that unless the start of a DOR was accurately predicted and pumping was reduced prior to the beginning of the drought, in the case that normal demand exceeds reservoir yield, the

reservoir would not actually be able to produce the reservoir yield because it would be drawn down by the normal demand before conservation measures could be implemented. In other words, the normal demand needs to be below the reservoir yield, or the reservoir yield could not actually be achieved. So, in these cases, the reservoir yield overestimates the available water.

In the case when a PWS uses multiple reservoirs for raw water supply an additional calculation is needed to identify the proportion of total normal demand on each source. The proportional demand approach was used in this evaluation similar to the approach by MDNR in the Missouri Water Supply Study of 2013. This calculation was only used in Cluster SW-5 and detailed calculations are included in its report.

7 Q10 Method

For systems in the region that rely on streamflow, the Minimum Design Standards for Missouri Community Water Systems stipulates in Chapter 3 Section 1.1.f:

> "When a river or stream is to be used as the sole source of water, the flow in the river or stream shall exceed the current registered and future downstream uses, instream flow recommendations, usually the 7 day Q 10 flow rate, and the design year future water system demand. Historical data must be used to determine that stream flows are adequate. Where the nearest gauging station is downstream of the intake site, a drainage area ratio or other approved method to represent the intake location must adjust the flow data. Data from an upstream station may be used. For streams where data does not cover the DOR, data from similar streams may be used to correlate or predict stream flows, with department approval" (MDNR 2013).

The 7Q10 is the 7 day average low flow rate that occurs once in 10 years on average. So, by definition, the flow in the stream during the DOR will be below the 7 day Q 10 flow rate. The 7 day Q 10 flow rate represents a moderate drought of the kind that occurs once in 10 years. This leaves no capacity for the water system to pump from the stream during any drought more severe than the 10 year return period drought.

In the north-central region of Missouri several systems use a combination of streamflow and reservoirs to provide water. An important step in evaluating the dependability of a source, is considering cases when augmenting (pumping) a source with water from streamflow is not an option. The Missouri Water Supply Study describes this circumstance in the following excerpt:

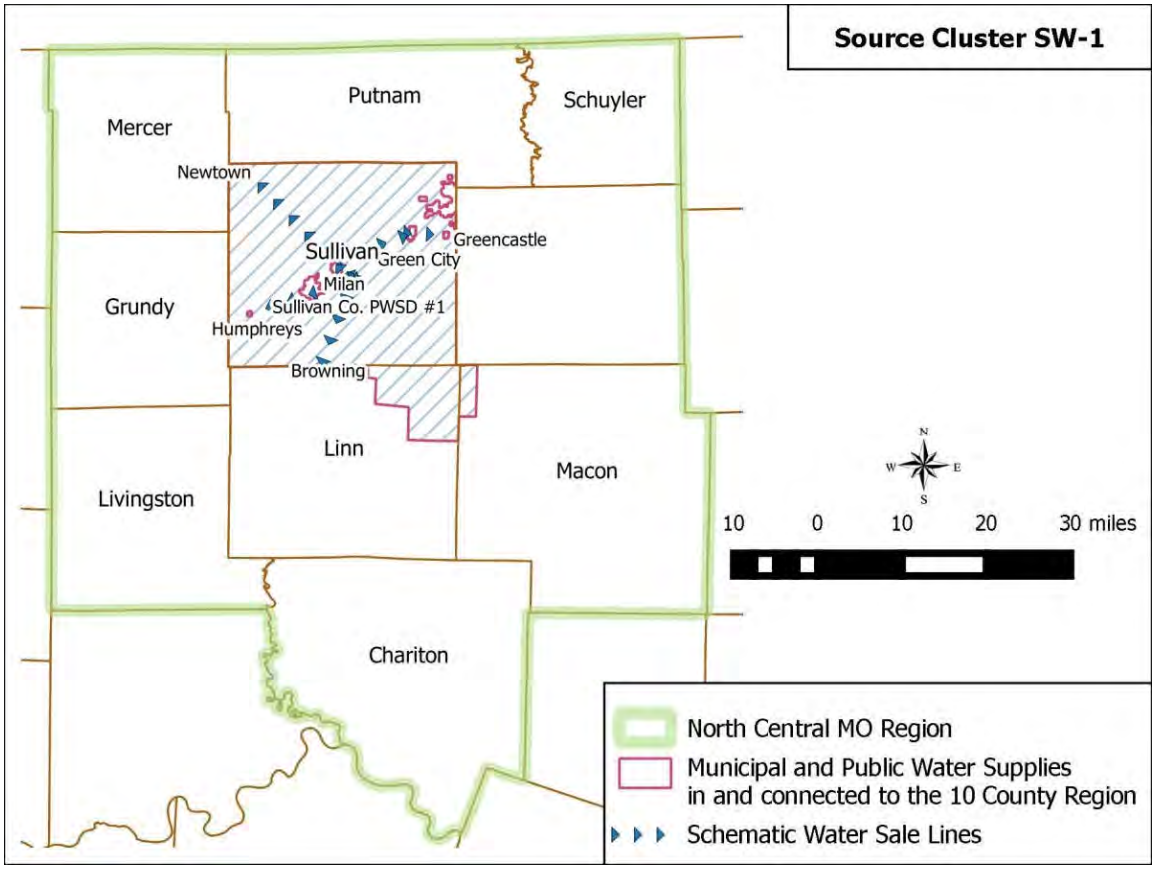
> "Several of the examined water supply systems are from a collection of surface water sources, which can include several small lakes in series or tandem and often supplemented by in-stream diversion pumps. These analyses were made for some of the most critical supplies. Cities usually use two sources to supply their needs. These sources are lakes and flowing streams. Water stored in lakes comes from rainfall runoff to the lakes. Many of the lakes are too small in size and drainage area to satisfy local needs. As a result, the supply provided by the lakes must be supplemented by other sources. A common practice is to pump from streams into the lakes during high stream flows in an attempt to keep water levels in lakes near full. During droughts one can expect the streams to dry up or stream flow to be so low that pumping cannot be achieved" (MDNR 2013).

The following surface water cluster reports provide information on specific systems and sources within each of the six clusters, as well as the determination of a source to be adequate or inadequate.

Surface Water Cluster Reports SW-1 to SW-6

Cluster SW-1

Sources Inadequate



There are currently two lake sources for Cluster SW-1, operated by the North Central Missouri Regional Water Commission (NCMRWC) near Milan, Missouri. The cluster map above shows the service area for this cluster and the Production and Demand table on the next page details systems dependent upon these sources for all water supply needs. The demands listed are average daily treated water usage, based on an annual period. NCMRWC currently produces approximately 0.572 MGD of treated water and sells another 0.923 MGD raw water to Premium Standard Farms, which operates its own treatment facility for industrial purposes. The single treatment facility is designed to produce 2.4 MGD and enough land is owned by the NCMRWC to expand the facility to an ultimate approximate capacity of 6.5 MGD treated water.

Since 1985 four communities in this cluster have abandoned water treatment activities. Green City was mandated by the MDNR to cease treatment activities in 2004. The Inactive Sources table on the next page identifies those communities and briefly describes the reasoning for closure.

Assessing the two reservoir sources, Elmwood Lake and Milan Lake (Golf Course Lake), it is important to note that pumping from Locust Creek is necessary to maintain current demand. Both the 194-acre Elmwood Lake and 41 acre Milan Lake are supplemented with pumping from Locust Creek during normal and dry periods to maintain adequate levels. During wet periods pumping is conducted as needed. As both sources continue to decay and silt, the available source water capacity continues to decline. This reduction of capacity threatens health, safety, and economic sustainability of communities dependent upon this supply. Modeling conservative scenarios over the next 50 years, with siltation and drought of record conditions, RESOP analysis shows that the Elmwood Lake and Milan Lake, respectively, could daily yield 0.800 and .140 MGD of raw water. Cluster SW-1's total raw water yield capacity is 0.940 MGD, which is 0.744 MGD less than the average daily raw water demand under current conditions, therefore the sources for Cluster SW-1 are inadequate. USGS Low Flow data shows the 7Q10 is less than 0.24 MGD which means that the stream will be unable to provide sufficient flow in a DOR.

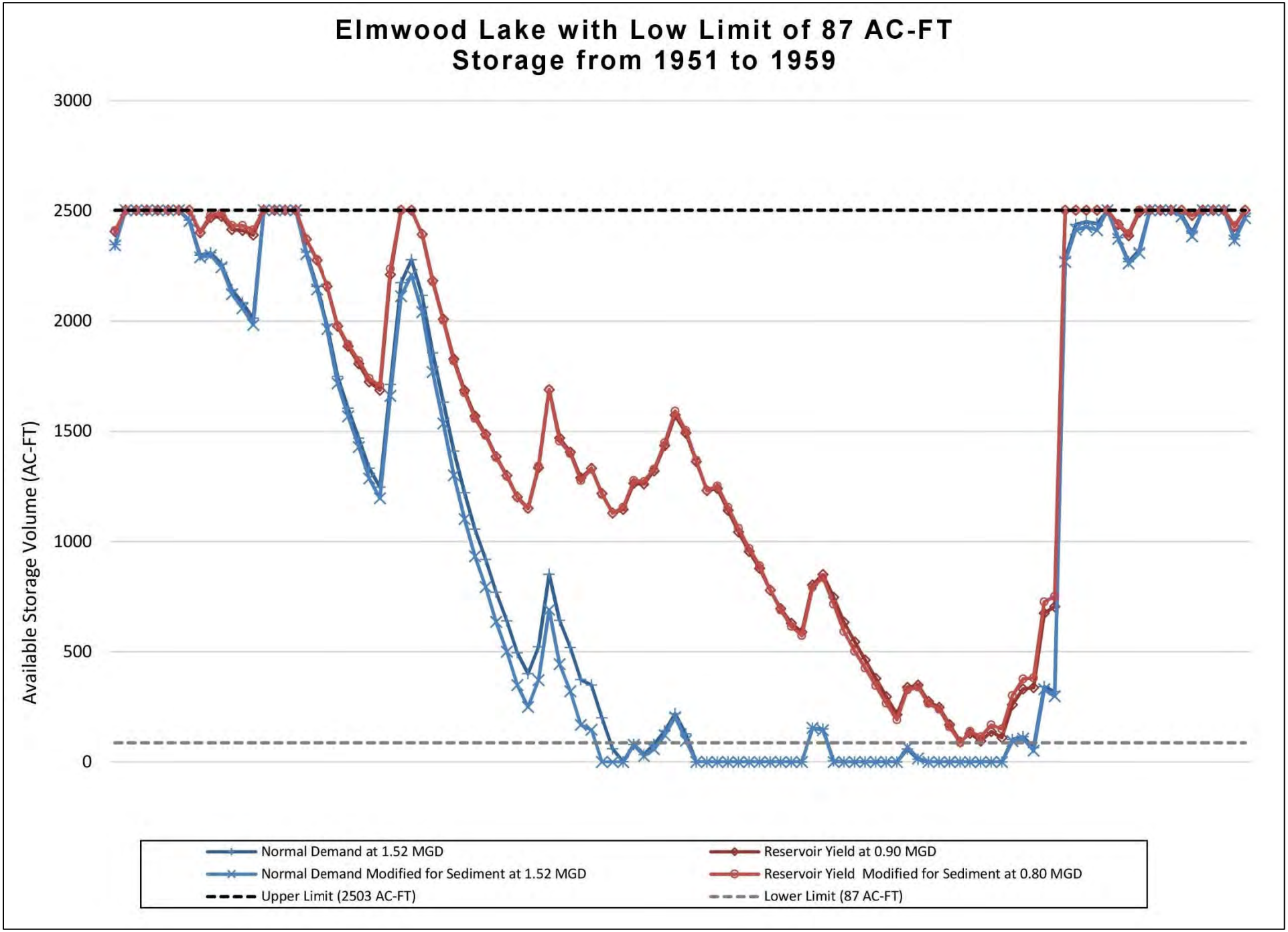
2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-1	North Central Missouri Regional Water Commission					1.572		n/a
	Green City						100%	0.122
	Green Castle						100%	0.034
	Milan						100%	0.180
	Sullivan County PWSD #1						100%	0.274
	Browning						100%	0.017
	Humphreys						100%	0.007
	Newtown						100%	0.016
	Premium Standard Farms (Raw Water Industrial Customer)						100%	0.923

Inactive Sources Within Cluster					
System ID#	System Type	System Name	County	Source	Year of Closure
MO2010329	Surface Water	Green City	Sullivan	Inadequate lakes to demand; single stage treatment facility became inadequate; closed plant; now purchase water from NCMRWC	2005
MO2010574	Groundwater	Newtown	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1995
MO2010389	Groundwater	Humphreys	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1990
MO2010108	Groundwater	Browning	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1990

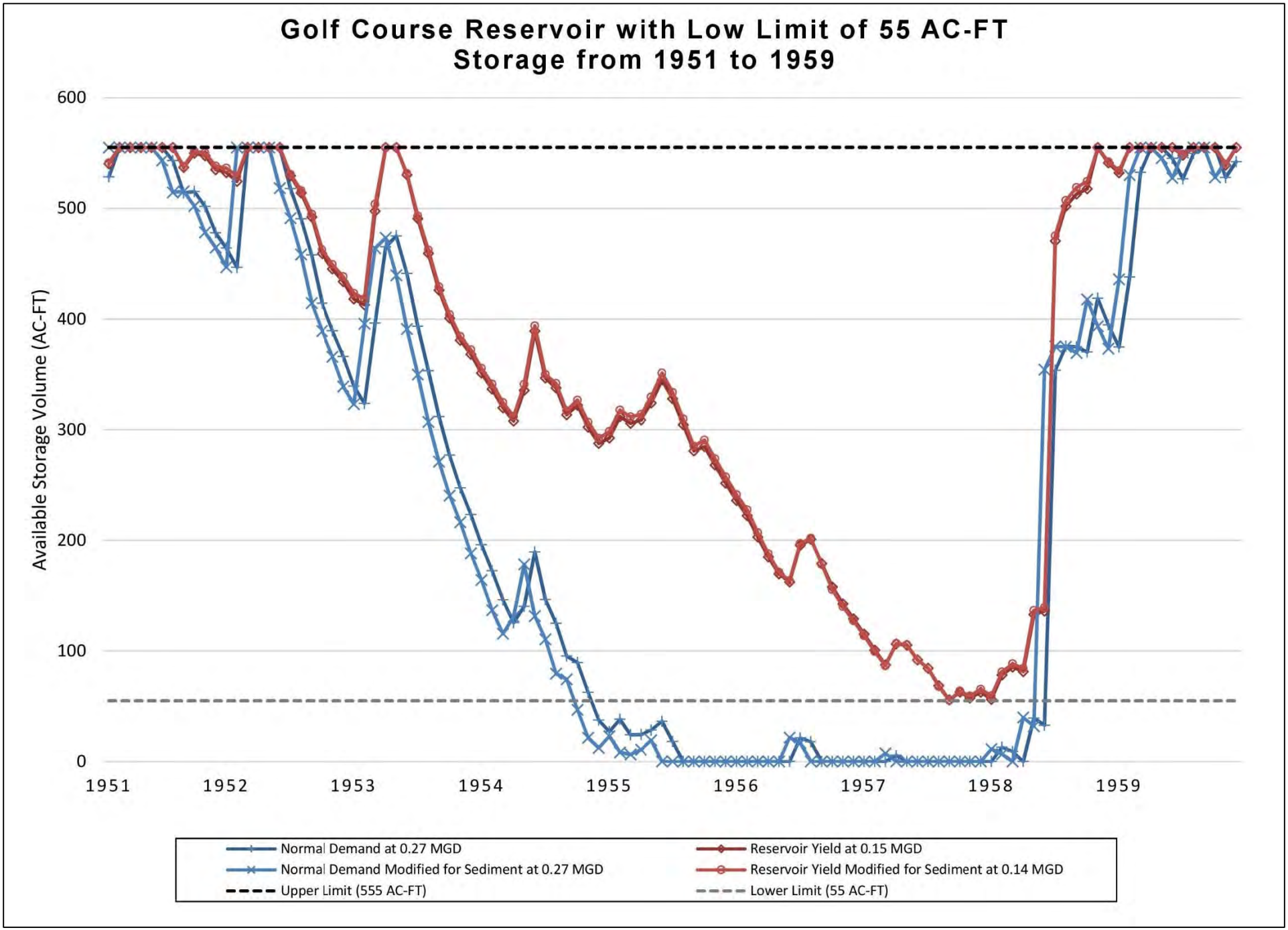
Surface Water Supply(s) Within Cluster											
		Cluster Current Demand		Raw Water Capacity Without Pumping, With Sediment		Excess Capacity (Reservoir Yield- Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
Cluster	Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)						
SW-1	Elmwood Reservoir	1.572	1.629	0.800	0.940	-0.689	S, R	1972	194.77	2503.2	2416.5
SW-1	Milan Lake (Golf Course)			0.140			S, R	1940	41.01	555.2	500.3

Results from USGS Low Flow Equations* for Stream Intakes in 10-county region									
				Inputs			Outputs		
Cluster	Supplier	PWS System ID	Intake	Drainage Area (Mi^2)	Length (mi)	Stream Variable	7Q10 (MGD)	30Q10 (MGD)	60Q10 (MGD)
SW-1	NCMRWC	2021537	Locust Creek at Intake	217.63	44.08	0.745	0.264	0.568	0.921

* Computed Statistics at Streamgages, and Methods for Estimated Low-Flow Frequency Statistics and Development of Regional Regression Equations for Estimating Low Flow Frequency Statistics at Ungaged Locations in Missouri, USGS 2013



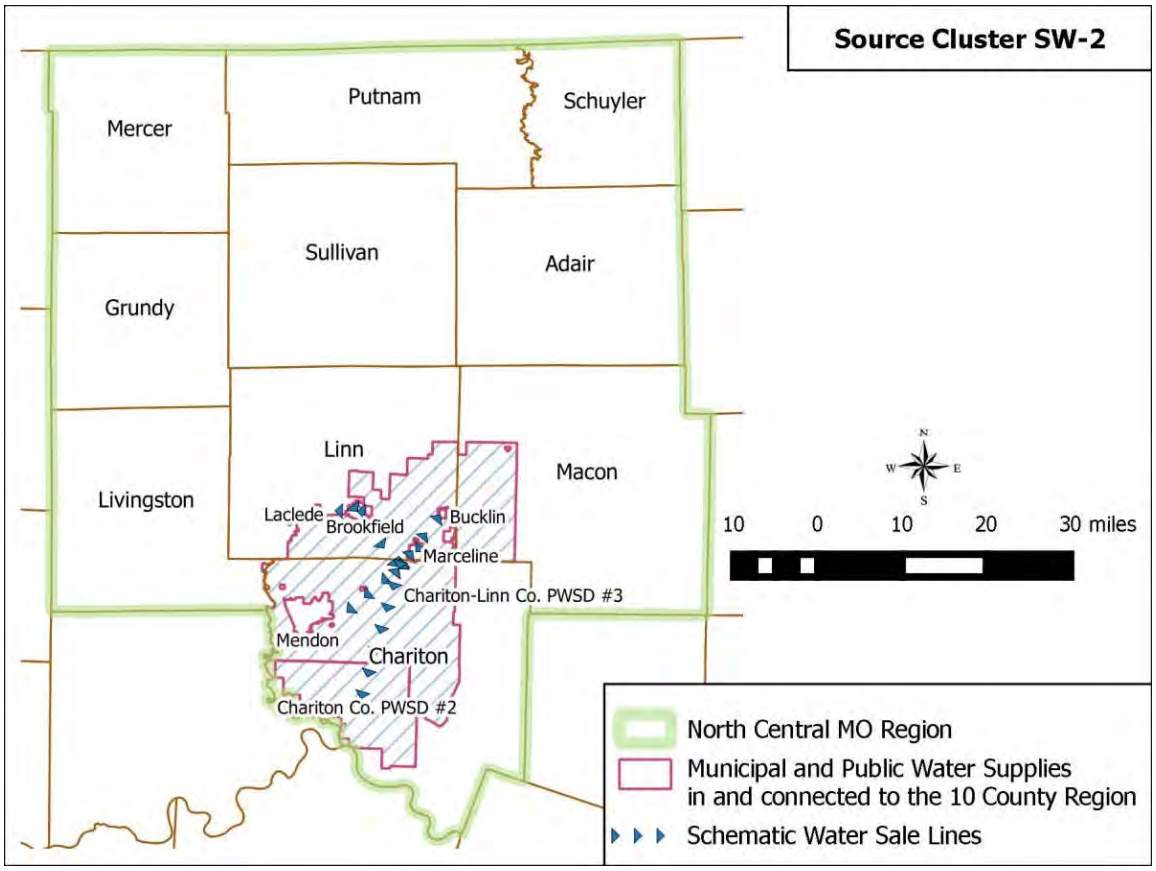
RESOP Graph 1 Elmwood Lake



RESOP Graph 2 Golf Course Reservoir

Cluster SW-2

Sources Inadequate



The two sources for Cluster SW-2 are the City of Brookfield (SW-2B) and the City of Marceline (SW-2M), both of which operate separate surface water reservoirs and separate water treatment facilities. These two communities and sources are included in Cluster SW-2 because of a common secondary system in Chariton-Linn PWSD #3. Marceline does not provide water to Brookfield, nor does Brookfield provide water to Marceline, but Chariton-Linn PWSD #3 is responsible for a large part of both sources demand. Of the 8 systems in this cluster that have abandoned treatment activities, 7 have been purchased by or purchase water from Chariton-Linn PWSD #3. These systems are noted on the Inactive Sources table in this section. The closure of these eight systems have caused demand to increase from both Brookfield and Marceline, causing a larger water deficit for these two larger communities during drought conditions.

The City of Brookfield maintains four ground storage basins, known as the Brookfield Reservoir. These basins are filled from a pump station in the adjacent Yellow Creek. This complex of basins has no significant recharge from runoff given the basin′s bermed perimeters, and the capacity, when full, total approximately 115 million gallons or 353 acre-feet. RESOP analysis is not available for this source but the 200 acre-feet needed for public confidence to comply with MDNR standards, will be excluded from the RESOP analysis of Brookfield City Lake instead. During a DOR these basins would provide approximately 200 days of raw water supply before being unusable. USGS low flow equations calculate the 7Q10 at .258 MGD which is well short of the daily raw supply needed to meet normal demand. Due to the extreme and prolonged nature of the DOR, Yellow Creek is not a dependable source of water. There for given the no pumping condition, the Brookfield Reservoir is not a viable source of water during extreme conditions.

The other Brookfield source is the Brookfield City Lake, which is also augmented with pumping from Yellow Creek. Due to mechanical issues with the pump station supplying the Lake in the early 2000′s the lake was reported to be over 12′ below normal pool, drastically reducing supply capacity. RESOP analysis on this lake

determined during DOR conditions the reservoir yield capacity is 0.180 MGD without augmenting from Yellow Creek. The current treated water normal demand on Brookfield's sources is 0.494 MGD, which corresponds to a raw water normal demand of 0.543 MGD. Comparing the reservoir yield capacity to the raw water normal demand equals a net negative source capacity of 0.363 MGD during DOR conditions.

The City of Marceline maintains two reservoirs and a creek pump station on Mussel Fork Creek to augment the reservoirs as needed. USGS low flow data shows that Mussel Fork Creek flow is not sufficient to pump during prolonged dry periods. The larger, New Marceline Lake serves as the primary source and is modeled to have a RESOP reservoir yield capacity of 0.448 MGD, without pumping, during the DOR. While the Old Marceline Reservoir, with the same conditions has a RESOP reservoir yield capacity of .060 MGD. The calculation of the Old Marceline Reservoir was provided from in the Missouri Water Supply System Study of 2013 (MDNR 2013). The system does have the capability to pump water from the Old Reservoir to the New Marceline Lake and the water treatment facility. The Marceline water treatment facility was built in 2000 and maintains an average flow of approximately 1,250 gpm.

Marceline's two sources can combine for a daily reservoir yield of 0.454 MGD, which is less than the current treated demand of 0.508 MGD. The Marceline raw water normal demand is approximately 0.572 MGD, which results in a net negative reservoir yield capacity of 0.118 MGD. Combined with the net negative yield capacity of Brookfield, Cluster SW-2 has a total net negative yield capacity of 0.515 MGD. This analysis concludes that Cluster SW-2 sources are inadequate.

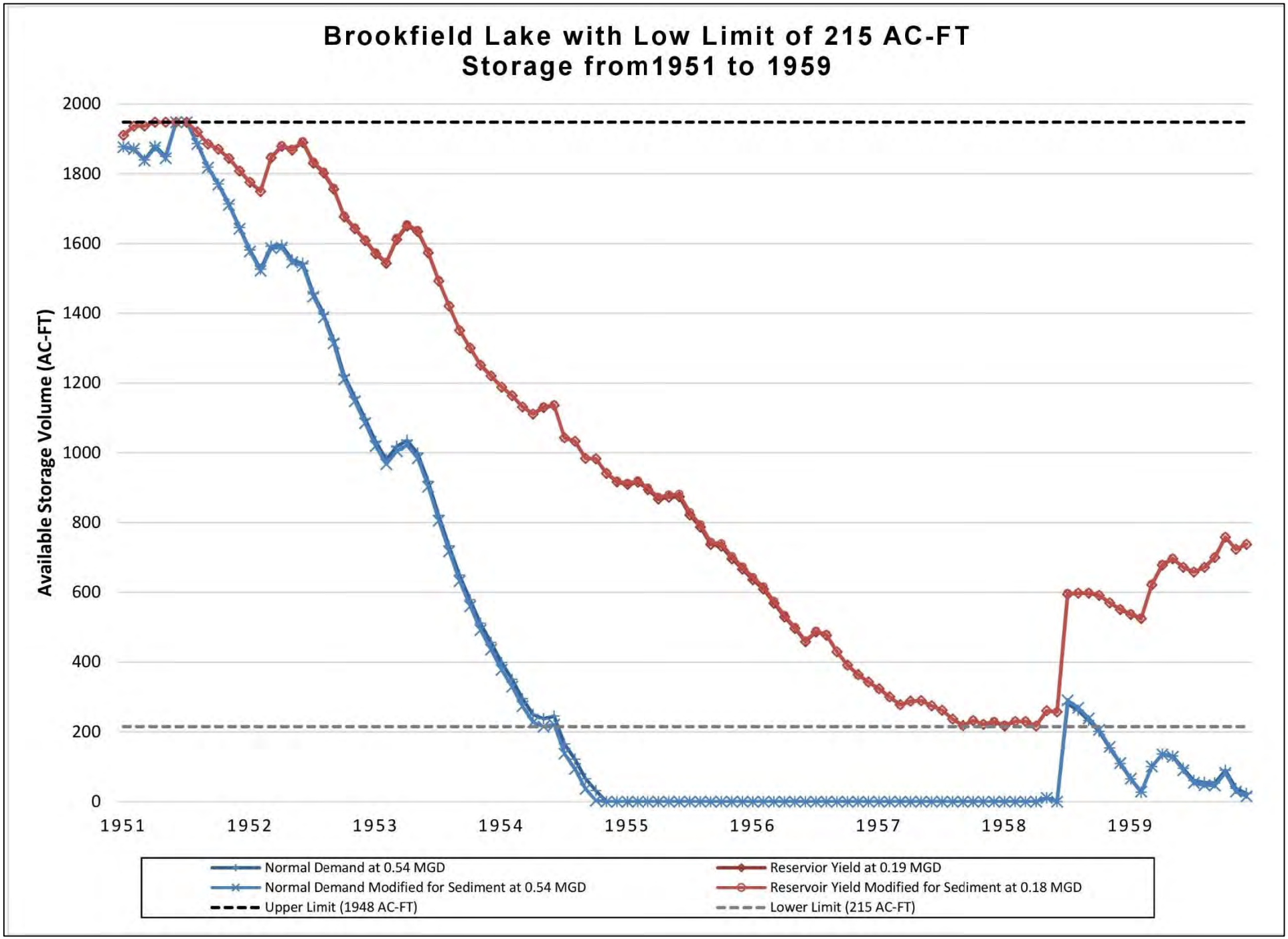
2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-2	Brookfield					0.494		0.376
	Laclede						100%	0.031
	Chariton-Linn PWSD #3						25%	0.351
	Bucklin						100%	0.017
	Mendon						100%	0.018
	Chariton PWSD #2						35%	0.049
	Marceline					0.520		0.257
	Chariton-Linn PWSD #3						75%	0.351
	Bucklin						100%	0.017
	Mendon						100%	0.018
	Chariton PWSD #2						35%	0.049

Results from USGS Low Flow Equations* for Stream Intakes in 10-county region									
				Inputs			Outputs		
Cluster	Supplier	PWS System ID	Intake	Drainage Area (Mi^2)	Length (mi)	Stream Variable	7Q10 (MGD)	30Q10 (MGD)	60Q10 (MGD)
SW-2	Marceline	2010497	Mussel Fork at Intake	146.7	55.6	0.695	0.100	0.229	0.284
SW-2	Brookfield	2010105	West Yellow Creek at intake	195.27	54.7	0.659	0.258	0.546	0.723

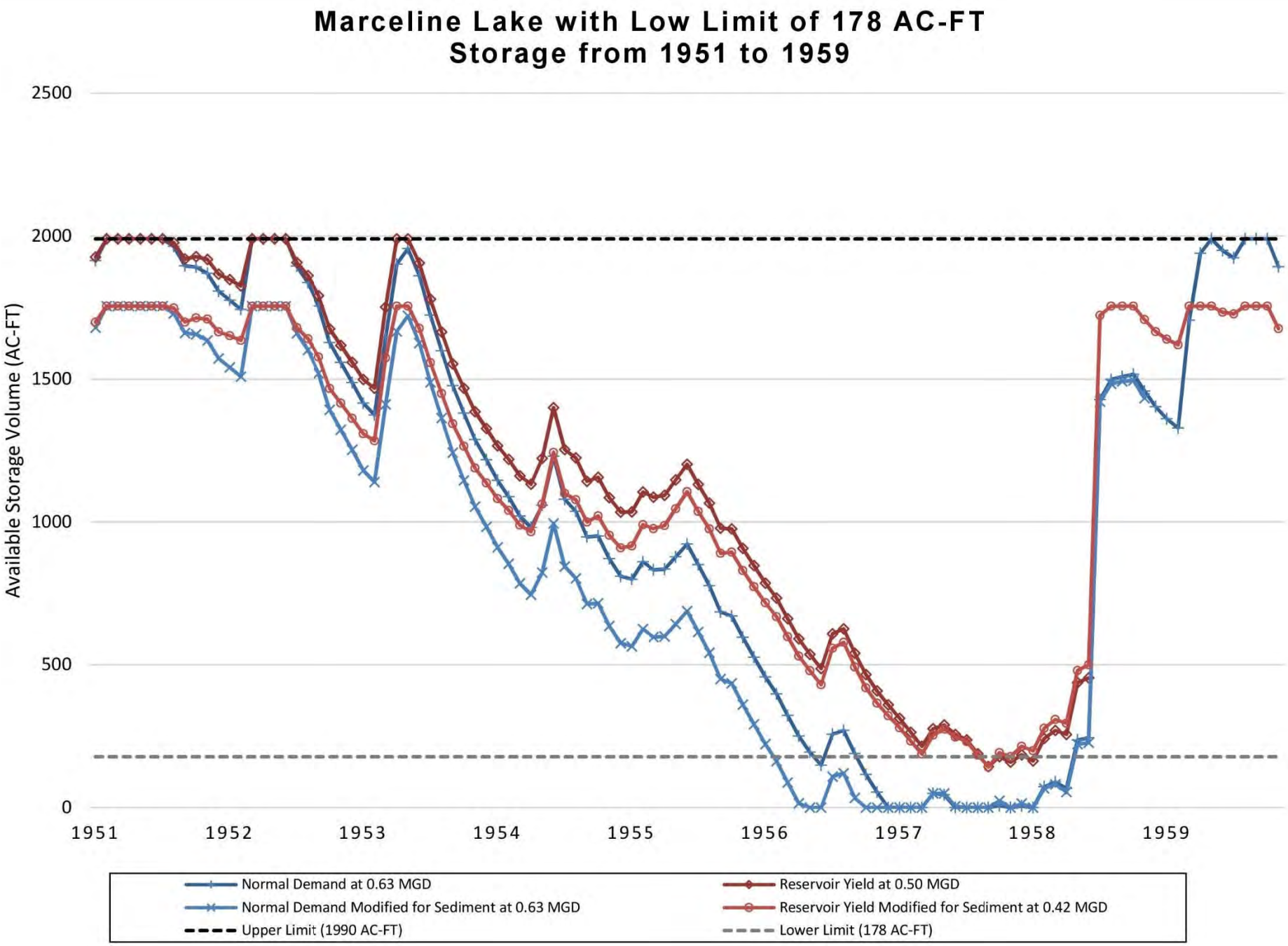
* Computed Statistics at Streamgages, and Methods for Estimated Low-Flow Frequency Statistics and Development of Regional Regression Equations for Estimating Low Flow Frequency Statistics at Ungaged Locations in Missouri, (USGS 2013)

Inactive Sources Within Cluster					
System ID#	type	System Name	County	Source	Year of Closure
MO2010112	Surface Water	Bucklin	Linn	Inadequate lake (shallow and heavily silted); struggled with disinfection-by-products; closed plant; now purchase water from Chariton-Linn #3.	2010
MO2010185	Groundwater	Laclede	Linn	Failed shallow wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Brookfield	1980
N/A	Surface Water	Ethel	Macon	Inadequate lake (shallow and heavily silted); closed inadequate treatment plant; adsorbed by Chariton-Linn #3	1990
N/A	Surface Water	New Cambria	Macon	Inadequate lake (shallow and heavily silted); closed inadequate treatment plant; adsorbed by Chariton-Linn #3	1990
N/A	Groundwater	Sumner	Chariton	Failed shallow wells with declining yield; closed plant; adsorbed by Chariton-Linn #3	2008
MO2010514	Groundwater	Mendon	Chariton	Failed shallow wells (declining yield, high in iron); closed plant; now purchase water from Chariton-Linn #3	2004
N/A	Groundwater	Rothville	Chariton	Failed shallow wells (declining yield, high in iron); closed plant; adsorbed by Chariton-Linn #3	1990
N/A	Surface Water	Lake Nehai Tonkayea	Chariton	Inadequate treatment plant; difficulty maintaining qualified operator; closed plant; adsorbed by Chariton-Linn #3	1990

		Cluster Current Demand		Raw Water Yield: Without Pumping, With Sediment Loading		Excess Capacity (Cluster Yield-Cluster Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
Cluster	Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)						
SW-2	Brookfield Lake	1.014	1.115	0.180	0.600	-0.515	S, R	1959	107.9	2070.3	1948.18
SW-2	Brookfield Reservoir			n/a			S	1952	63.4	n/a	n/a
SW-2	Marceline Lake			n/a			S	1928	61.2	n/a	n/a
SW-2	Marceline Lake (New)			0.420			S, R	1980	172.8	1990	1812

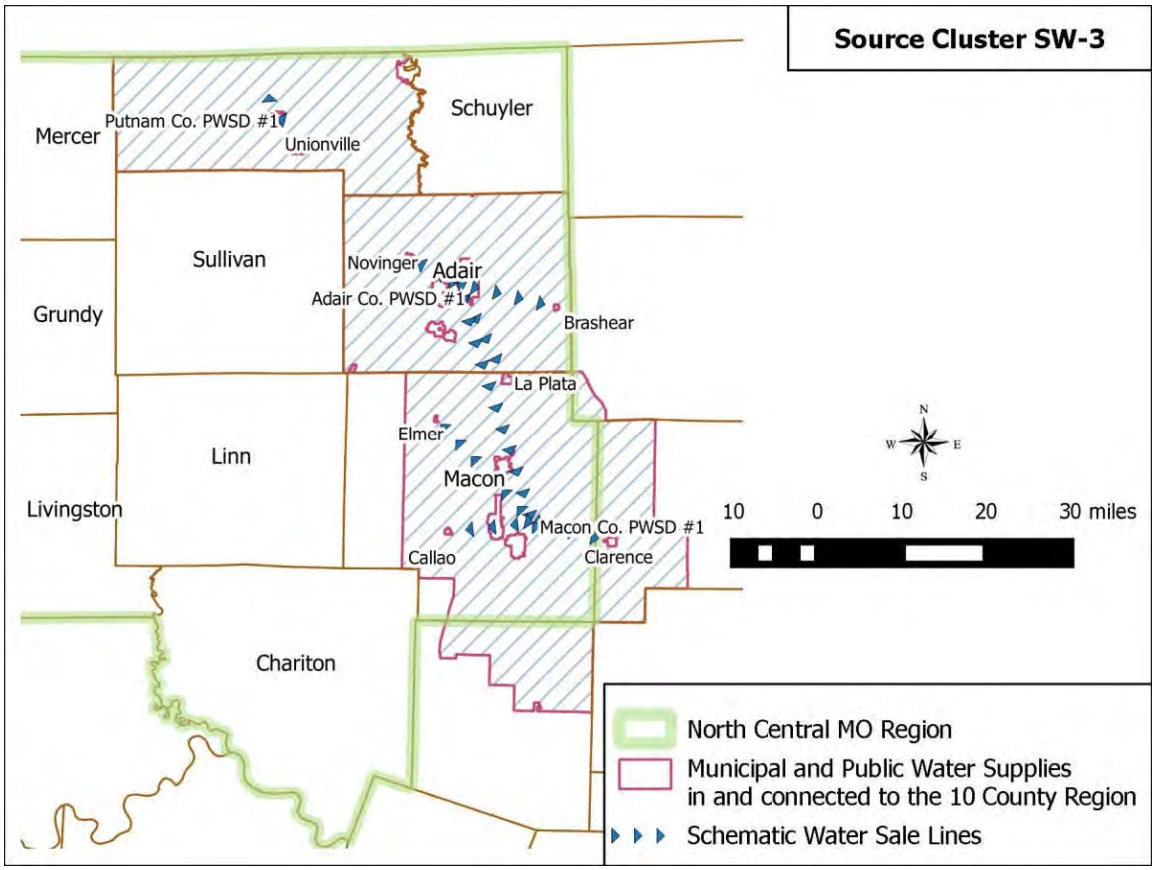


RESOP Graph 1Brookfield Lake


Marceline Lake with Low Limit of 178 AC-FT
Storage from 1951 to 1959
Available Storage Volume (AC-FT)
2500
2000
1500
1000
500
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Normal Demand at 0.63 MGD
Reservoir Yield at 0.50 MGD
Normal Demand Modified for Sediment at 0.63 MGD
Reservoir Yield Modified for Sediment at 0.42 MGD
Upper Limit (1990 AC-FT)
Lower Limit (178 AC-FT)

Cluster SW-3

Source Inadequate



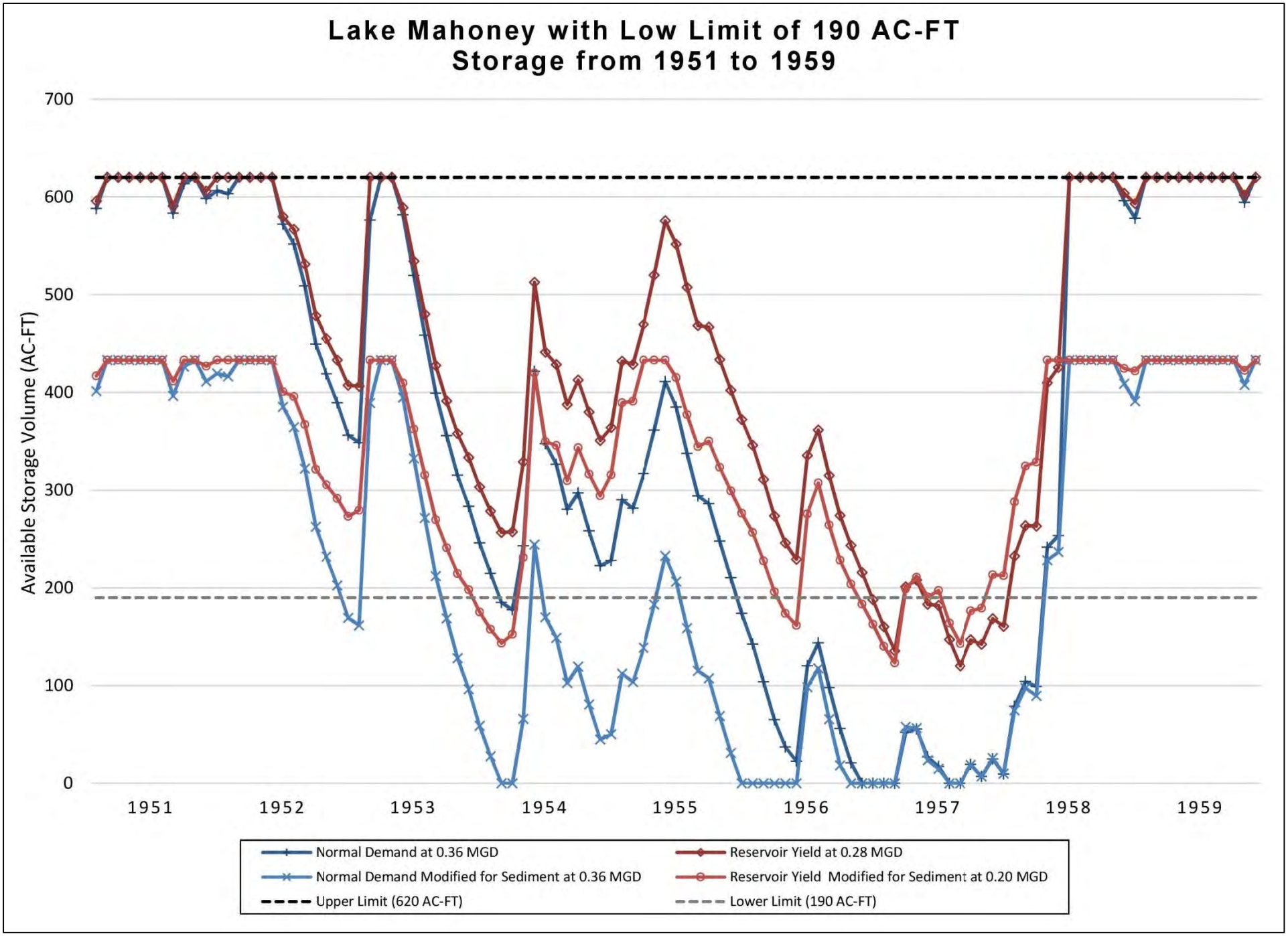
There is currently one source for Cluster SW-3, operated by the City of Unionville, Missouri. Lake Mahoney, which is a 187-acre water supply reservoir, sits at the headwaters to Lake Thunderhead. Lake Thunderhead is a private recreation lake that covers 1,140 acres. The City owned, Lake Mahoney, was originally used for water supply but due to its inadequate size, silting, and high organic content, the City draws water from Thunderhead. It is understood that the agreement between the Lake Thunderhead Homeowners Association and the City of Unionville is not recorded in writing. For this reason Lake Thunderhead is not considered a viable long-term source of water and will not be included in the evaluation.

The service area for water from Unionville is predominately Putnam County. The Source Cluster SW-3 map above depicts a large region that is supplied by the City of Unionville. Examination of the Average Daily Production and Demand table on the next page revels, less than 1 percent of the water to Adair County PWSD #1 is provided by Unionville through Putnam County PWSD #1. None of the water from Unionville enters the Macon County PWSD #1 system. Because of the limited distribution piping detail these relationships are best evaluated in conjunction with the Production and Demand table data. Adair County PWSD #1 purchases less than 5,000 gallons a day to provide for a few customers near Putnam County PWSD #1 service area. Since 1985, records indicate no closed sources within this cluster. Portions of the water treatment facility were upgraded in 2015 to reduce disinfection-by-products and to improve operability of the facility. The decay and siltation of Lake Mahoney will continue to degrade water quality and will remain the limiting factor in the sustainability of dependable water for the communities it serves.

RESOP analysis shows that Lake Mahoney reservoir yield capacity during the DOR is 0.200 MGD. The treated water normal demand for the cluster is 0.330 MGD (or .363 MGD raw water), which results in a net negative raw water daily capacity of 0.163 MGD. Due to this net negative capacity, Cluster SW-3 by analysis has an inadequate source.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-3	Unionville					0.33		0.165
		Putnam County PWSD #1					68%	0.207
			Lake Thunderhead HOA				100%	0.021
			Adair PWSD #1				0.75%	0.463
				Brashear			100%	0.014
				LaPlata			100%	0.079
				Novinger			100%	0.026
				Macon County PWSD #1			1%	0.014
					Callao		100%	0.024
					Clarence		100%	0.065
					Elmer		100%	0.005

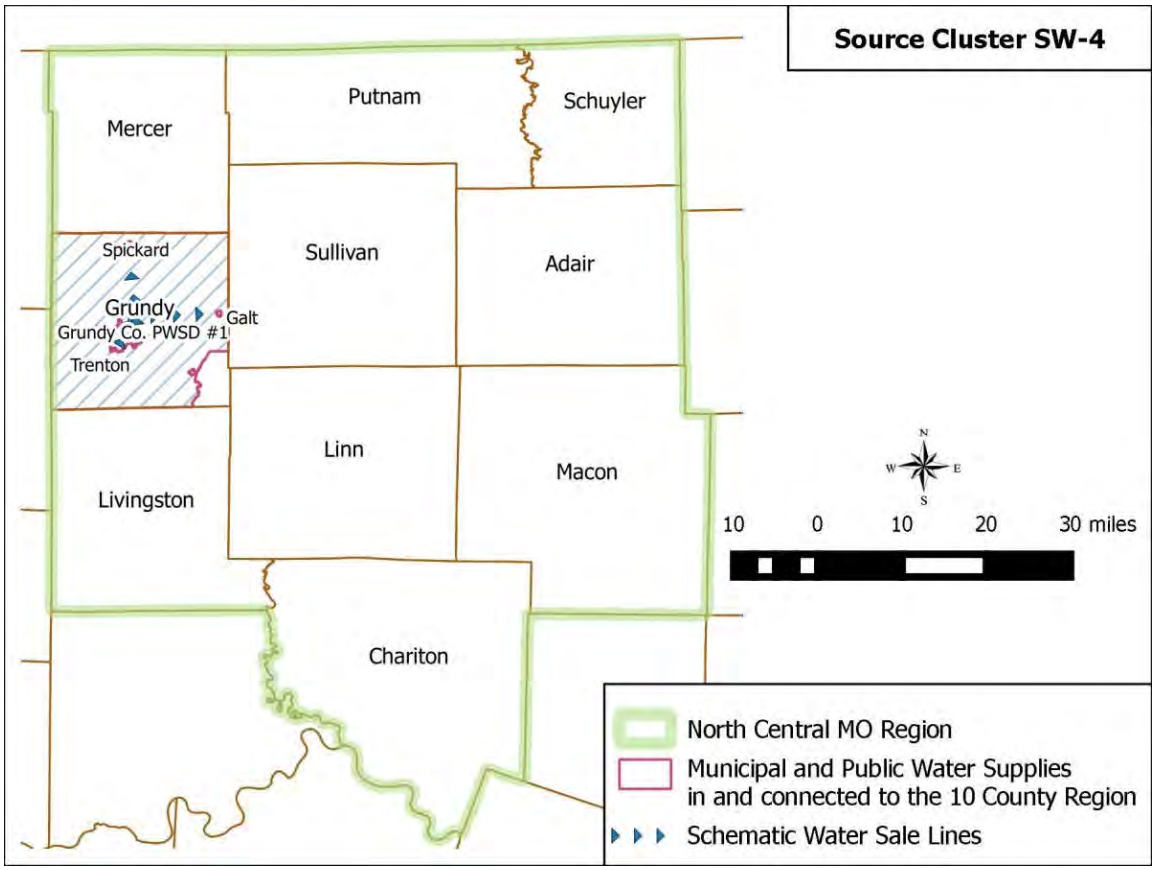
		Cluster Current Demand		Raw Water Yield: Without Pumping, With Sediment Loading		Excess Capacity (Cluster Yield- Cluster Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
Cluster	Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)						
SW-3	Unionville Reservoir	0.33	0.363	0.200	0.200	-0.163	S, R	1941	73.5	620	430



RESOP Graph 1 Lake Mahoney

Cluster SW-4

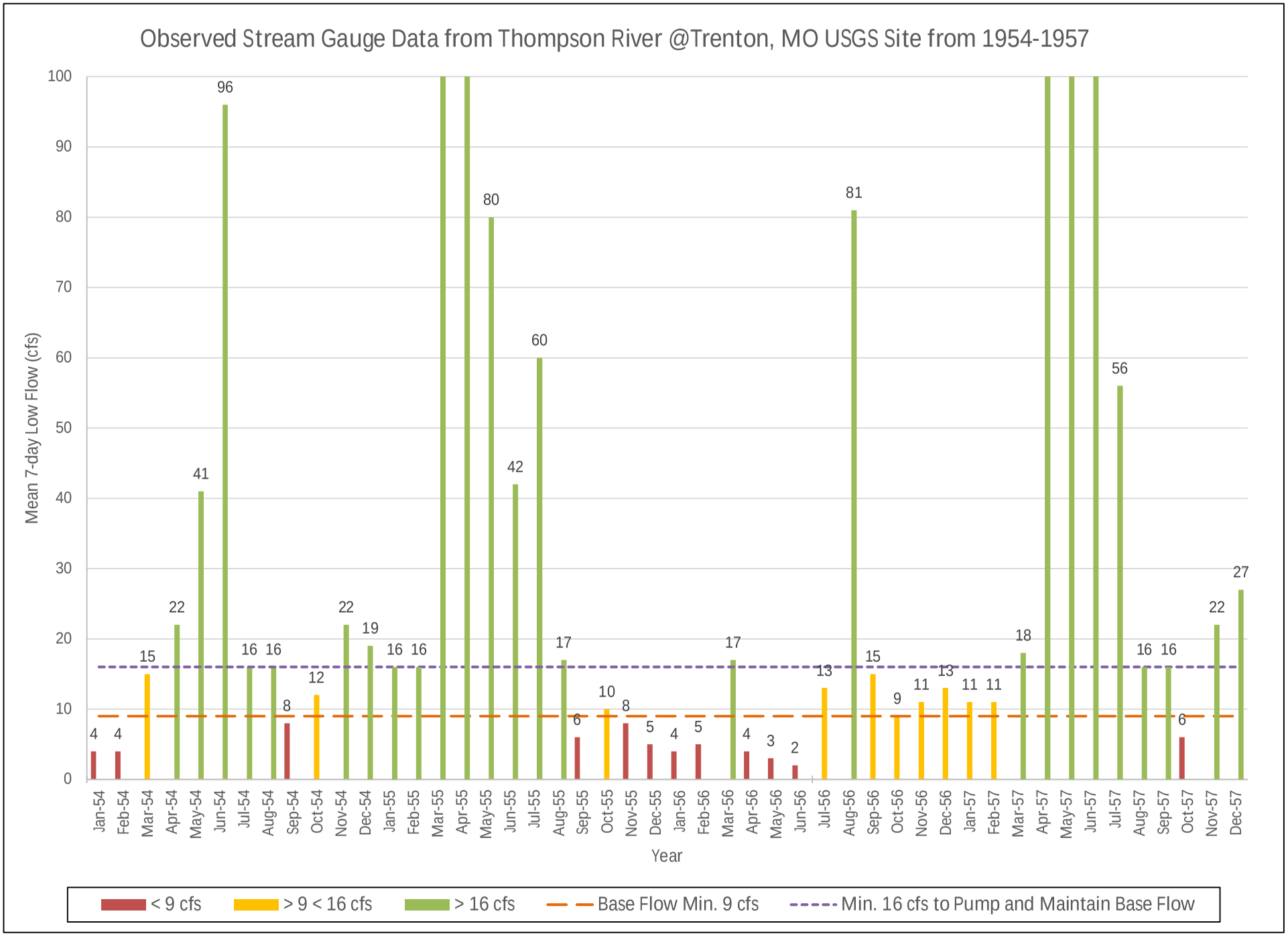
Source Inadequate



There is currently one source for Cluster SW-4, which is operated by Trenton Municipal Utilities of Trenton, Missouri. Water is pulled from the Thompson River via intake, and pumped to two raw water storage reservoirs. When these reservoirs are full, and have minimum sediment they have a total capacity of 164.5 million gallons. The North Reservoir has a maximum capacity of 140 million gallons and the South Reservoir has a maximum capacity of 24.5 million gallons. From these reservoirs Trenton Municipal Utilities produces approximately 1.72 MGD of treated water which serve the city of Trenton and customers of Grundy County PWSD #1. The water treatment plant is designed to produce 3,000 gpm and is understood to be in serviceable condition.

Since 1985 two communities in this cluster have abandoned water treatment activities and now purchase water from Grundy PWSD #1. The Inactive Systems table on the next page identifies those communities and briefly describes the reasoning for closure.

To produce 1.720 MGD of treated water approximately 1.892 MGD of raw water is need, due to treatment losses. Summing the entire volume of the reservoirs and dividing it by 1.892 MGD approximates 86.9 days of supply. The Minimum Design Standards for Missouri Community Water Systems recommends a 120 day surplus reserve storage after predicted depletion levels during a prolonged severe drought should be considered (MDNR 2013). Trenton does not have 120 days of surplus reserve storage under normal conditions. The reservoirs are bermed (meaning limited rain recharge) and depend on flow from the Thompson River and therefore also look at 3.1.1.f, which suggests a 7 Q 10 evaluation of the source. The Observed Stream Gauge Data from the Thompson River at Trenton, Missouri USGS Site from 1954-1957 shows prolonged periods of low flow. It is important to note that the minimum flow must be above 9 cfs for pumping to occur from the river as noted in the Missouri Water Supply Study (MDNR 2013). The intake pumps rated at 3,125 gpm (6.96 cfs), but the flow must be above 16 cfs to pump at full capacity. At 3,125 gpm the current demand of 1.892 gallons can be pumped in approximately 10 hours. Given that Trenton has less than 120 days of storage and documents periods of insufficient flow in the Thompson River to pump water, Cluster SW-4 by analysis to have an inadequate source.



Graph 1 Observed Stream Data from Thompson River at Trenton, MO

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-4	Trenton Municipal Utilities					1.718		1.477
		Grundy County PWSD #1					100%	0.241
			Galt				100%	0.021
			Spickard				100%	0.028

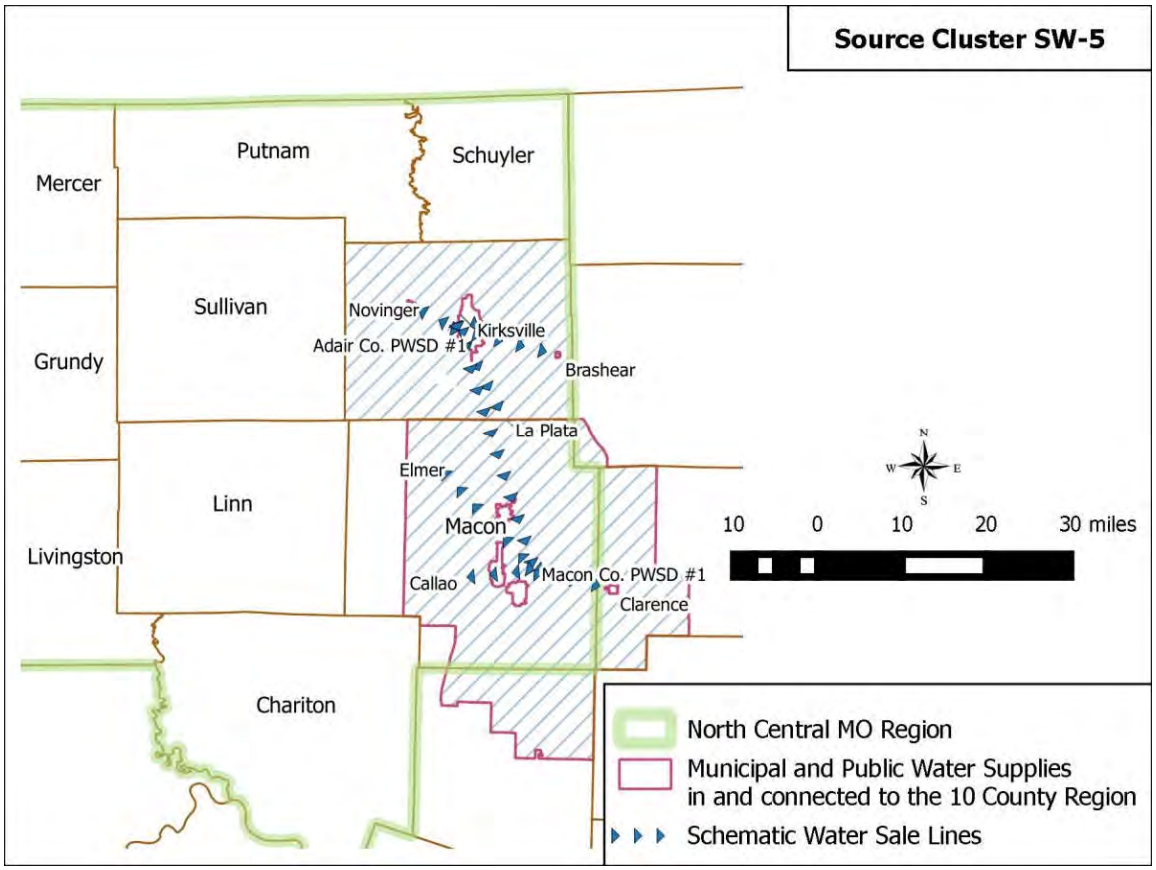
Inactive Sources Within Cluster					
System ID#	type	System Name	County	Source	Year of Closure
MO2010300	Groundwater	Galt	Grundy	Failed shallow wells (declining yield, high in iron); closed plant; now purchase water from Grundy PWSD #1	1990
MO2010753	Groundwater	Spickard	Grundy	Failed shallow wells (declining yield); closed plant; now purchase water from Linn-Livingston #3	1985

Results from USGS Low Flow Equations* for Stream Intakes in 10-county region									
				Inputs			Outputs		
Cluster	Supplier	PWS System ID	Intake	Drainage Area (Mi^2)	Length (mi)	Stream Variable	7Q10 (MGD)	30Q10 (MGD)	60Q10 (MGD)
SW-4	Trenton	2010796	Thompson River at Intake	1722.3	155.46	0.714	6.268	8.673	12.949

* Computed Statistics at Streamgages, and Methods for Estimated Low-Flow Frequency Statistics and Development of Regional Regression Equations for Estimating Low Flow Frequency Statistics at Ungaged Locations in Missouri, USGS 2013

Cluster SW-5

Source Inadequate



There is currently two sources for Cluster SW-5, Forest Lake and Hazel Creek Lake, which are operated by the City of Kirksville, Missouri. Water is pulled, from the Forest Lake or Hazel Creek Lake, via intakes and pumped to the treatment facility to a 7-million gallon, earthen, pretreatment settling basin. The 585-acre Forest Lake is owned by the State of Missouri and is operated as a Thousand Hills State Park. The 501.7 acre Hazel Creek Lake is owned and operated by the City of Kirksville. Both lakes' primary purposes are recreation with a secondary purpose of water supply. Dependent upon routine water quality tests, operators pump water from either lake to the pretreatment basin. This basin is located at the water treatment plant is sized to provide approximately two days of raw water storage.

Since 1985, two communities in this cluster have abandoned water treatment activities and purchase water from secondary system of Kirksville, Adair County PWSD #1 and Macon County PWSD #1. The Inactive Systems table on the next page identifies those communities and briefly describes the reasoning for closure.

To calculate the lower limits for RESOP modeling the first step was to evaluate the bathymetry provided by USGS. Based upon this data which provided reservoir elevations and corresponding volumes in acre-feet, the known elevation of inlets was noted and a minimum depth over the inlet was selected. In this case the inlet elevations site higher than the bottom one-third elevation change from the total elevation given by the bottom of reservoir to spillway elevation. The unusable volume according to this calculation was set at 2,120 acre-feet for Forest Lake and 1,450 acre-feet for Hazel Creek Lake

For RESOP modeling and evaluation purposes only one source can be evaluated at a time so a proportional demand approach was used in this evaluation similar to the approach in the Missouri Water Supply Study (MDNR 2013). The proportions were calculated by dividing each sources daily reservoir yield capacity by the daily cluster yield capacity. Running RESOP analysis using the lower limits described previous, the individual reservoir yields for Forest and Hazel Creek lakes were 2.69 MGD and 1.48 MGD respectively. To calculate the proportional demand the individual reservoir yields were divided by the total combined yield, 4.43 MGD, resulting in Forest

Lake yields 66.7% (2.95 MGD of the total 4.43 MGD) and Hazel Creek Lake yields the remaining 33.3 percent (1.265 MGD of the total 4.43 MGD) of the total combined yield. In addition, the Design Standards of Missouri Community Water Systems a suggested minimum of 120 days of surplus storage beyond predicted depletion levels during a prolonged and severe drought for public confidence. The 2015 treated water demand, found in the Average Daily Production and Demand table, was 3.432 MGD. This correlates to an approximate total average daily raw water demand of 3.775 MGD or proportionally, 2.510 MGD (3.775 multiplied by 66.6 percent) from Forest Lake and 1.265 MGD (3.775 multiplied by 33.3 percent) from Hazel Creek Lake.

To comply with Missouri minimum design standards these proportional demands must be multiplied by 120 days, corresponding to 301.2 MG for Forest Lake and 151.2 MG for Hazel Creek. Converting the public confidence volumes to acre-feet will allow the RESOP analysis to be reevaluated for a new lower limit that includes public confidence. To convert gallons to acre feet the following calculation was used:

$$\times \frac{\quad}{\quad} \quad \frac{\quad}{\quad} \times \frac{\quad}{\quad} \quad \frac{\quad}{\quad} = \qquad .$$

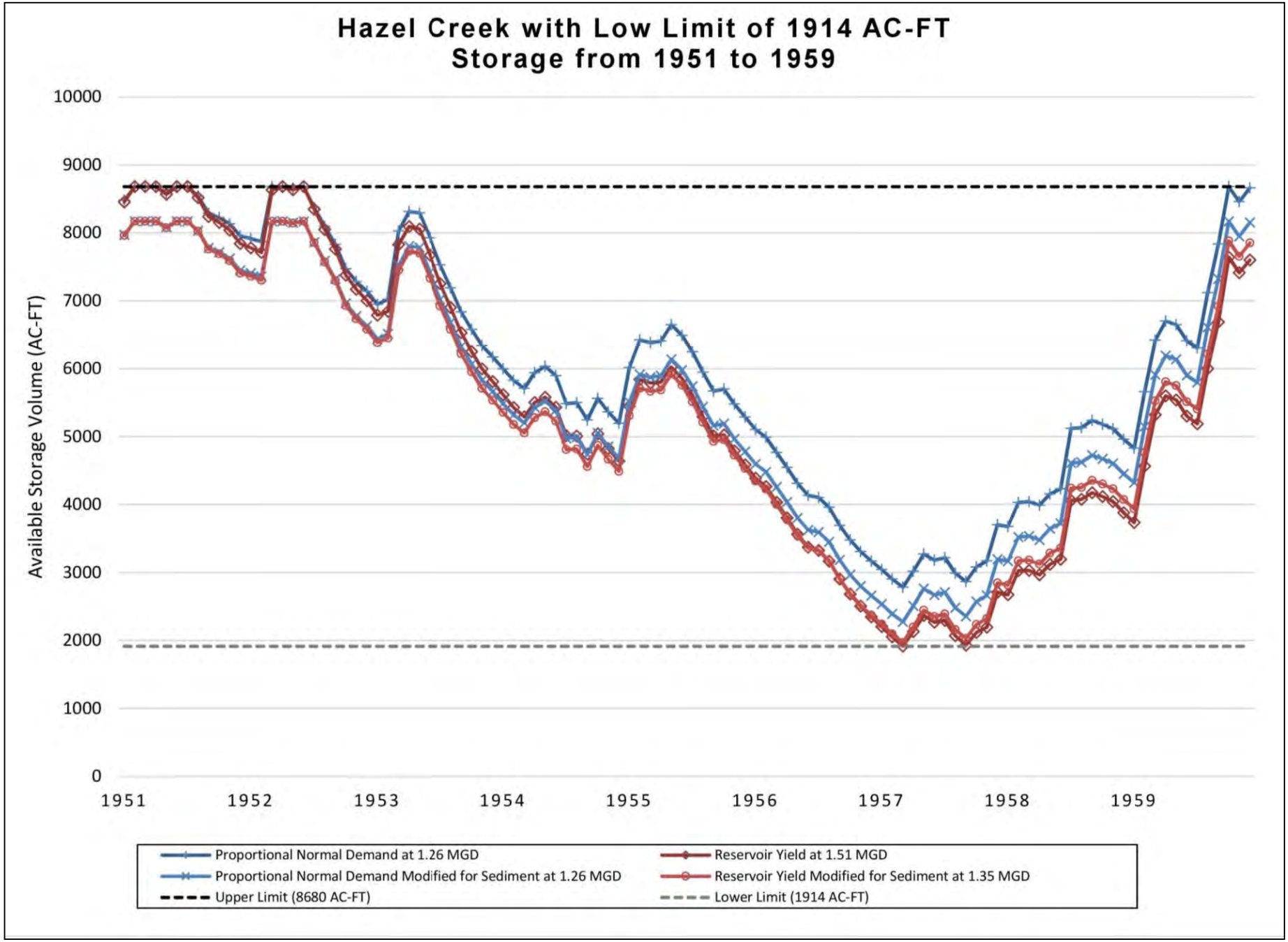
The consumer confidence for Forest Lake equals 924 acre-ft. and 464 acre-ft. for Hazel Creek Lake, which corresponding to new lower limits of 3044 acre-ft. and 1914 acre-ft., respectively. Given the new lower limit the reservoir yields were recalculated in RESOP to be 3,044 acre-ft. (Forest Lake) and 1,914 acre-ft. (Hazel Creek Lake). The new reservoir yield for the two supplies, inclusive of public confidence, are 2.69 MGD (Forest Lake) and 1.35 MGD (Hazel Creek Lake), for a total cluster yield capacity of 4.04 MGD. To compare the current normal demand treatment losses must be accounted for, this is done by adding a 10 percent factor of the treated demand from 2015. The average daily treated water quantity is shown in the Production and Demand table below, and totals 3.432 MGD. Adding 10% the raw water used on an average day in 2015 was 3.775 MGD. Subtracting this demand from the combined reservoir yield equals 0.265 MGD of excess capacity.

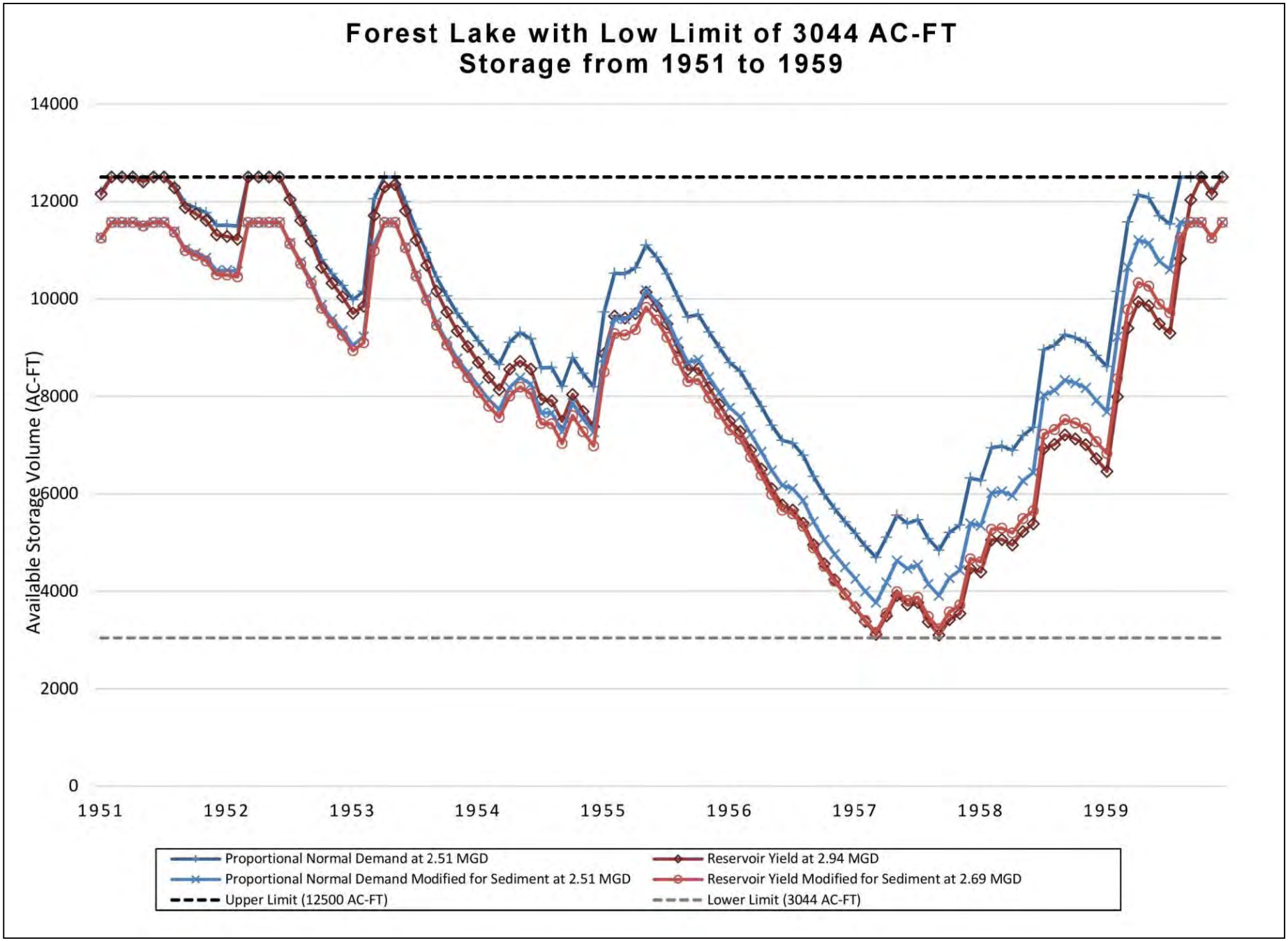
In December 2015, Kraft-Heinz Company announced a $250 million expansion of the Kraft Foods/ Oscar Mayer plant located in Kirksville, Missouri (Hunsicker 2016). City staff it was indicated in correspondence with Allstate that the expansion would increase the daily demand by approximately 0.350 MGD of treated water to the facility. This increase in demand is not reflected in the 2015 demand data but is important in this evaluation. Adding the impending raw water demand of 0.385 MGD or (0.350 MGD x 1.1=raw demand) to the 3.775 MGD of current demand totals 4.16 MGD, which is 0.125 MGD beyond the RESOP reservoir yield. Therefore, the sources of Cluster SW-5 are inadequate for the current and impending demand under DOR conditions.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-5	Kirksville					3.432		2.970
		Adair PWSD #1					99%	0.462
			Brashear				100%	0.014
			LaPlata				100%	0.079
			Novinger				100%	0.026
			Macon County PWSD #1				1%	0.139
				Callao			100%	0.024
				Clarence			100%	0.065
				Elmer			100%	0.005

Inactive Sources Within Cluster					
System ID#	type	System Name	County	Source	Year of Closure
MO2010587	Groundwater	Novinger	Adair	Failed shallow wells (declining yield); closed plant; now purchase water from Adair PWSD #1	2005
MO2010451	Surface Water	La Plata	Macon	Inadequate lakes; closed inadequate treatment plant; now purchase water from Adair PWSD #1	2000

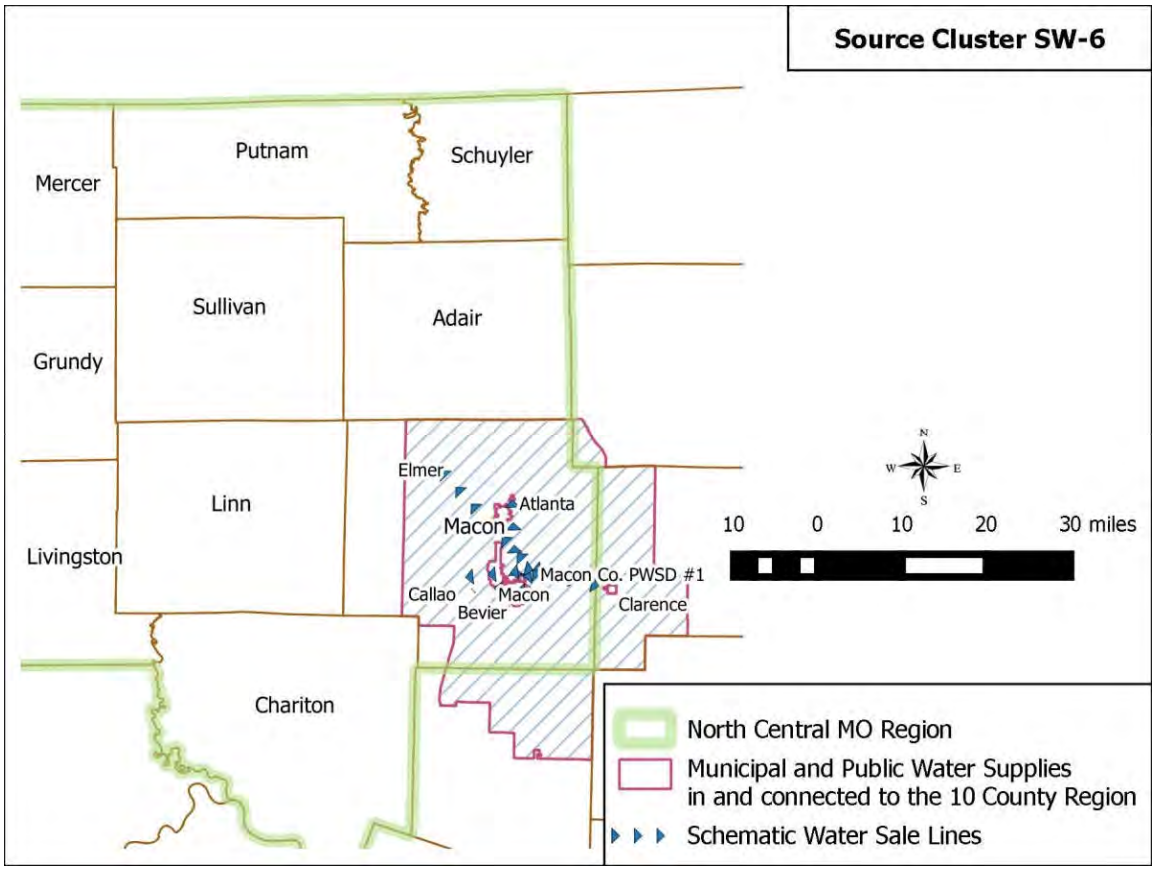
Surface Water Supply(s) Within Cluster											
		Cluster Current Demand		Raw Water Yield: Without Pumping, With Sediment Loading							
Cluster	Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)	Excess Capacity (Cluster Yield-Cluster Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
SW-5	Forest Lake*	2.51	2.76	2.691	4.040	-0.120	R, S	1951	585.2	12500	10,380
SW-5	Hazel Creek Lake*	1.27	1.40	1.349			R, S	1982	501.7	8680	7,230


Hazel Creek with Low Limit of 1914 AC-FT
Storage from 1951 to 1959
Available Storage Volume (AC-FT)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Proportional Normal Demand at 1.26 MGD
Proportional Normal Demand Modified for Sediment at 1.26 MGD
Upper Limit (8680 AC-FT)
Reservoir Yield at 1.51 MGD
Reservoir Yield Modified for Sediment at 1.35 MGD
Lower Limit (1914 AC-FT)


Forest Lake with Low Limit of 3044 AC-FT
Storage from 1951 to 1959
Available Storage Volume (AC-FT)
14000
12000
10000
8000
6000
4000
2000
0
1951
1952
1953
1954
1955
1956
1957
1958
1959
Proportional Normal Demand at 2.51 MGD
Proportional Normal Demand Modified for Sediment at 2.51 MGD
Upper Limit (12500 AC-FT)
Reservoir Yield at 2.94 MGD
Reservoir Yield Modified for Sediment at 2.69 MGD
Lower Limit (3044 AC-FT)

Cluster SW-6

Source Adequate



There is currently one sources for Cluster SW-6, Long Branch Lake, which is operated by the U.S. Army Corps of Engineers. The primary purpose of Long Branch Lake is flood control, with secondary purposes of water supply and recreation. Macon Municipal Utilities (MMU) has purchased rights to 4,400 acre-feet of water supply storage within the reservoir. According to MMU this is approximately 36 percent more capacity then the current demand. The current treated water demand for Cluster SW-6 is 2.50 MGD, as noted in the Production and Demand table on the next page.

Since 1985, three communities in this cluster have abandoned water treatment activities and now purchase water from the secondary system of Macon County PWSD #1. The Inactive Systems table on the next page identifies those communities and briefly describes the reasoning for closure.

A RESOP model was not developed for this source given known characteristics of the lake. Long Branch Lake has a total of 36,800 acre-feet at normal pool. Of that 24,400 acre feet are allocate for water supply storage. The rights to the remaining 20,000 acre-feet are held by the U.S. Army Corps of Engineers. For purposes of this evaluation only the 4,400 acre-feet will be considered as usable capacity.

The Missouri Water Supply Study did not evaluate Long Branch specifically, but it did mention it as a potential source of water for Sugar Creek Lake in Moberly, Missouri, as seen in the following (MDNR 2013)

> "When flow in East Fork Chariton River is not sufficient for diversion, the city would be able to purchase water from Long Branch Reservoir at Macon. Water can be released from Long Branch Reservoir and allowed to flow downstream to the pump intake near Moberly. Moberly has been reporting East Fork Chariton River as a supply source beginning in 1992.

The volume of water that would be required by pumping from East Fork Chariton River:

1954…….. 317.3 million gallons
1955…….. 421.3 million gallons
1956…… 421.3 million gallons
1957…….. 421.3 million gallons
1958…….. 208.5 million gallons“

If this emergency release were needed, it is assumed it would come from the 20,000 acre-feet of water supply at a volume of nearly three times what is needed for pumping due to losses and capture rate. More information is needed to access this potential. This uncertainty is a reason for not including the currently unused water supply reserve in the cluster evaluation.

Cluster SW-6 has a total excess yield capacity of 0.650 MGD and, therefore, the source is adequate for the current demand under DOR conditions.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-6	Macon					2.5		
		Atlanta					100%	0.020
		Bevier					100%	0.056
		Macon County PWSD #1					89%	1.232
			Callao				100%	0.024
			Clarence				100%	0.065
			Elmer				100%	0.005

Inactive Sources Within Cluster					
System ID#	type	System Name	County	Source	Year of Closure
MO2010247	Groundwater	Elmer	Macon	Failed shallow wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Macon PWSD #1	1985
MO2010035	Surface Water	Atlanta	Macon	Inadequate lake; struggled with disinfection-by-products; closed plant; now purchase water from Macon	1985
MO2010125	Groundwater	Callao	Macon	Failed shallow wells (declining yield); closed plant; now purchase water from Macon PWSD #1	1990

	Cluster Current Demand		Raw Water Yield: Without Pumping, With Sediment Loading		Excess Capacity (Cluster Yield- Cluster Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)						
Long Branch Lake	2.5	2.75	3.400	3.400	0.650	C, S, R	1979	2682.8	8,680	7,230

Summary of Surface Water Cluster Evaluations

The six surface water clusters were evaluated under the assumptions of 50 years of sediment loading into reservoirs, DOR recharge rates, full reservoir capacity at beginning of time sequence, and that volume associated with the lower one-thrid reservoir elevation is unusable. Additionally, quantity standards in Chapter 3 of the Minimum Design Standards for Missouri Community Water Systems (MDNR 2013) were used to evaluate clusters reliability. The analysis ignores the predicted increases in drought length and severity caused by climate change and focuses on the ability of a source to meet current normal demand.

Totaling the 2015 normal demand of surface water clusters with inadequate sources during a drought, equal in magnitude to the DOR, equals 8.416 MGD. Note this total includes the impending demand (0.35 MGD) for Kirksville as noted in the Cluster SW-5 report. A complete listing of the Surface Water Cluster Production & Demand Table from 2015 is located in Appendix J. The impact of inadequate cluster water sources could result in the complete depletion of water in 5 of 6 the existing clusters. Figure 7, below, shows clusters with inadequate sources in red and Cluster SW-6, the only adequate source, in green. Each segment of the pie corresponds to a surface water producer within the 10 county region. The size of each segment is proportionate to the average daily demand produced by each system, shown as the value at the end of the labels in MGD.

A total of 11.401 MGD of treated surface water was produced in 2015 according to data provided by systems. The current regional trend, as shown by Baker 2015, is that systems have been abandoning treatment facilities and sources as they degrade beyond the point of serviceability or if they become too expensive to maintain.

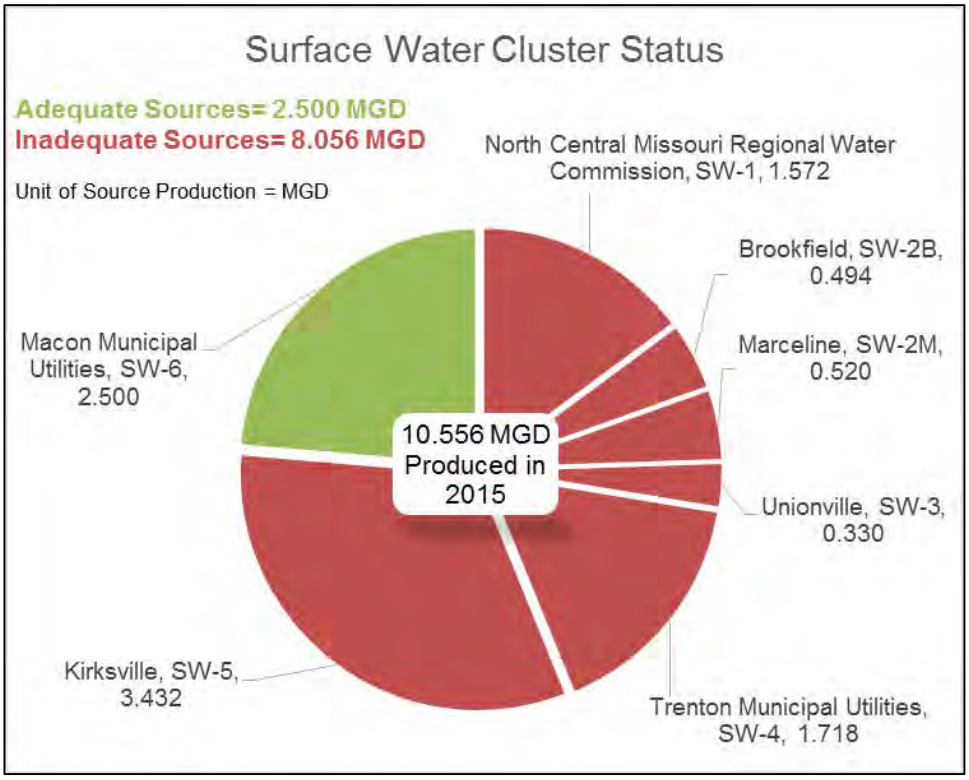


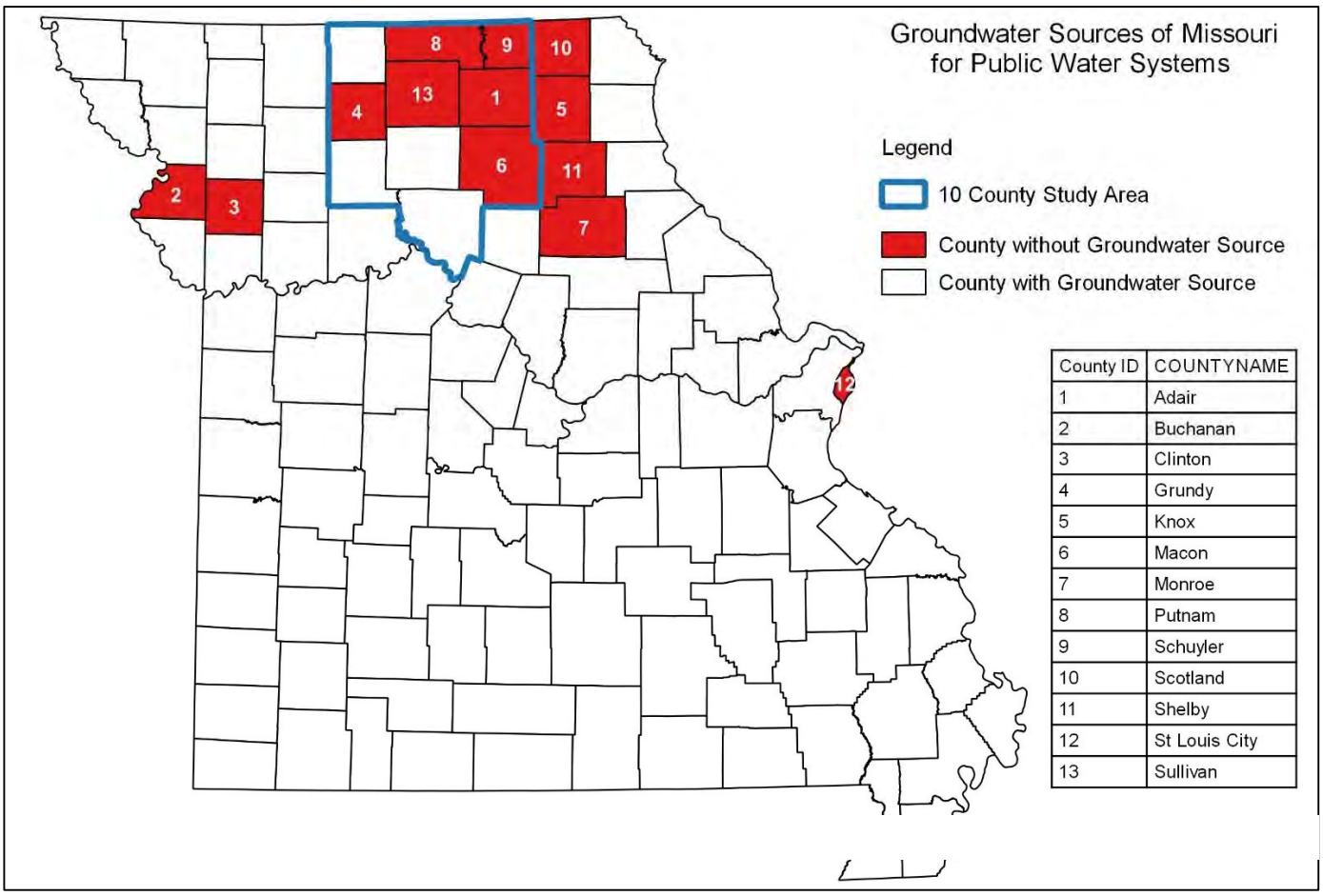
Figure 7: Regional Surface Water Cluster Summary.

Overview of Groundwater Cluster Evaluations

The analysis of groundwater sources, is based on regional and local geology, historical data, and engineering design criteria. Specific well analysis cannot definitively predict how long or at what rate a well will yield water or what water quality. Therefore, this evaluation will summarize historic geologic findings from both the Missouri Geologic Survey and individual systems; review the history of wells (abandoned, active, inactive, plugged and boring results) within the region; and explain assumptions based on local engineering experience. A determination of a clusters adequacy to provide long-term, reliable water will be based on the evaluation criteria and will be included in the Groundwater Summary. Data used in this evaluation is based on individual system interviews, reports by USGS, MDNR, and individual well drillers. The Missouri Spatial Data Information Service (MSDIS) and Missouri Geologic Survey provided the GIS metadata.

The evaluation of groundwater sources for individual clusters is complicated by a host of variables that range from water quantity to quality. These factors are illuminated in the excerpt from Miller later in this section. This unpredictability goes beyond daily variation in water quality and/or hydraulic head, but can change without notice and render a well permanently useless for supply. This uncertainty and known required maintenance of wells serves as the basis for MDNR recommendation to have redundant sources for groundwater supplies for communities as outlined in Chapter 3 Section 2.1.2 of the Minimum Design Standards for Missouri Community Water Systems.

As of 2016, MDNR data confirms that four of the 10 counties in the study region of north-central Missouri have public drinking water facilities that use a groundwater source for raw water (MDNR 2016). These include: Chariton, Linn, Livingston, and Mercer counties. State wide, 13 counties in Missouri which do not have a single groundwater source system, see Figure 8 below. Six of those 13 are within the 10-county study area, and all 13 are located north of the Missouri River. Additionally, four of the 13 counties outside of the study area are directly adjacent to the study area. Buchanan County, which is outside of the study area, does not have a public water



County ID	COUNTYNAME
1	Adair
2	Buchanan
3	Clinton
4	Grundy
5	Knox
6	Macon
7	Monroe
8	Putnam
9	Schuyler
10	Scotland
11	Shelby
12	St Louis City
13	Sullivan

treatment system, and is served by Missouri River alluvium groundwater wells from a supplier in adjacent Andrew County.

The distinct lack of groundwater-type public water systems in the northern part of Missouri, as depicted in Figure 8, is based on the hydrogeology of the region. The following excerpt is from the Groundwater Resources of Missouri, which is Volume III of the Missouri State Water Plan Series. The excerpt summarizes hydrogeology the Northwestern Provence of Missouri, which overlays seven of the western counties in the region of study.

> "Groundwater resources in much of northwest Missouri are poor. The thick carbonate aquifers that supply large quantities of high-quality water in the Ozarks and east central Missouri are also present at great depth in the northwestern part of the state. In northwest Missouri they yield water so highly mineralized that, for practical purposes, it is unusable. Bedrock formations in the Northwestern Missouri groundwater province older than Pennsylvanian-age yield highly-mineralized water. Usable quantities of groundwater are locally available from Pennsylvanian strata, but yields are typically low and the water quality is marginal. Glacial deposits, depending on thickness and texture, can yield from zero to more than 500 gpm. Except for the Missouri River alluvium, alluvial deposits in northwestern Missouri generally yield small quantities of water. This is because the alluvial sediments of the smaller rivers are finer grained and more poorly-sorted than those of the Missouri River. However, there are significant exceptions to this, especially near the mouths of major northwest Missouri rivers where the alluvium may yield quantities of water suitable for irrigation or public water supply. Many years ago, geologists recognized that the stratigraphy and geomorphology of this area are so complex and site specific that it is difficult to predict either the lithologic character or the thickness of material likely to be encountered at any drill site. So, in 1956, using funds provided by the Missouri Legislature, the Missouri Geological Survey (now the Division of Geology and Land Survey) began an ambitious test drilling program to determine the thickness and character of the glacial drift in the Northwestern Missouri groundwater province. The project, which ended in1960, included 19 of the 23 counties in the province. These drilling studies did much to help northwest Missouri towns and rural residents develop safer, more reliable water supplies. The four northwestern Missouri counties excluded from detailed drilling studies were found not to contain appreciable thicknesses of permeable glacial drift materials. Limited funds prevented their study, as well as a similar study to cover the northeastern part of the state. Table 14 is a listing of county studies available for the area. The studies are a valuable aid to finding and developing water supplies. Groundwater storage estimates for northwest Missouri included with this report rely heavily on the data collected during the 1950s" (MDNR 1997).

The available groundwater data set is the Public Water Wells data set, which provides information about wells in the state of Missouri. The parent data set is the Wellhead Information Management System (WIMS) database that is maintained by the MDNR, Missouri Geological Survey, Geological Survey Program, and Wellhead Protection Section. The WIMS database resulted from implementation of the Water Well Drillers Law of 1985. The information about well location, well ownership, well completion date, well construction, well yield, static water level, and borehole stratigraphy was provided by well drillers as required by state statute RSMo 256.600-256.640. Wells drilled prior to July of 1987 are not included in this data set. A WIMS well search is also available online at http://dnr.mo.gov/mowells/publicLanding.do.

A database of public drinking wells, including closure information, was not required until after the 1996 amendment to the Safe Drinking Water Act. The Safe Drinking Water Information System (SDWIS) database is historically incomplete for many small rural systems that have drilled dozens of wells over the last 100 years and plugged those that became inadequate or untreatable. Planners and engineers are left to evaluate groundwater availability and reliability based on regional geologic reports and community-specific records as available.

Figure 9, below, was developed with the metadata provided by Missouri Geologic Survey in the Well Log data set. The data was originally from the 1950's exploration Miller referenced filtered to provide a graphical representation of the over 500 wells drilled to evaluate the geology of the area. The drillers' logs, which included yield information, are grouped by color and size, and the borings, which did not include yield data are marked with "x." The drillers' notes of potential yield were given in ranges; for example, the highest yielding test hole, located in Putnam County, had a noted range of 500-1,000 gpm. The other potentially high yielding test hole was in Mercer County and was noted to have a potential yield of 300-600 gpm. For purposes of the graphic, the high-range value was used on the entire data set. Schuyler, Adair, and Macon counties were not included in the 1950s study.

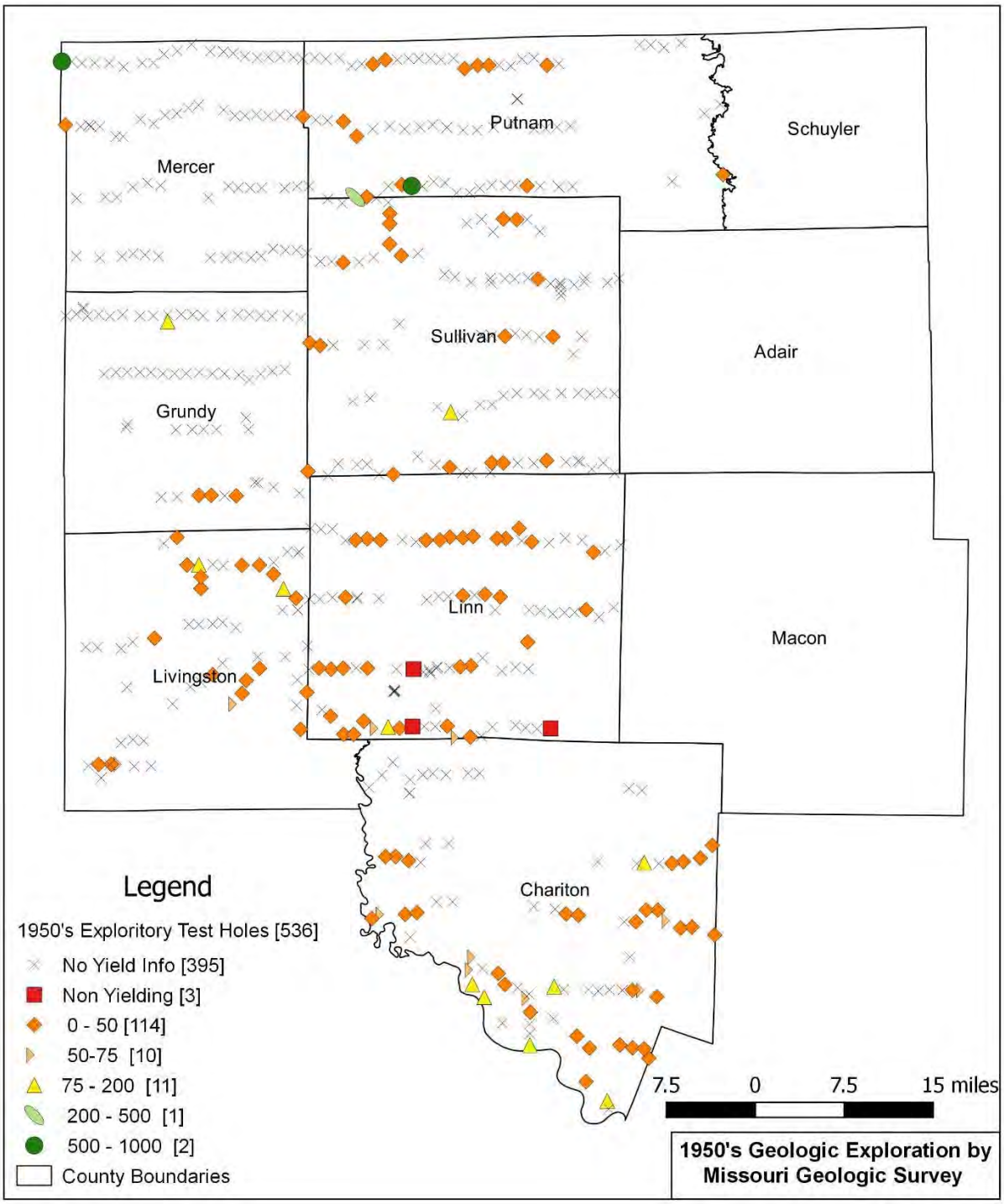
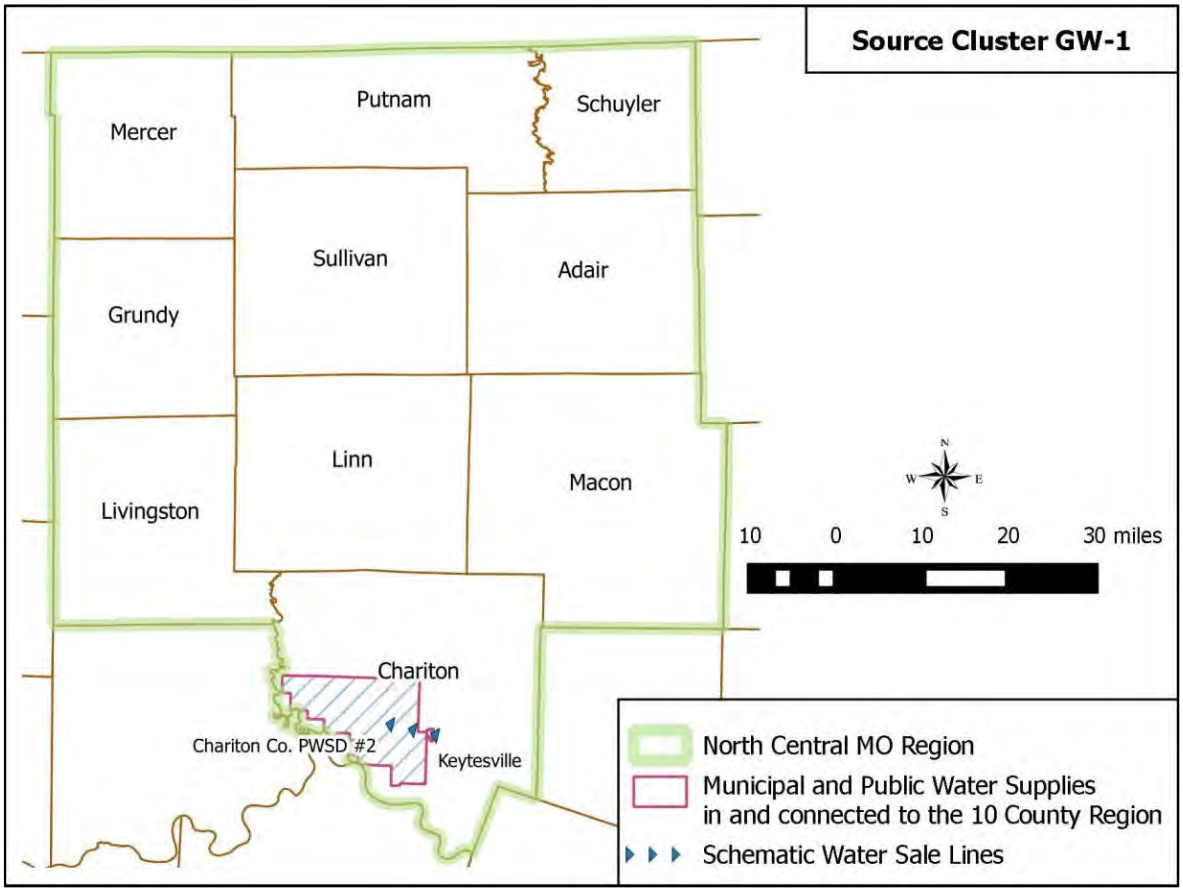


Figure 9: 1950s Exploratory Test Holes in Northwest Missouri

Groundwater Cluster Reports GW-1 to GW-9

Cluster GW-1

Sources Inadequate



Cluster GW-1 is supplied by three groundwater wells and is owned and operated by the City of Keytesville, Missouri. MDNR records indicate that wells #1 through #3 are inactive, and last recorded yields were 11, 10 and 7 gpm respectively. Collectively, the old wells yielded a total 28 gpm for a full 24 hours which would produce approximately 0.032 MGD. This constant draw was still short of needs, causing the City to drill three replacement wells. The current wells, Well #4, #5, and #6, are documented as producing 0.053 MGD (or 36 gpm) each. The treatment facility is designed for a maximum flow of 115 gpm (or .138 MGD @ 20 hours of run time) and is listed as an iron removal type, which was likely a contributing factor to the decline in yield from wells #1-3.

It is important to note that the wells in this cluster are within 8 miles of the Missouri River channel and 2 miles of the Chariton River channel. The wells are located in modern alluvium, near major streamflows, which is uncharacteristic for the majority of the sources in the evaluated 10 county region. This proximity can be misleading to the long-term dependability of wells. Given the history of declining wells, this evaluation has identified Cluster GW-1's sources as inadequate.

The Daily Production and Demand table below details Chariton PWSD #2 purchases approximately 0.022 MGD from Keytesville.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-1	Keytesville					0.0530		0.031
	Chariton PWSD #2						45%	0.049

Keytesville

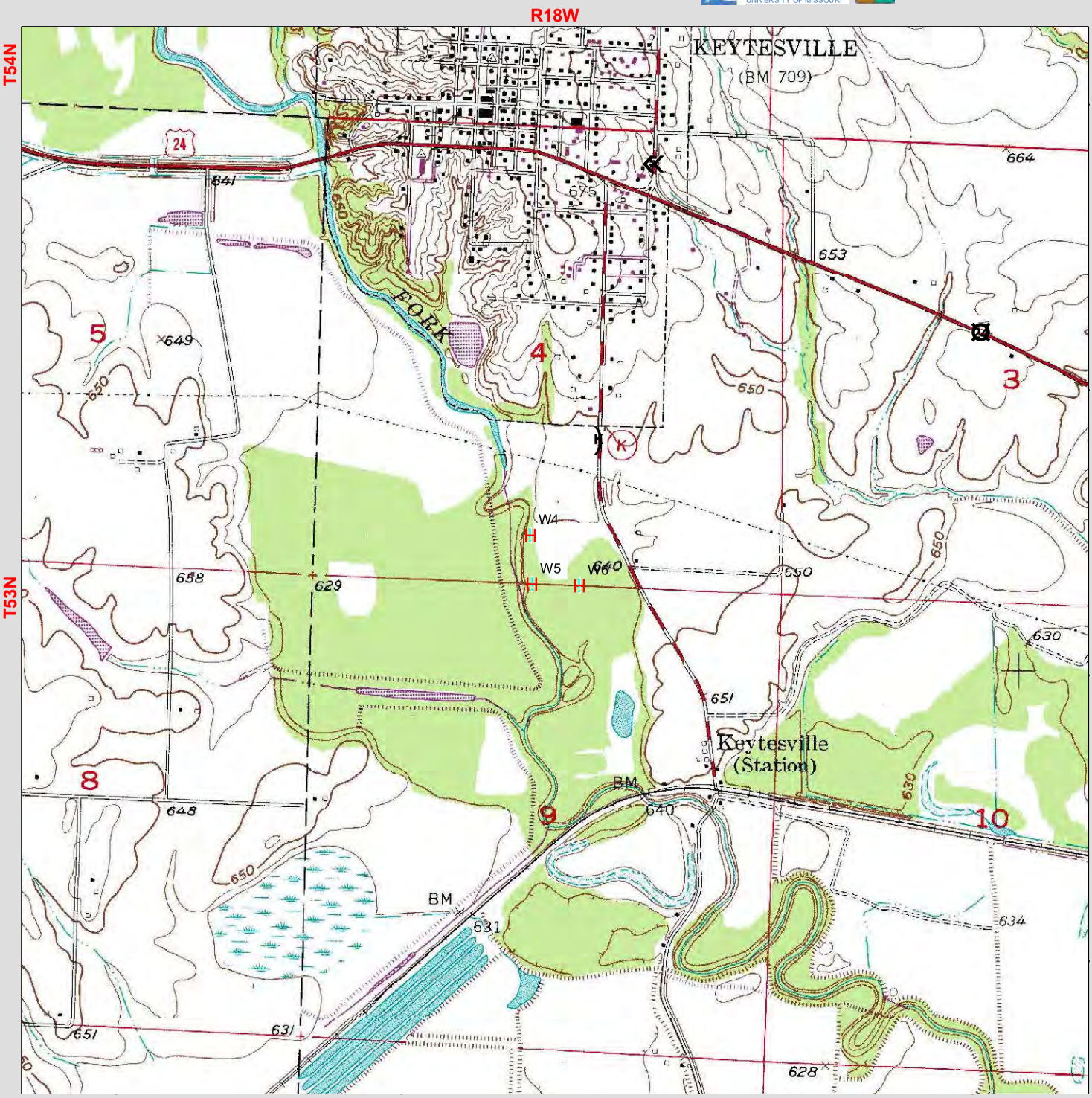
PWSS No. 2010420

3 Wells, Chariton County

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



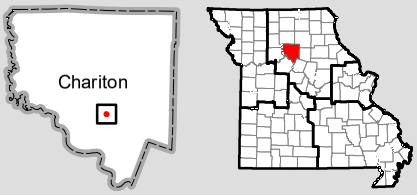
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Feet

0 1,600 3,200

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Keytesville

PWSS No. 2010420

Chariton County

3 wells

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Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W4	W5	W6
Extended PWS #	2010420104	2010420105	2010420106
Local Well Name	replaces Well #1	replaces Well #2	replaces Well #3
Well ID #	18053	18054	18055
DGLS ID #			
Facility Type	City	City	City
Status	Active	Active	Active
Latitude	39.42094	39.4194	39.41936
Longitude	-92.93667	-92.9366	-92.93467
Location Method	GPS	GPS	GPS
Method Accuracy (ft)	98	98	98
USGS 7.5 Quadrangle	Keytesville	Keytesville	Keytesville
County	Chariton	Chariton	Chariton
MoDNR Region	Northeast	Northeast	Northeast
Date Drilled (year)	2004	2004	2004
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium
Total Depth Formation	Pennsylvanian	Pennsylvanian	Pennsylvanian
Total Depth	52	50	49
Ground Elevation (ft)			
Top Seal	Tremie Grout	Tremie Grout	Tremie Grout
Bottom Seal			
Casing Depth (ft)	48	50	35
Casing Size (in)	24	24	24
Casing Type	Steel	Steel	Steel
Elev. of Casing Top (ft)			
Outer Casing Depth (ft)			
Outer Casing Size (in)			
Screen Length (ft)		15	15
Screen Size (in)			
Static Water Level (ft)	12	8	11
Well Yield (gpm)			
Head (ft)			
Draw Down (ft)			
Pump Test Date (year)			
Pump Type			Submersible
Pump Manufacturer			Grundfos
Pump Depth (ft)	20	18	18
Pump Capacity (gpm)	150	150	150
Pump Meter (Y/N)			
VOC Detection (Y/N)			
Nitrate Detection (Y/N)			
Chlorination (Y/N)			
Filtration (Y/N)			
GWUDISW (Y/N)			
Surface Drainage			
State Approved(Y/N)			
Date Abandoned (year)			
Date Plugged (year)			

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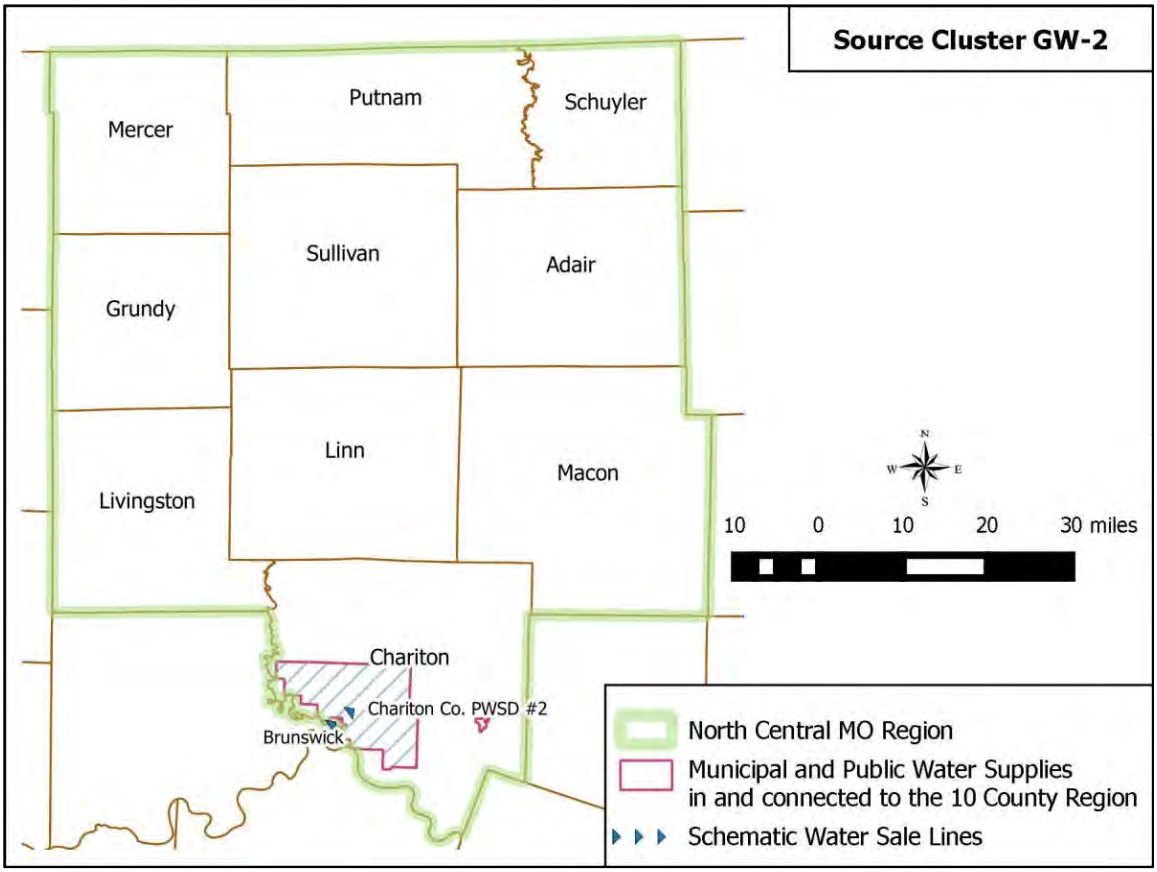
Cluster GW-2

Sources Adequate



Cluster GW-2 is supplied by groundwater wells and is owned and operated by the Missouri American Water Company - Brunswick. The data for the following table was based on MDNR Sanitary Survey's and was accessed via the Drinking Water Watch website (MDNR 2016). Note that the Well #3 yield (MGD) was calculated from the Yield (gpm) x 1,440 (60 minutes/ hour x 24 hours/ day). The limiting factor is the treatment facility which is designed for a maximum flow of 300 gpm or 0.360 MGD (based on 20 hours of run time). It is important to note that Well #3 in this cluster is within 800 feet of the Grand River channel and 4,300 feet of the Missouri River channel. Given the immediate proximity to a major stream flow, location in modern alluvium, and no known history of declining yield, Cluster GW-2's source is identified as adequate.

Missouri American - Brunswick	Yield (gpm)	Yield (MGD)	Pump Capacity (gpm)	Design Rate (gpm)
Well #1	19	0.028	150	
Well #2	52	0.075	150	
Well #3	715	1.030	400	
Treatment Plant				300

The treated water demands of 2015 are shown in the following table.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-2	Mo American Brunswick					0.0841		0.057
		Chariton PWSD #2					55%	0.049

Mo American - Brunswick

PWSS No. 2010109

3 Wells, Chariton County

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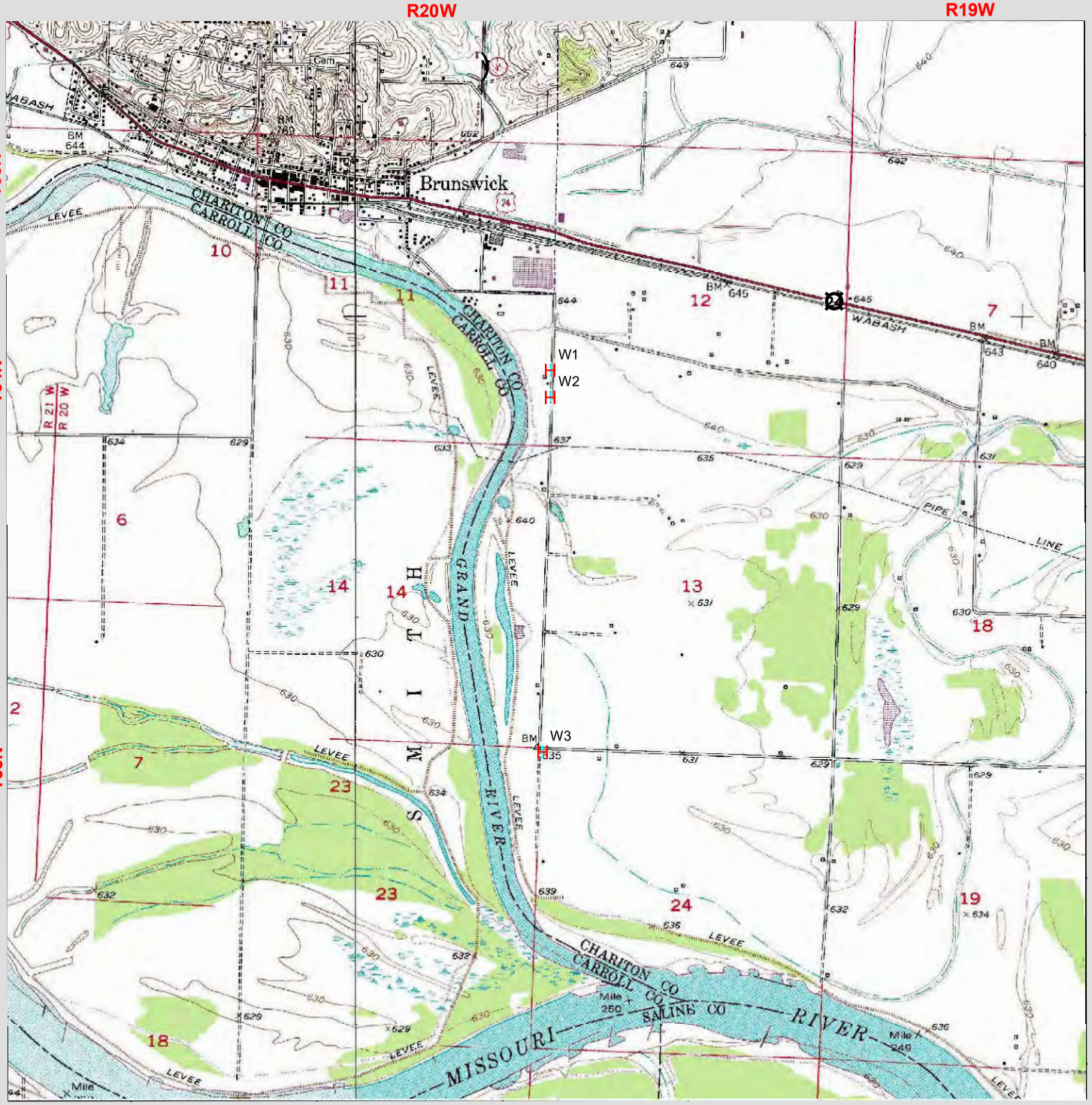
Missouri Department of Natural Resources



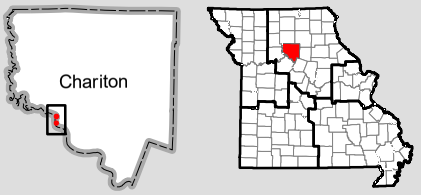
Well System

System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Miles

0 0.5 1

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Mo American - Brunswick

PWSS No. 2010109

Chariton County

3 wells

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Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W2	W3
Extended PWS #	2010109101	2010109102	2010109103
Local Well Name	Well #1	Well #2	Well #3
Well ID #	14612	14613	14614
DGLS ID #			
Facility Type	City	City	City
Status	Active	Active	Active
Latitude	39.41411	39.41281	39.39561
Longitude	-93.11311	-93.11311	-93.11361
Location Method	DRG/MAP	DRG/MAP	DRG/MAP
Method Accuracy (ft)	33	33	33
USGS 7.5 Quadrangle	Brunswick East	Brunswick East	Brunswick East
County	Chariton	Chariton	Chariton
MoDNR Region	Northeast	Northeast	Northeast
Date Drilled (year)	1951	1952	1982
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium
Total Depth Formation	Alluvium	Alluvium	Alluvium
Total Depth	65	65	82
Ground Elevation (ft)			
Top Seal	Pump Base	Pump Base	Mechanical Seal
Bottom Seal	Steel Plate	Steel Plate	Steel Plate
Casing Depth (ft)	26	26	31
Casing Size (in)	24	24	24
Casing Type	Steel	Steel	Steel
Elev. of Casing Top (ft)	644	644	640
Outer Casing Depth (ft)			
Outer Casing Size (in)			
Screen Length (ft)	20	20	25
Screen Size (in)	12	12	16
Static Water Level (ft)	15	15	4
Well Yield (gpm)	200	150	750
Head (ft)			
Draw Down (ft)	5	11	5
Pump Test Date (year)	1993	1993	1993
Pump Type	Submersible	Submersible	Submersible
Pump Manufacturer	Crown	Crown	Crown
Pump Depth (ft)	52	52	
Pump Capacity (gpm)	160	160	160
Pump Meter (Y/N)	Y	Y	Y
VOC Detection (Y/N)	N	N	N
Nitrate Detection (Y/N)	N	N	N
Chlorination (Y/N)	Y	Y	Y
Filtration (Y/N)	Y	Y	Y
GWUDISW (Y/N)	N	N	N
Surface Drainage	Satisfactory	Satisfactory	Satisfactory
State Approved(Y/N)	Y	Y	Y
Date Abandoned (year)			
Date Plugged (year)			

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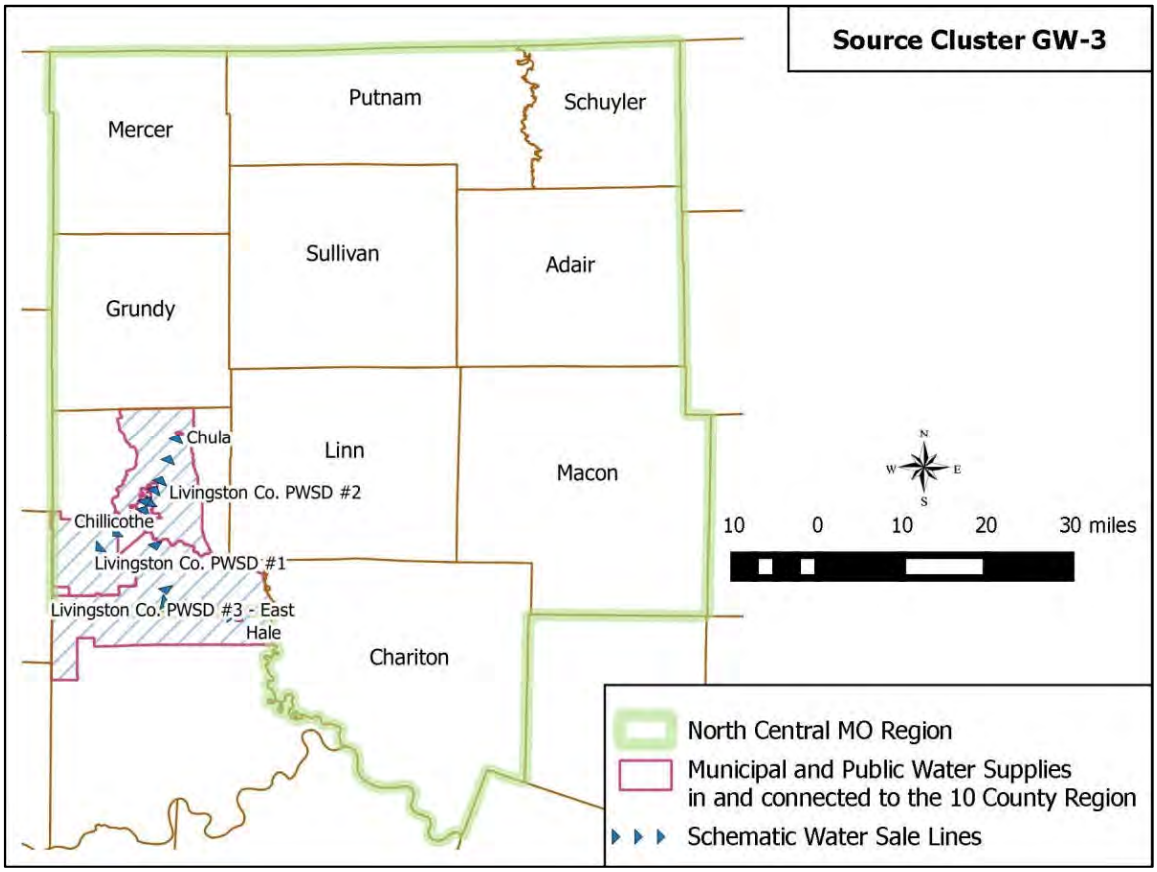
Cluster GW-3

Sources Adequate



Cluster GW-3 is supplied by groundwater wells and is owned and operated by Chillicothe Municipal Utilities. MDNR records indicate six active alluvial wells ranging in yield from 650-1,000 gpm each and are located in the alluvium for the Grand River. The iron removal type water treatment plant has a design capacity of 2,200 gpm or 2.64 MGD (running for 20 of 24 hours a day).

The Production and Demand table details the three wholesale customers and their customers. Livingston County PWSD #2 utilizes treated water form Chillicothe for approximately 49 percent of their total demand. In 2015, Chillicothe Municipal Utilities produced approximately 60 percent of the total groundwater in the 10-county study region. Livingston PWSD #1, closed its groundwater treatment plant in 2005 after well yield declined below demand and approximately 28 test wells failed to produce a viable solution. This information is included in Appendix C.

Given the immediate proximity to major modern alluvium and stream flow, Cluster GW-3 is identified as having adequate sources.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-3	Chillicothe Municipal Utilities					1.3		0.893
	Livingston Co. PWSD #1						100%	0.077
	Livingston Co. PWSD #2						49%	0.151
	Chula						100%	0.016
	Livingston Co. PWSD #3 East						100%	0.197
	Hale						100%	0.043

Chillicothe Municipal Utilities

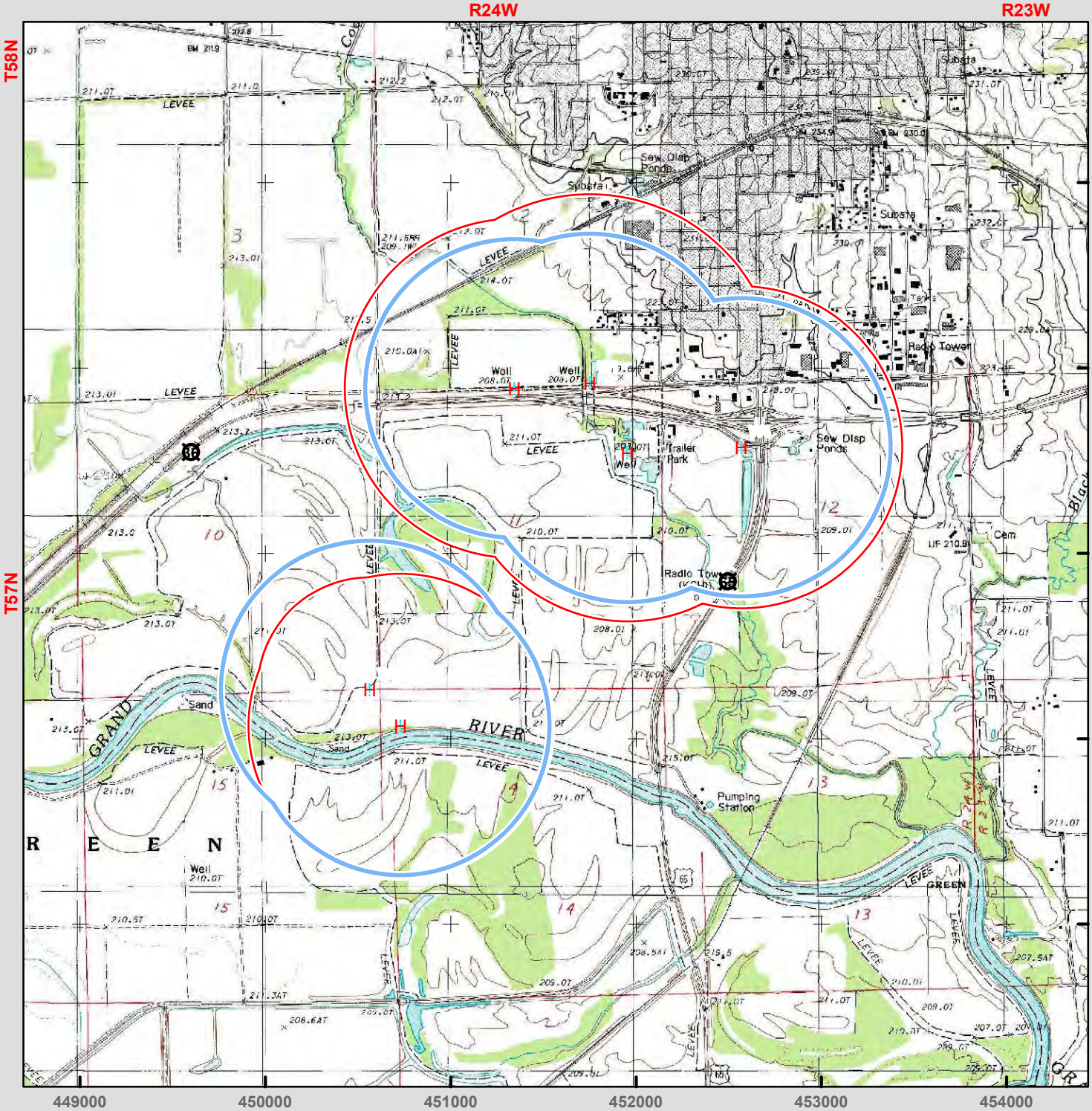
PWSS No. 2010162

6 Wells, Livingston County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



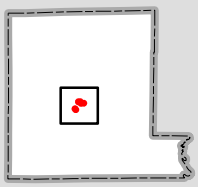
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Miles

0 0.5 1

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Chillicothe Municipal Utilities

PWSS No. 2010162

Livingston County, sheet 1 of 2

6 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W2	W3	W4	W5
Extended PWS #	2010162101	2010162102	2010162103	2010162104	2010162105
Local Well Name	Well #1	Well #2	Well #3	Well #4	Well #5
Well ID #	13827	13828	13829	13830	16992
DGLS ID #				029061	
Facility Type	City	City	City	City	City
Status	Active	Active	Active	Active	Active
Latitude	39.77485	39.77456	39.77146	39.77177	39.758125
Longitude	-93.5634	-93.56816	-93.56101	-93.55383	-93.575196
Location Method	DRG/MAP	DRG/MAP	DRG/MAP	DRG/MAP	PLSS
Method Accuracy (ft)	33	33	33	33	800
USGS 7.5 Quadrangle	Chillicothe	Chillicothe	Chillicothe	Chillicothe	Chillicothe
County	Livingston	Livingston	Livingston	Livingston	Livingston
MoDNR Region	Northeast	Northeast	Northeast	Northeast	Northeast
Date Drilled (year)	1968	1971	1971	1993	
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Glacial Deposits	Glacial Deposits	Glacial Deposits	Glacial Deposits	Glacial Deposits
Total Depth Formation	Glacial Deposits	Glacial Deposits	Glacial Deposits	Glacial Deposits	Glacial Deposits
Total Depth	105	120	126	110	135
Ground Elevation (ft)	676	676	682	659	682
Top Seal	Mechanical Seal	Mechanical Seal		Cement Grout	Cement Grout
Bottom Seal	Steel Plate	Steel Plate		Cement Grout	Gravel Pack
Casing Depth (ft)				75	115
Casing Size (in)				18	18
Casing Type	Steel	Steel	Steel	Steel	Steel
Elev. of Casing Top (ft)					
Outer Casing Depth (ft)				30	20
Outer Casing Size (in)				42	48
Screen Length (ft)	25	30	28	35	20
Screen Size (in)	18	18	18	18	18
Static Water Level (ft)	38	37	42	18	
Well Yield (gpm)	700	700	650	950	
Head (ft)	154	186	150		158
Draw Down (ft)	30	31	24	32	
Pump Test Date (year)	1991	1991	1991	1992	
Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine	Submersible	Vertical Turbine
Pump Manufacturer	Layne & Bowler	Layne & Bowler			
Pump Depth (ft)	80	80	60	86	
Pump Capacity (gpm)	1000	1000	1000	950	1000
Pump Meter (Y/N)	Y	Y	Y	Y	
VOC Detection (Y/N)	Y	N	N	N	
Nitrate Detection (Y/N)	N	N	N	N	
Chlorination (Y/N)	Y	Y	Y	Y	
Filtration (Y/N)	Y	Y	Y	Y	
GWUDISW (Y/N)	N	N	N	N	
Surface Drainage	Satisfactory	Satisfactory			
State Approved(Y/N)	Y	Y	Y	Y	
Date Abandoned (year)					
Date Plugged (year)					

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Chillicothe Municipal Utilities

PWSS No. 2010162

Livingston County, sheet 2 of 2

6 wells

Prepared by:

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W8
Extended PWS #	2010162108
Local Well Name	Well #6
Well ID #	18865
DGLS ID #	
Facility Type	City
Status	Active
Date Drilled (year)	
Material (C/U)	Unconsolidated
Base of Casing Formation	Glacial Deposits
Total Depth Formation	Glacial Deposits
Total Depth	
Ground Elevation (ft)	682
Top Seal	Cement Grout
Bottom Seal	Cement Grout
Static Water Level (ft)	
Well Yield (gpm)	
Head (ft)	
Draw Down (ft)	
VOC Detection (Y/N)	
Nitrate Detection (Y/N)	
Chlorination (Y/N)	
Filtration (Y/N)	
Date Plugged (year)	

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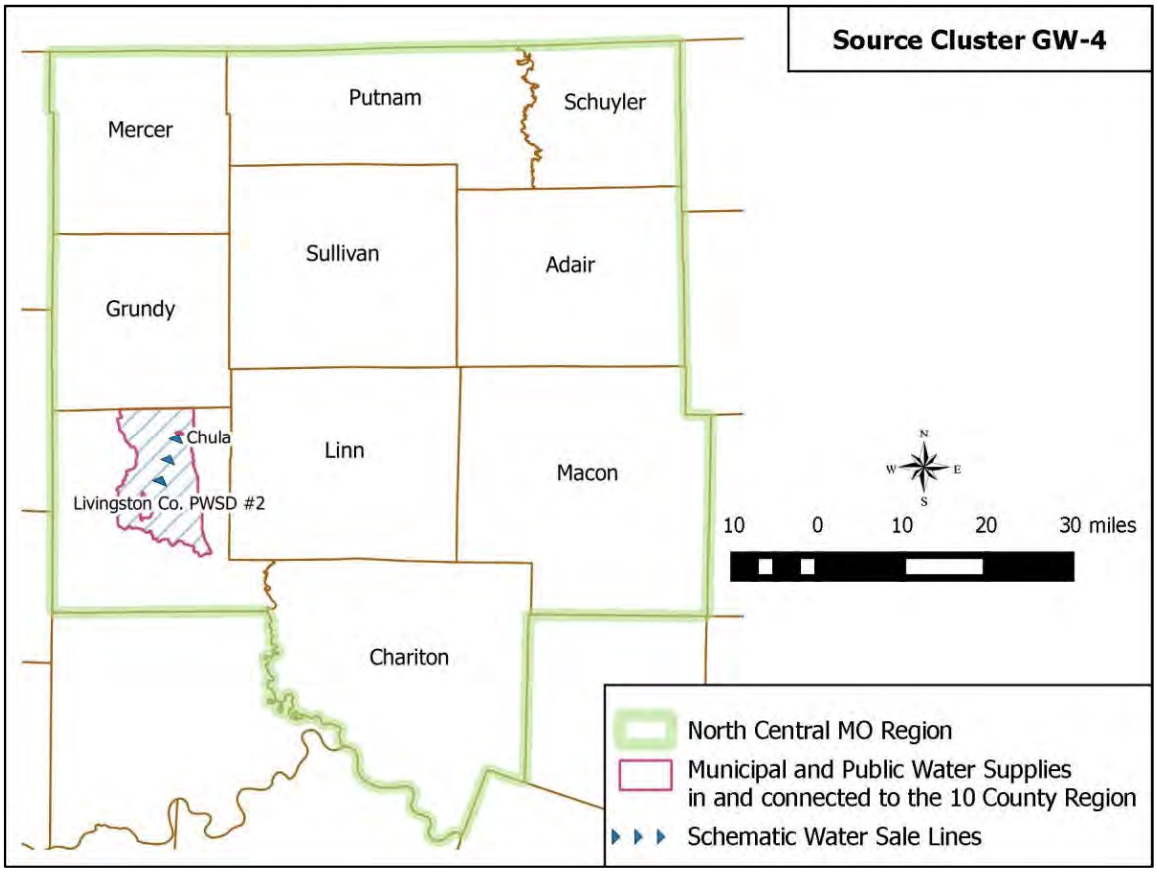
Cluster GW-4

Sources Inadequate



Cluster GW-4 is supplied, in part, by a groundwater well owned and operated by Livingston County PWSD #2. Missouri DNR records indicate the well was drilled in 2013 and yields approximately 276 gpm. The iron removal water treatment plant was designed for a maximum flow of 230 gpm. Based on 2015 annual average water production and demand data from the district, the well produces approximately 51 percent (0.087 MGD) of the total system demand (0.167 MGD). The remaining 49 percent (0.080 MGD) is purchased from Chillicothe Municipal Utilities. Note demand and production numbers do not equate, this error is attributed to water loss within the system by conversation with system staff.

The City of Chula began purchasing water from Livingston County PWSD #2 in 1985 after closing its water treatment plant after declining yield limited its capacity.

Well log data shows that Livingston County PWSD #2 has two inactive wells, Well #1 drilled in 1964 and Well #2 drilled in 1988. The data does not indicate a date of closure for the wells. The glacial deposit formation, which the wells are documented as located in, is known to contain high iron and varying quantities of water. Well #2 was drilled to a total depth of 139 feet below the surface and had a static water level of 53 feet below the surface. Drawdown information lists the depth at 110 feet below the surface when the 250 gpm pump was running. This slow recharge is an important factor in the reliability of a groundwater well. Additional information on Well #1 and Well #2 is located in Appendix F. Given the history of declining wells, this evaluation has identified Cluster GW-4's sources as inadequate.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-4	Livingston Co. PWSD #2					0.087	52%	0.151
	Chula						100%	0.016

Livingston Co. PWSD #2

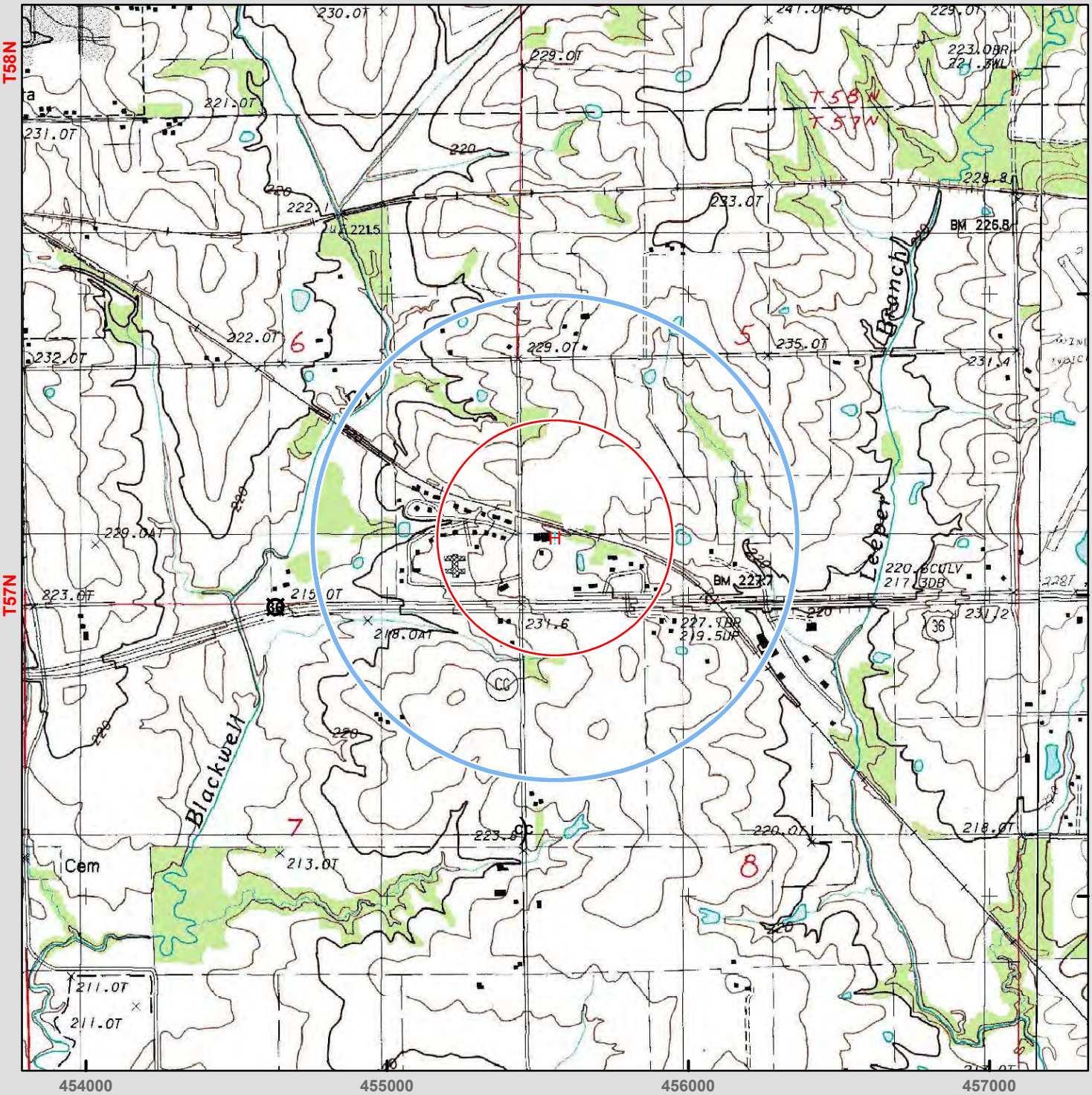
PWSS No. 2024353

1 Well, Livingston County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



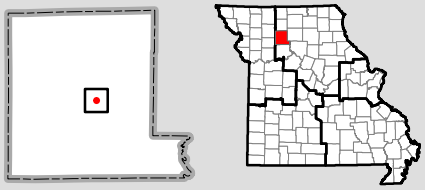
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



N

Feet

0 1,500 3,000

SWAP - Source Water Assessment Plan --
http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Livingston Co. PWSD #2

PWSS No. 2024353

Livingston County

1 well

Prepared by:

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W3
Extended PWS #	2024353103
Local Well Name	Well #3
Well ID #	18764
DGLS ID #	_____
Facility Type	Water District
Status	Active
Date Drilled (year)	2013
Material (C/U)	Unconsolidated
Base of Casing Formation	Alluvium
Total Depth Formation	Alluvium
Total Depth	185
Ground Elevation (ft)	775
Top Seal	Cement Grout
Bottom Seal	Cement Grout
Static Water Level (ft)	95
Well Yield (gpm)	276
Head (ft)	_____
Draw Down (ft)	_____
VOC Detection (Y/N)	_____
Nitrate Detection (Y/N)	_____
Chlorination (Y/N)	_____
Filtration (Y/N)	_____

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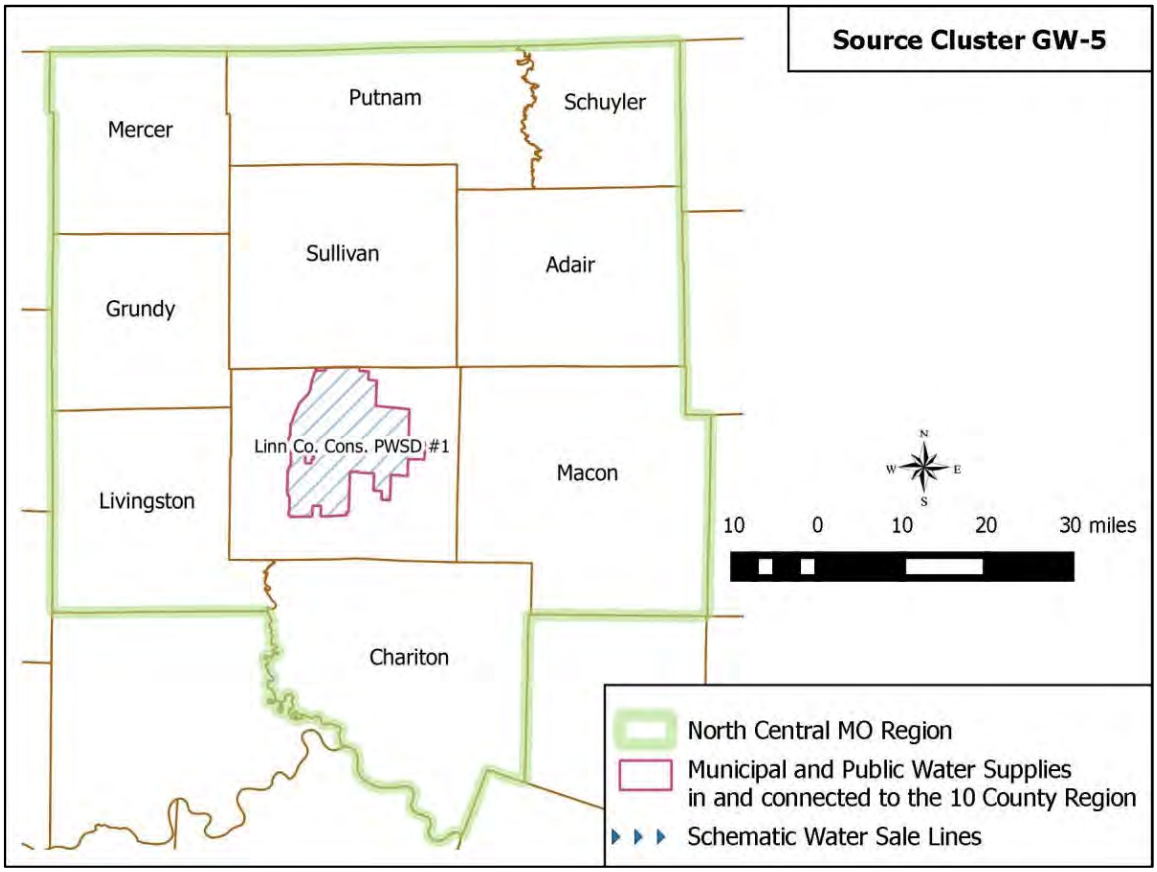
Cluster GW-5

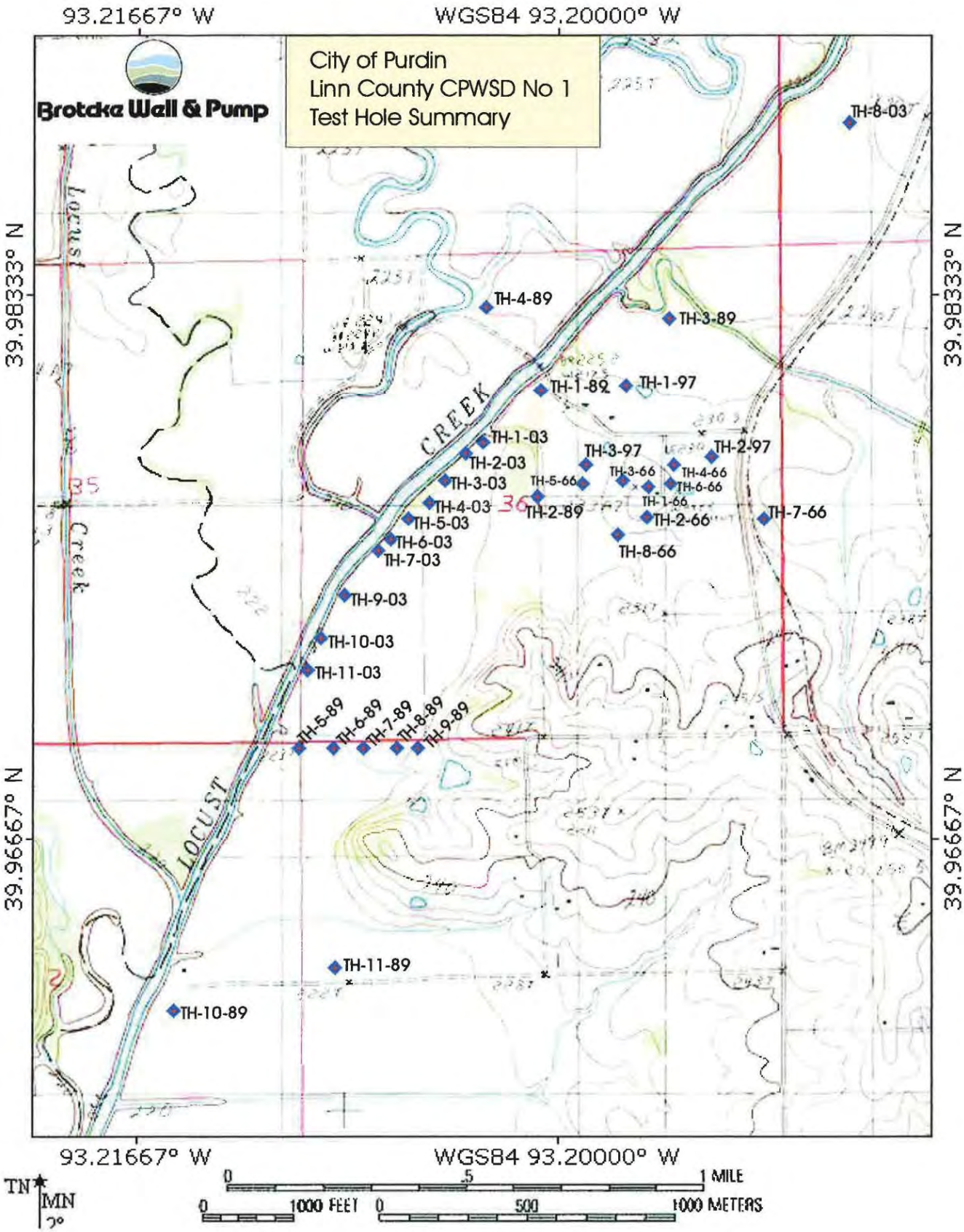
Sources Inadequate



Cluster GW-5 is supplied by five groundwater wells and is owned and operated by Linn County Consolidated PWSD #1. The 2015 average daily treated water normal demand for this cluster was 0.085 MGD and serves approximately 1,620 people. Missouri DNR records and information from district staff was used to develop the Water Yield and System Capacities table below. Note that Well #3 is not used due to its high iron content.

Water Yield and System Capacities				
Linn Co. Cons. PWSD #2	Yield (gpm)	Yield (MGD)	Pump Capacity (gpm)	Design Rate (gpm)
Well #1	32	0.046	41	
Well #2	41	0.059	75	
Well #3	-	-	75	
Well #4	75	0.108	75	
Well #5	20	0.029	25	
Treatment Plant				200

The letter in Appendix B describes the 2003 test hole activities, where 11 test holes were unsuccessful in identifying an alluvial well capable of producing 50 gpm. The map included in the letter is duplicated on the next page and shows the 33 test holes drilled by Brotcke Well and Pump from 1966 to 2003. Based on the history of the wells in this cluster to be influenced by high iron content, and because of continued deterioration of existing wells and the difficulty in identifying new wells, long-term water reliability within Cluster GW-5 is uncertain, therefore, its sources are identified as inadequate.


93.21667° W
WGS84 93.20000° W
Brotcke Well & Pump
City of Purdin
Linn County CPWSD No 1
Test Hole Summary
39.98333° N
39.96667° N
TH-8-03
TH-4-89
TH-3-89
TH-1-89
TH-1-97
TH-1-03
TH-2-03
TH-3-03
TH-4-03
TH-5-03
TH-6-03
TH-7-03
TH-3-97
TH-2-97
TH-3-66
TH-4-66
TH-6-66
TH-5-66
TH-1-66
TH-2-89
TH-2-66
TH-7-66
TH-8-66
TH-9-03
TH-10-03
TH-11-03
TH-5-89
TH-6-89
TH-7-89
TH-8-89
TH-9-89
TH-11-89
TH-10-89
CREEK
LOCUST
Creek
35
36
TN
MN
0
.5
1 MILE
1000 FEET
500
1000 METERS

Linn Co. Cons. PWSD #1

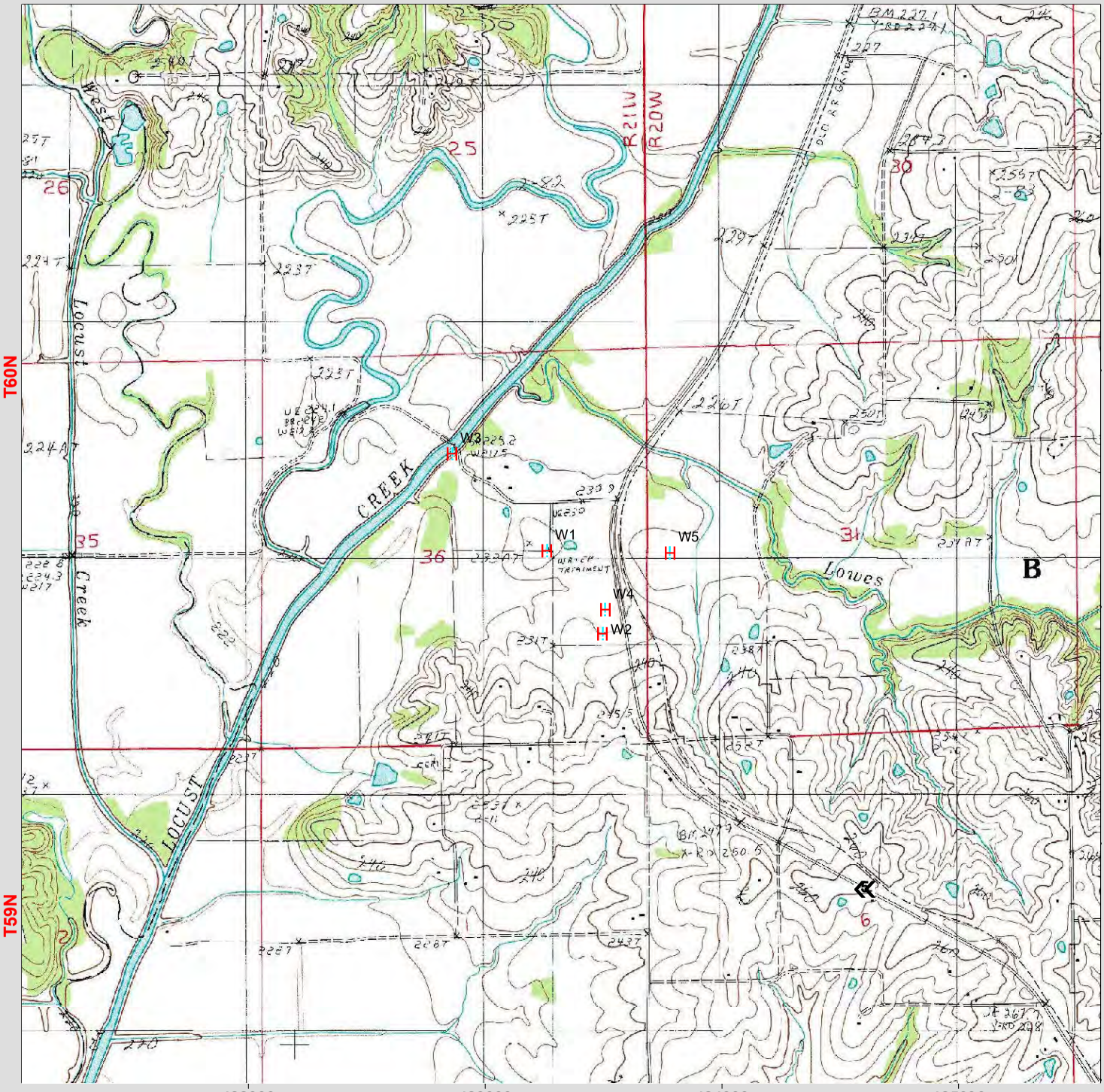
PWSS No. 2024346

5 Wells, Linn County

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



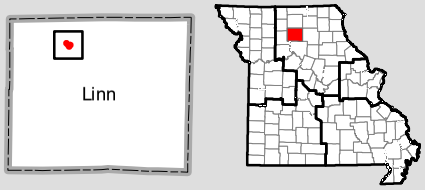
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



N

Feet

0 1,900 3,800

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Linn Co. Cons. PWSD #1

PWSS No. 2024346
Linn County
5 wells

Prepared by:

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W2	W3	W4	W5
Extended PWS #	2024346101	2024346102	2024346103	2024346104	2024346105
Local Well Name	Well #1	Well #2	Well #3	Well #4	Well #5
Well ID #	13867	13868	13869	13870	18025
DGLS ID #					
Facility Type	Water District	Water District	Water District	Water District	Water District
Status	Active	Active	Active	Active	Active
Date Drilled (year)	1969			1997	
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated	
Base of Casing Formation	Alluvium			Alluvium	
Total Depth Formation	Alluvium			Alluvium	
Total Depth	78			72	
Ground Elevation (ft)	758	748	722	764	
Top Seal	Pitless Adapter			Cement Grout	
Bottom Seal	Cement Grout				
Static Water Level (ft)	40				
Well Yield (gpm)					
Head (ft)				125	
Draw Down (ft)					
VOC Detection (Y/N)	N	N	N	N	
Nitrate Detection (Y/N)	N	N	N	N	
Chlorination (Y/N)	Y	Y	Y		
Filtration (Y/N)	Y	Y	Y		

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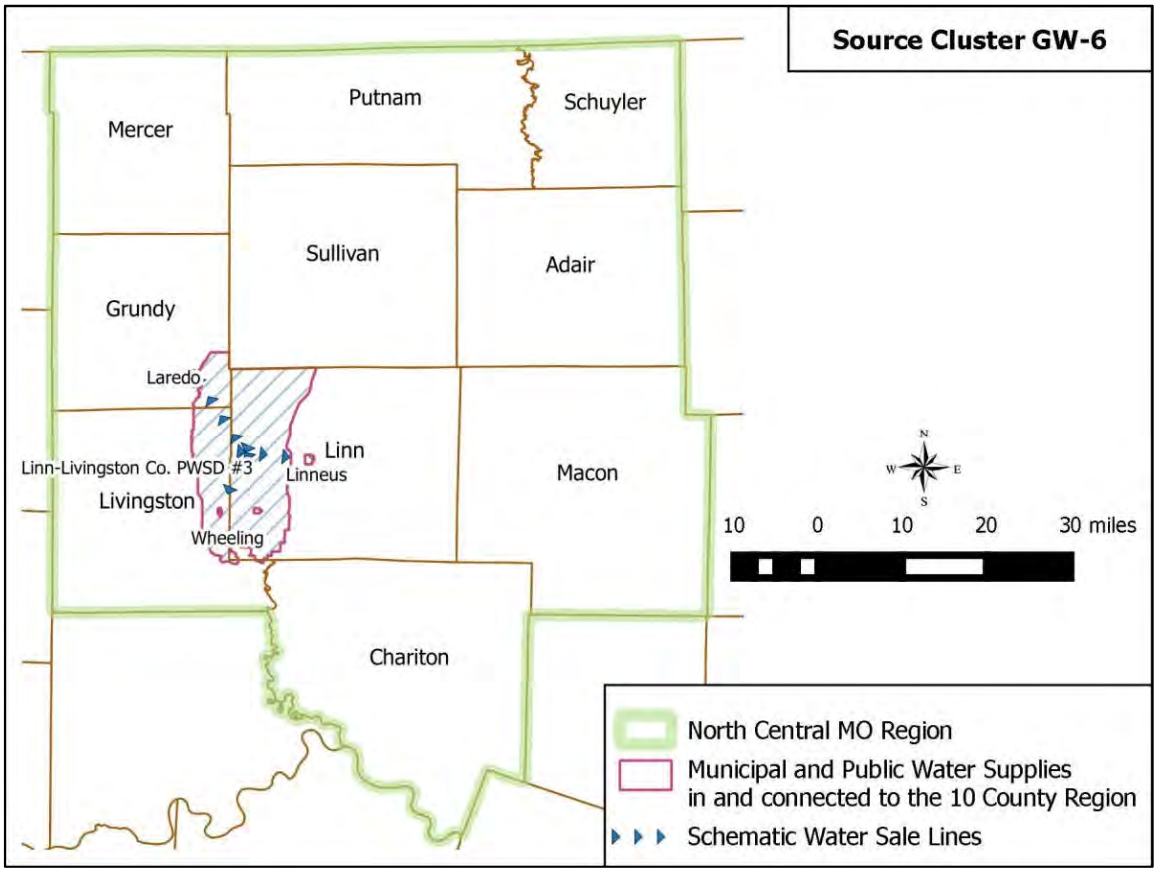
Cluster GW-6

Sources Inadequate



Three wells currently provide water for Cluster GW-6, which is owned and operated by Linn-Livingston County PWSD #3. MDNR records indicate wells #1, #3, and #4 are active. Well #2 is inactive due to high sand content and reduced yield. Well #1 is treated for iron bacteria every six to eight weeks during production, which is about four to five months a year. Laredo, a wholesale customer of Linn-Livingston County PWSD #3, closed its groundwater treatment plant due to high iron in 2000. Wheeling, also a wholesale customer, closed its groundwater treatment plant after decades of struggling with declining yield and high iron content as well. A listing of the closed systems within all the clusters can be found in Appendix C.

The current water demands in the cluster are detailed in the following table and total 0.168 MGD of treated water.

Given the history of declining wells and location in glacial deposits, this evaluation has identified Cluster GW-6's sources as inadequate.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-6	Linn-Livingston PWSD #3					0.168		0.107
	Laredo						100%	0.013
	Linneus						100%	0.028
	Wheeling						100%	0.020

Linn-Livingston Co. PWSD #3

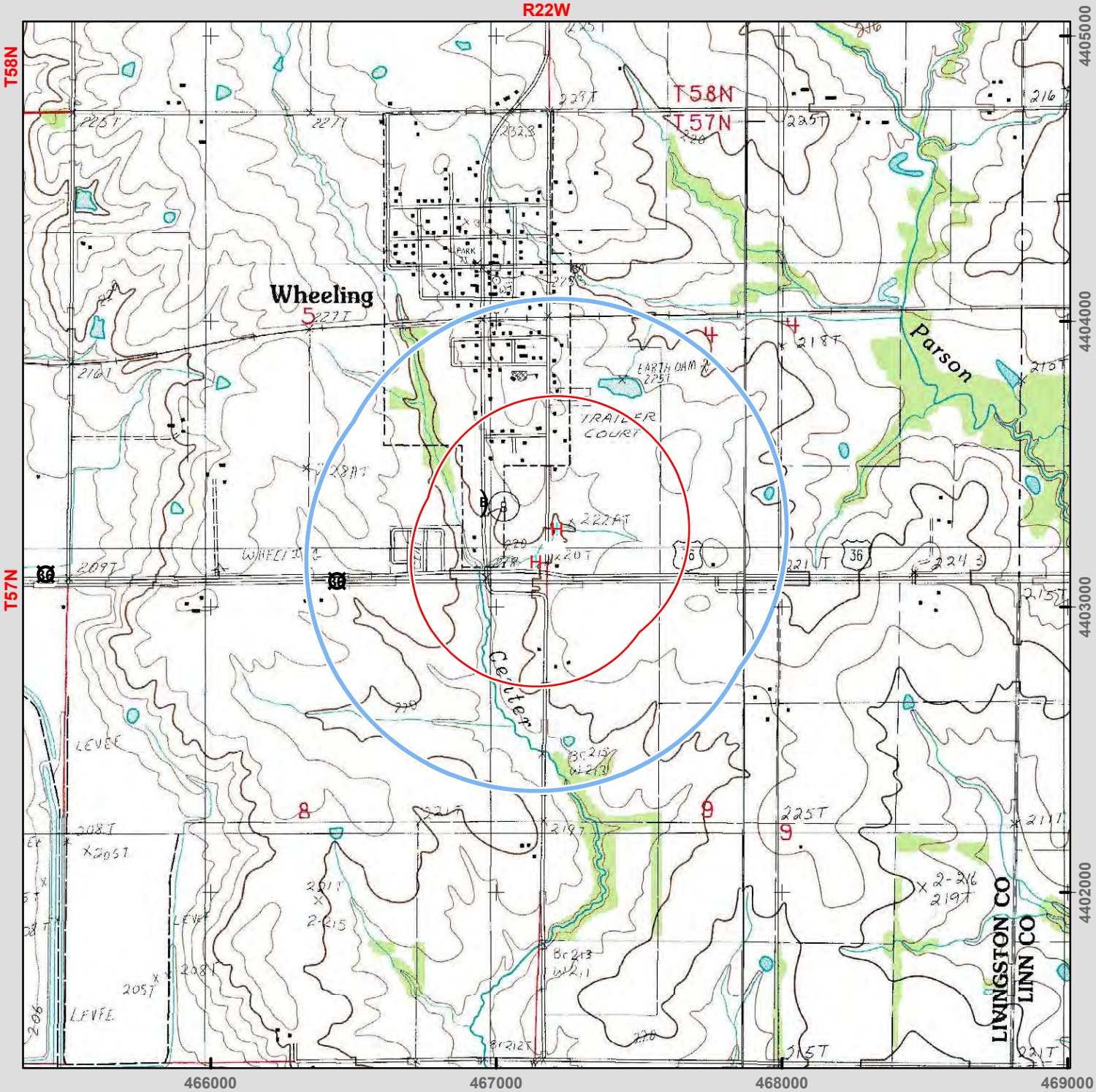
PWSS No. 2024350

2 Wells, Livingston County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



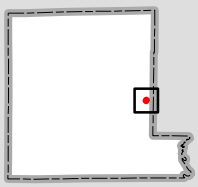
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Feet

0 1,600 3,200

SWAP - Source Water Assessment Plan --
http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Linn-Livingston Co. PWSD #3

PWSS No. 2024350

Livingston County

2 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W3
Extended PWS #	2024350101	2024350103
Local Well Name	Well #1, Old Well	Well #3
Well ID #	13831	18093
DGLS ID #		
Facility Type	Water District	Water District
Status	Active	Active
Latitude	39.77878	39.77775
Longitude	-93.38288	-93.383722
Location Method	DRG/MAP	GPS
Method Accuracy (ft)	33	98
USGS 7.5 Quadrangle	Wheeling	Wheeling
County	Livingston	Livingston
MoDNR Region	Northeast	Northeast
Date Drilled (year)	1964	2000
Material (C/U)	Unconsolidated	Unconsolidated
Base of Casing Formation	Glacial Deposits	Glacial Deposits
Total Depth Formation	Glacial Deposits	Glacial Deposits
Total Depth	137	131
Ground Elevation (ft)	754	
Top Seal		
Bottom Seal		
Casing Depth (ft)	115	116
Casing Size (in)	12	18
Casing Type	Steel	Steel
Elev. of Casing Top (ft)		
Outer Casing Depth (ft)		
Outer Casing Size (in)		
Screen Length (ft)	15	15
Screen Size (in)	30	
Static Water Level (ft)	58	
Well Yield (gpm)	225	
Head (ft)		
Draw Down (ft)	20	21
Pump Test Date (year)	1992	
Pump Type	Vertical Turbine	
Pump Manufacturer		
Pump Depth (ft)		
Pump Capacity (gpm)		250
Pump Meter (Y/N)	Y	
VOC Detection (Y/N)	N	
Nitrate Detection (Y/N)	N	
Chlorination (Y/N)	Y	
Filtration (Y/N)	Y	
GWUDISW (Y/N)	N	
Surface Drainage		
State Approved(Y/N)	Y	
Date Abandoned (year)		
Date Plugged (year)		

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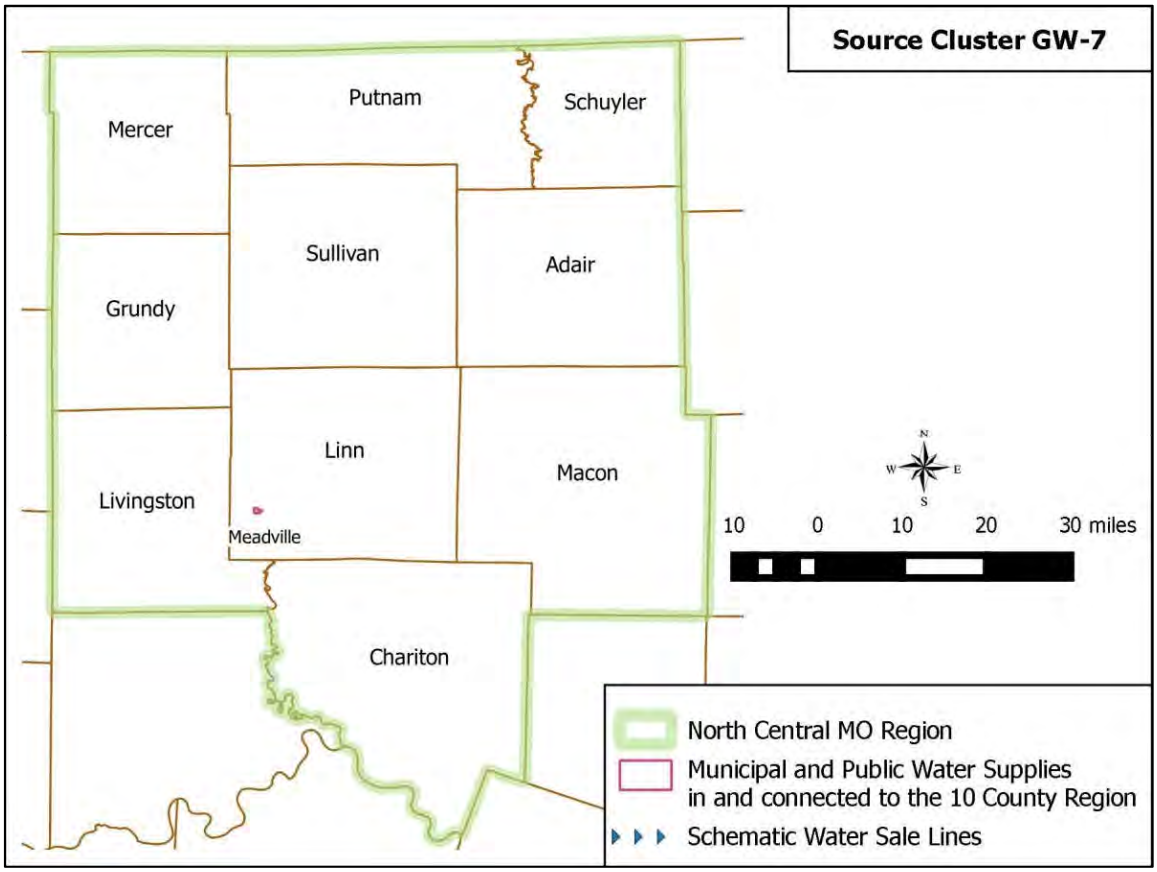
Cluster GW-7

Sources Inadequate



Cluster GW-7 is supplied by two groundwater wells, which are owned and operated by the City of Meadville, Missouri. Well #1 and Well #3 yield approximately 60 gpm each to provide water to the 50 gpm, iron removal, water treatment plant. These two wells are located within 20 feet of each other. The 2015 average daily normal demand was 0.033 MGD serving a population of approximately 450.

Given the location of the wells in glacial deposits, this evaluation has identified Cluster GW-7's sources as inadequate.

Meadville

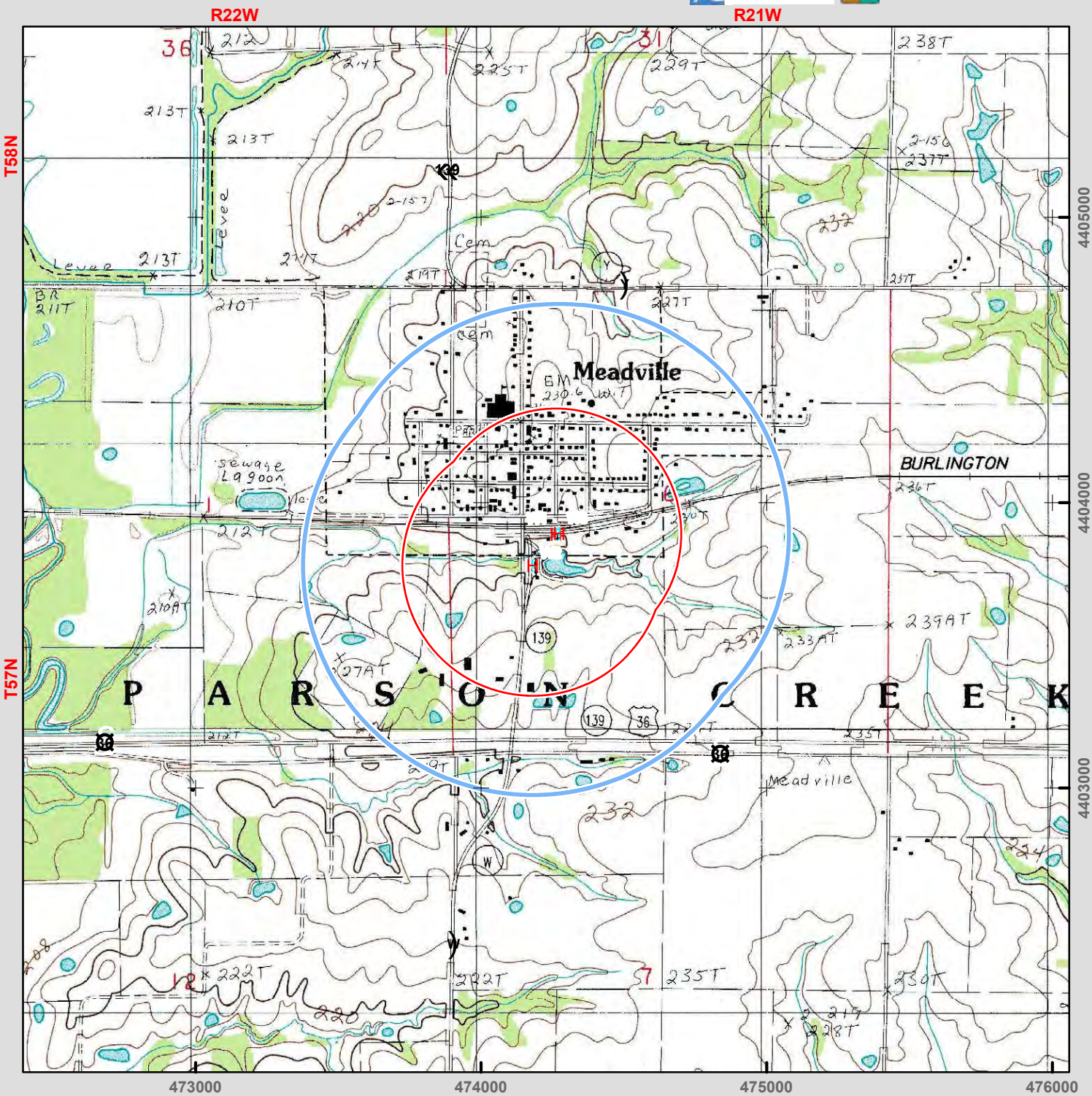
PWSS No. 2010512

3 Wells, Linn County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



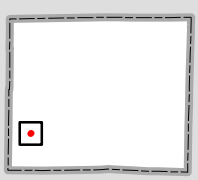
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Feet

0 1,600 3,200

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Meadville

PWSS No. 2010512

Linn County

3 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W2	W3
Extended PWS #	2010512101	2010512102	2010512103
Local Well Name	Well #1	Well #2	Well #3
Well ID #	14937	14936	14938
DGLS ID #			
Facility Type	City	City	City
Status	Active	Emergency	Active
Latitude	39.78458	39.78358	39.78459
Longitude	-93.30058	-93.30152	-93.30045
Location Method	DRG/MAP	DRG/MAP	DRG/MAP
Method Accuracy (ft)	33	33	33
USGS 7.5 Quadrangle	Meadville	Meadville	Meadville
County	Linn	Linn	Linn
MoDNR Region	Northeast	Northeast	Northeast
Date Drilled (year)	1954	1954	1977
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Glacial Deposits	Glacial Deposits	Glacial Deposits
Total Depth Formation	Glacial Deposits	Glacial Deposits	Glacial Deposits
Total Depth	70	68	82
Ground Elevation (ft)			
Top Seal			
Bottom Seal			
Casing Depth (ft)			74
Casing Size (in)			16
Casing Type	Steel	Steel	Steel
Elev. of Casing Top (ft)			
Outer Casing Depth (ft)			
Outer Casing Size (in)			
Screen Length (ft)			10
Screen Size (in)			10
Static Water Level (ft)			43
Well Yield (gpm)			35
Head (ft)			
Draw Down (ft)			34
Pump Test Date (year)			1977
Pump Type	Vertical Turbine		Submersible
Pump Manufacturer			
Pump Depth (ft)			77
Pump Capacity (gpm)	50	50	40
Pump Meter (Y/N)	Y		Y
VOC Detection (Y/N)	N	N	N
Nitrate Detection (Y/N)	N	N	N
Chlorination (Y/N)			Y
Filtration (Y/N)	Y		Y
GWUDISW (Y/N)	N		N
Surface Drainage			
State Approved(Y/N)			Y
Date Abandoned (year)			
Date Plugged (year)			

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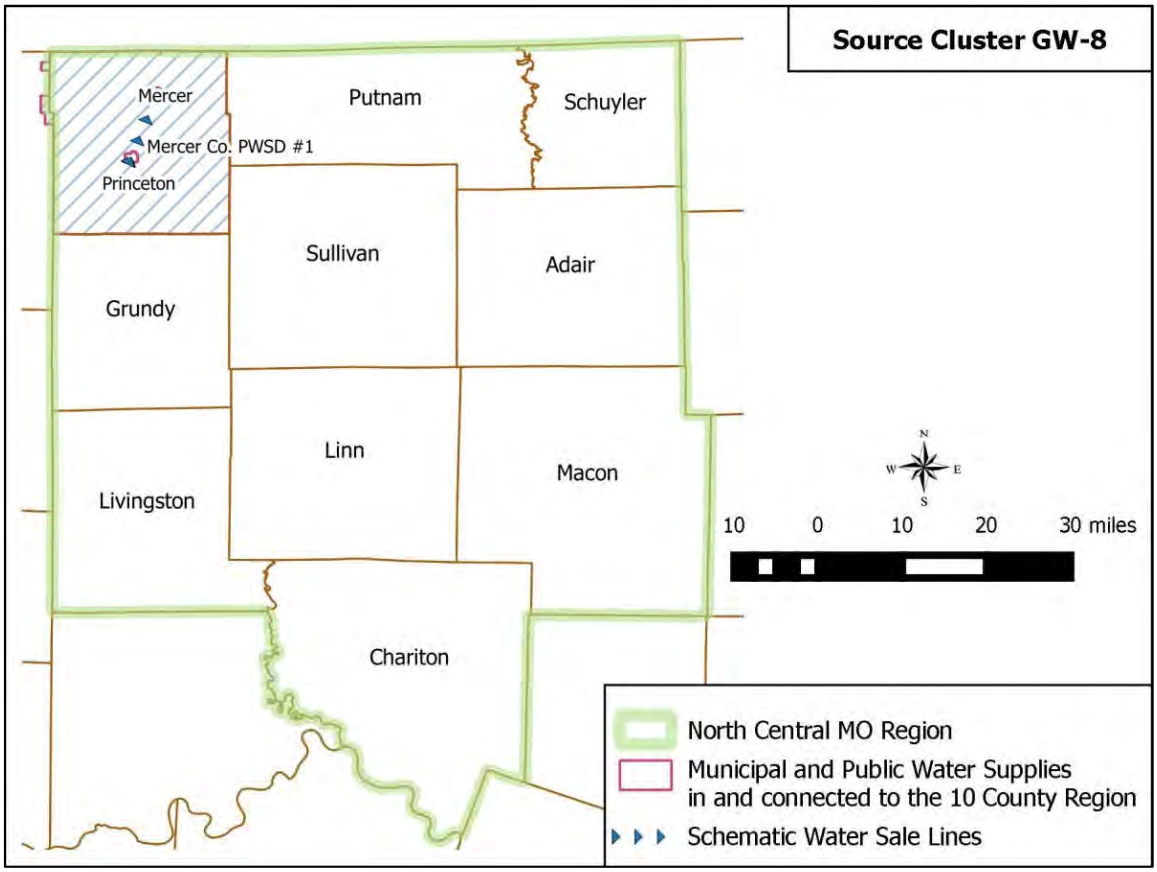
Cluster GW-8

Sources Inadequate



Cluster GW-8 is served by six groundwater wells owned and operated by the City of Princeton, Missouri. These wells are documented as being located in the alluvium of the Weldon River. MDNR records indicate eight wells pugged or inactive in the system, detailed in the Well History table below. Given the history of declining wells Cluster GW-8 is identified as having inadequate soures.

Well History				
Well #	Status	Year Drilled	Year Abandoned	Year Plugged
Well # 1	Plugged	1973	-	2009
Well # 1, Old	Plugged	-	1995	1995
Well # 2B	Plugged	1968	-	2002
Well # 3	Inactive	1971	-	-
Well # 5	Plugged	-	-	2002
Well # 7	Plugged	1978	-	2002
Well # 12	Plugged	-	1995	1995
Well # 13	Plugged	-	1995	1995

The Production and Demand table below details the 2015 average consumption of the 0.137 MGD within the cluster.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-8	Princeton					0.137		0.078
	Mercer						100%	0.024
	Mercer County PWSD #1						18%	0.195

Princeton

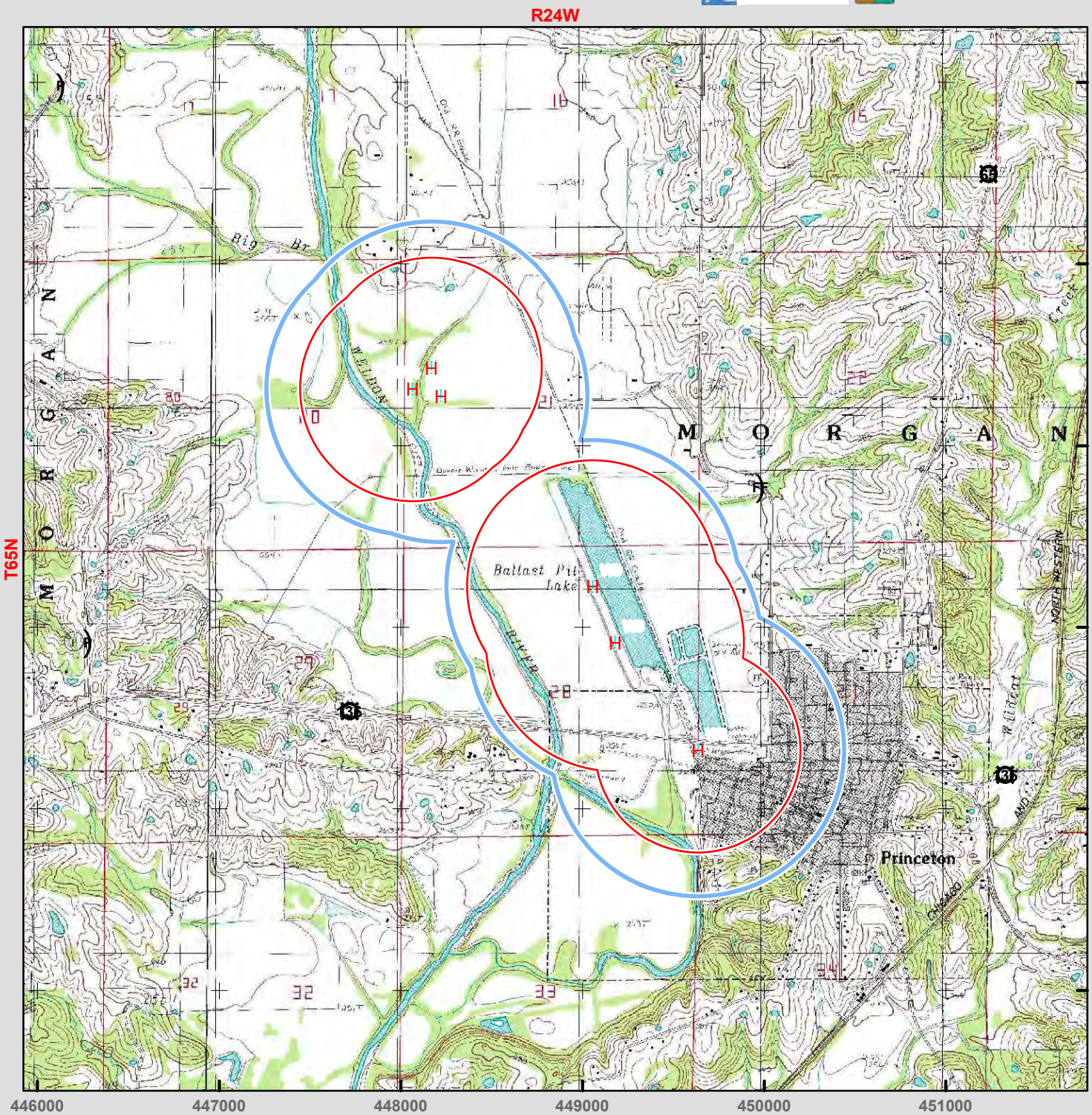
PWSS No. 2010664

6 Wells, Mercer County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



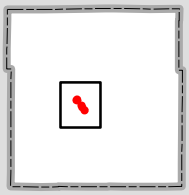
Well System

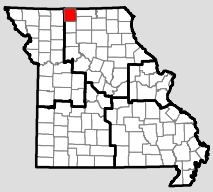
H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer





Miles

0 0.5 1

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Princeton

PWSS No. 2010664

Mercer County, sheet 1 of 2

6 wells

Prepared by:

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W3	W8	W9	W10	W11
Extended PWS #	2010664103	2010664108	2010664109	2010664110	2010664111
Local Well Name	Well #2A	Well #8	Well #9	Well #10	Well #11
Well ID #	13680	14544	14543	14546	14545
DGLS ID #					
Facility Type	City	City	City	City	City
Status	Active	Active	Active	Active	Active
Date Drilled (year)	1957	1980	1980	1995	
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth Formation	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
Total Depth	42	37	39	45	44
Ground Elevation (ft)	830	825	825	825	825
Top Seal					Cement Grout
Bottom Seal					Cement Grout
Static Water Level (ft)	12	18	19		18
Well Yield (gpm)	65	90	90		225
Head (ft)		75	75	88	89
Draw Down (ft)	10	11	13		18
VOC Detection (Y/N)	N	N	N	N	N
Nitrate Detection (Y/N)	N	N	N	N	N
Chlorination (Y/N)	Y	Y	Y	Y	
Filtration (Y/N)	Y	Y	Y		

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Princeton

PWSS No. 2010664

Mercer County, sheet 2 of 2

6 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W14
Extended PWS #	2010664114
Local Well Name	Well #12
Well ID #	17224
DGLS ID #	
Facility Type	City
Status	Active
Latitude	40.41783
Longitude	-93.61218
Location Method	GPS
Method Accuracy (ft)	75
USGS 7.5 Quadrangle	Princeton
County	Mercer
MoDNR Region	Northeast
Date Drilled (year)	2004
Material (C/U)	Unconsolidated
Base of Casing Formation	Glacial Deposits
Total Depth Formation	Glacial Deposits
Total Depth	44
Ground Elevation (ft)	825
Top Seal	
Bottom Seal	
Casing Depth (ft)	41
Casing Size (in)	24
Casing Type	
Elev. of Casing Top (ft)	846.5
Outer Casing Depth (ft)	31
Outer Casing Size (in)	48
Screen Length (ft)	10
Screen Size (in)	24
Static Water Level (ft)	19
Well Yield (gpm)	
Head (ft)	89
Draw Down (ft)	
Pump Test Date (year)	
Pump Type	Submersible
Pump Manufacturer	
Pump Depth (ft)	
Pump Capacity (gpm)	150
Pump Meter (Y/N)	Y
VOC Detection (Y/N)	
Nitrate Detection (Y/N)	
Chlorination (Y/N)	
Filtration (Y/N)	
GWUDISW (Y/N)	
Surface Drainage	
State Approved(Y/N)	
Date Abandoned (year)	
Date Plugged (year)	

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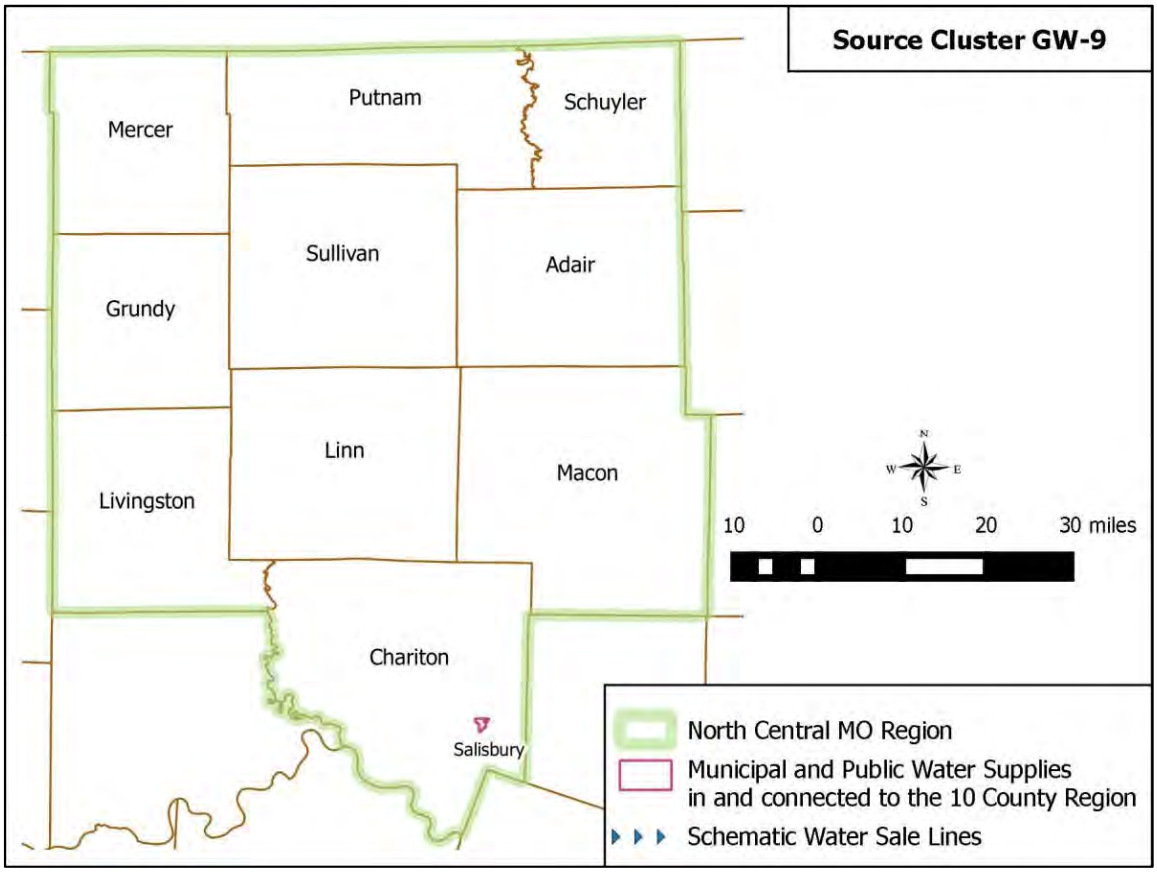
Cluster GW-9

Sources adequate



Cluster GW-9 is supplied by two groundwater wells, which are owned and operated by the City of Salisbury, Missouri. Well #1 has high ammonia content and is not actively used. Well #2 and Well #3 are alternated in use having a routine yield of approximately 300 gpm in the alluvium of the Chariton River. The 2015 average daily normal demand was 0.175 MGD which was produced by the iron removal water treatment plant (MDNR 2016).

Given the proximity to the Chariton River and no known history of declining yield wells, Cluster GW-9 is identified as having adequate sources.

Salisbury

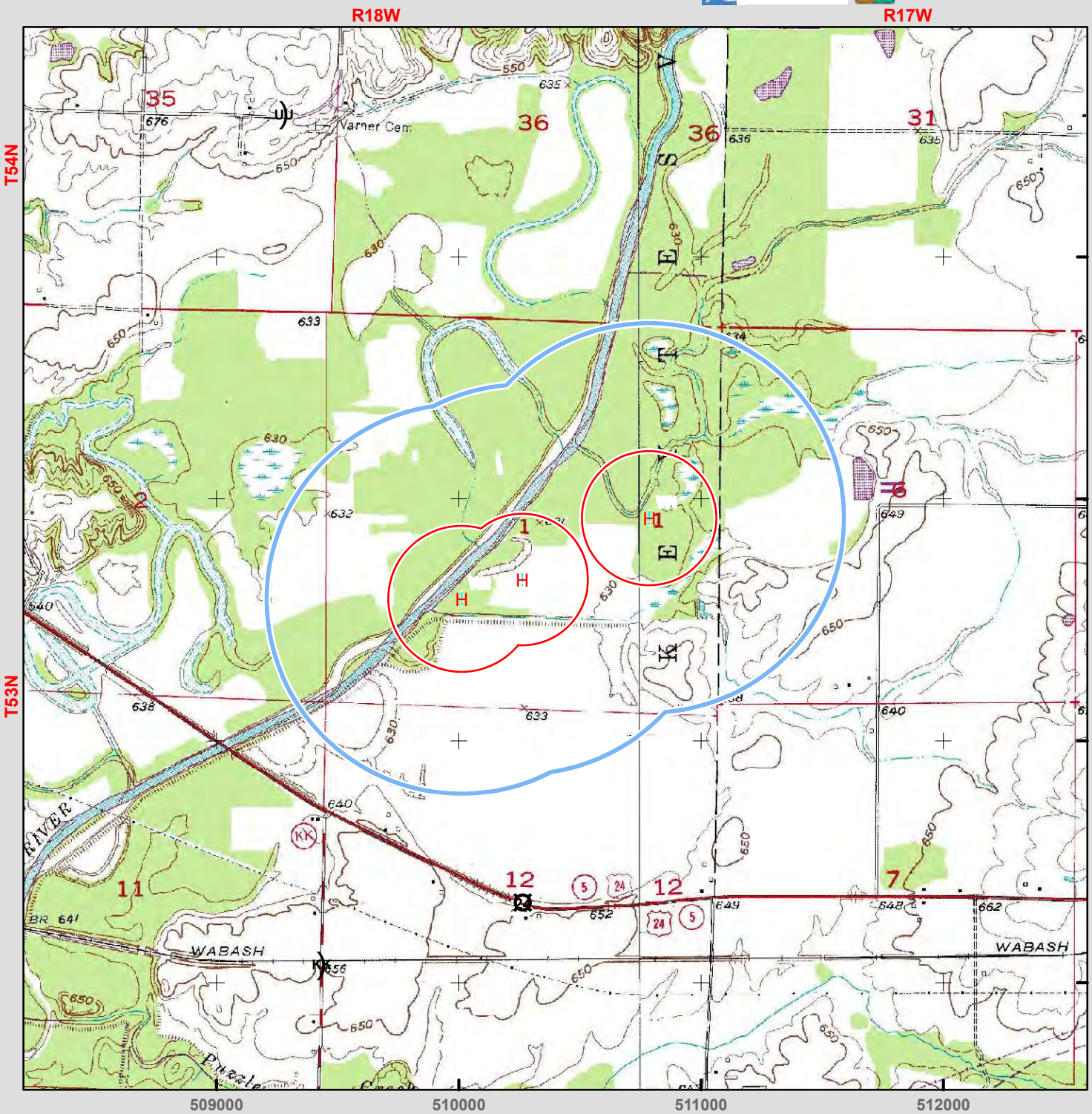
PWSS No. 2010722

3 Wells, Chariton County

Prepared by:

Map Update: Jan 22, 2016

Missouri Department of Natural Resources



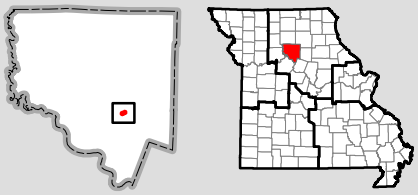
Well System

H System Well

SWAP Delineation Boundary

20-year time of travel

Half-mile buffer



Feet

0 1,900 3,800

SWAP - Source Water Assessment Plan --
http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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Salisbury

PWSS No. 2010722

Chariton County

3 wells

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Sheet Update: Jan 25, 2016

Missouri Department of Natural Resources

Well Number	W1	W2	W3
Extended PWS #	2010722101	2010722102	2010722103
Local Well Name	Well #1	Well #2	Well #3
Well ID #	14628	14630	14629
DGLS ID #			
Facility Type	City	City	City
Status	Emergency	Active	Active
Latitude	39.42475	39.42175	39.422472
Longitude	-92.874694	-92.883694	-92.880778
Location Method	GPS	GPS	GPS
Method Accuracy (ft)	100	100	100
USGS 7.5 Quadrangle	Salisbury	Keytesville	Keytesville
County	Chariton	Chariton	Chariton
MoDNR Region	Northeast	Northeast	Northeast
Date Drilled (year)	1980	1981	1980
Material (C/U)	Unconsolidated	Unconsolidated	Unconsolidated
Base of Casing Formation	Alluvium	Alluvium	Alluvium
Total Depth Formation	Alluvium	Alluvium	Alluvium
Total Depth	68	60	70
Ground Elevation (ft)	738	663	613
Top Seal			
Bottom Seal			
Casing Depth (ft)	68	60	70
Casing Size (in)	24	24	24
Casing Type	Steel	Steel	Steel
Elev. of Casing Top (ft)	645	648	645
Outer Casing Depth (ft)			
Outer Casing Size (in)			
Screen Length (ft)	12	12	12
Screen Size (in)	24	24	24
Static Water Level (ft)	30	28	30
Well Yield (gpm)	250	250	250
Head (ft)	42	42	44
Draw Down (ft)	36	35	38
Pump Test Date (year)	1980	1981	1980
Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine
Pump Manufacturer			
Pump Depth (ft)	55	55	55
Pump Capacity (gpm)	600	600	600
Pump Meter (Y/N)	Y	Y	Y
VOC Detection (Y/N)	N	N	N
Nitrate Detection (Y/N)	N	N	N
Chlorination (Y/N)	Y	Y	Y
Filtration (Y/N)	Y	Y	Y
GWUDISW (Y/N)	N	N	N
Surface Drainage			
State Approved(Y/N)	Y	Y	Y
Date Abandoned (year)			
Date Plugged (year)			

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Summary of Groundwater Cluster Evaluations

Approximately 39 percent of Missouri's population is served by groundwater sources (MDNR 2015). In 2015, the groundwater sources of north-central Missouri, accounted for approximately 15.5 percent (2.122 MGD) of the total (13.723 MGD) treated drinking water produced in the 10-county study area. This percentage supports the claims of geologists, well drillers, engineers, and planners that there is a pronounced lack of quality, plentiful groundwater in north-central Missouri. If quality, plentiful groundwater were available in the region, it would be reasonable to assume that comparing the percentage of the total water produced would be similar to that of the state. Additionally, it would be reasonable to assume that there would be more than nine groundwater systems in the four of 10 counties within the region that utilize groundwater as a source of raw water.

Of the 2.122 MGD of groundwater produced in the region, Chillicothe Municipal Utilities (Cluster GW-3) provided nearly 1.30 MGD or 61.3 percent of the total average daily demand supplied by groundwater. This large volume producer also comports with geologic analysis which states: "In general, the most favorable alluvial deposits appear to be those of the lower parts of the Grand and Chariton rivers." (MDNR 1997) The other eight groundwater clusters provided a combined total average of 0.822 MGD. A total of four of the 9 groundwater systems in the study region are located within the alluvium of the Grand and Chariton rivers. They include Chillicothe, Missouri American-Brunswick, Keytesville, and Salisbury.

Other groundwater systems in the study region include: Livingston County PWSD #2, Princeton, Linn County Consolidated PWSD #1, Meadville, and Linn-Livingston PWSD #3 and are located in pre-glacial deposits or smaller stream modern alluvium. The fact that these systems have found enough water, after extensive test hole drilling, to supply their current demand is also explained by Miller as, "pre-glacial alluvial deposits are, unfortunately, limited in areal extent, and are found in rather narrow linear trends, much the same as modern alluvial valleys" (MDNR 1997).

An example of a public water system struggling to find quality and plentiful water is Linn County Consolidated PWSD #1 (Cluster GW-5). A letter explaining the unsuccessful findings from Brotcke Well and Pump from 2003 is included in Appendix B. The embedded map from that letter details the locations of over 30 drilled test wells from 1966-2003. Because of the low average daily demand of 0.085 MGD, the cluster has been able to meet demand with the existing wells, although system staff indicated that Well #2 is virtually unusable due to excessive iron content.

Wells in this region are in decline and losing yield. This has resulted in the closing of 16 groundwater treatment facilities since 1980 and numerous closed/abandoned wells of the current groundwater systems. Appendix C lists the closed systems in the region and Appendix F contains a table of closed wells for active groundwater systems.

Under current demand conditions and the cumulative history of the region, this evaluation has determined that three of the nine ground water clusters might provide an adequate source of dependable quality water for the future. These systems are GW-2 (MO American- Brunswick), GW-3 (Chillicothe Municipal Utilities), and GW-9 (Salisbury). These three systems provided 1.559 MGD (or 73.5 percent) of treated ground water within the study region in 2015. The remaining 0.563 MGD, of treated groundwater, was provided by six systems, ranging in production from 0.033 MGD to 0.168 MGD. The corresponding raw water demand of the six inadequate source clusters, estimating 10 percent treatment losses, totals 0.619 MGD.

A complete listing of the Groundwater Cluster Production and Demand Table from 2015 is located in Appendix K. The impact of inadequate cluster water sources could result in the complete depletion of water in six of nine the existing clusters. Figure 10, below, shows clusters with inadequate sources in red and those with adequate sources, in green. Each segment of the pie corresponds to a groundwater producer within the 10-county region. The size of each segment is proportionate to the average daily demand produced by each system, shown as the value at the end of the labels in MGD.

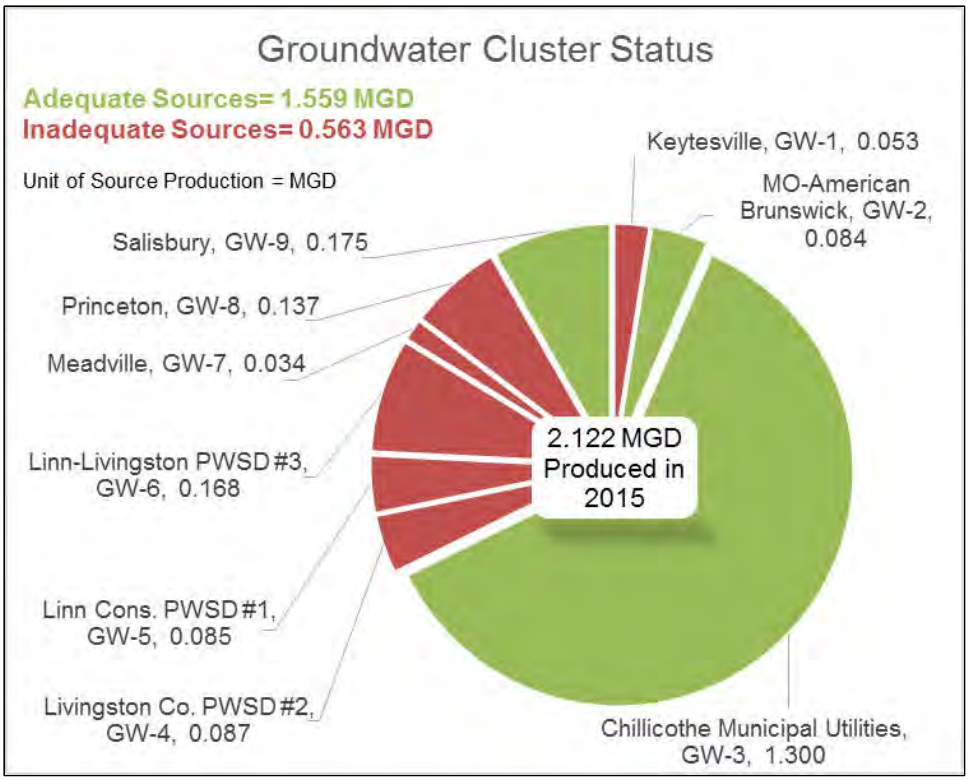


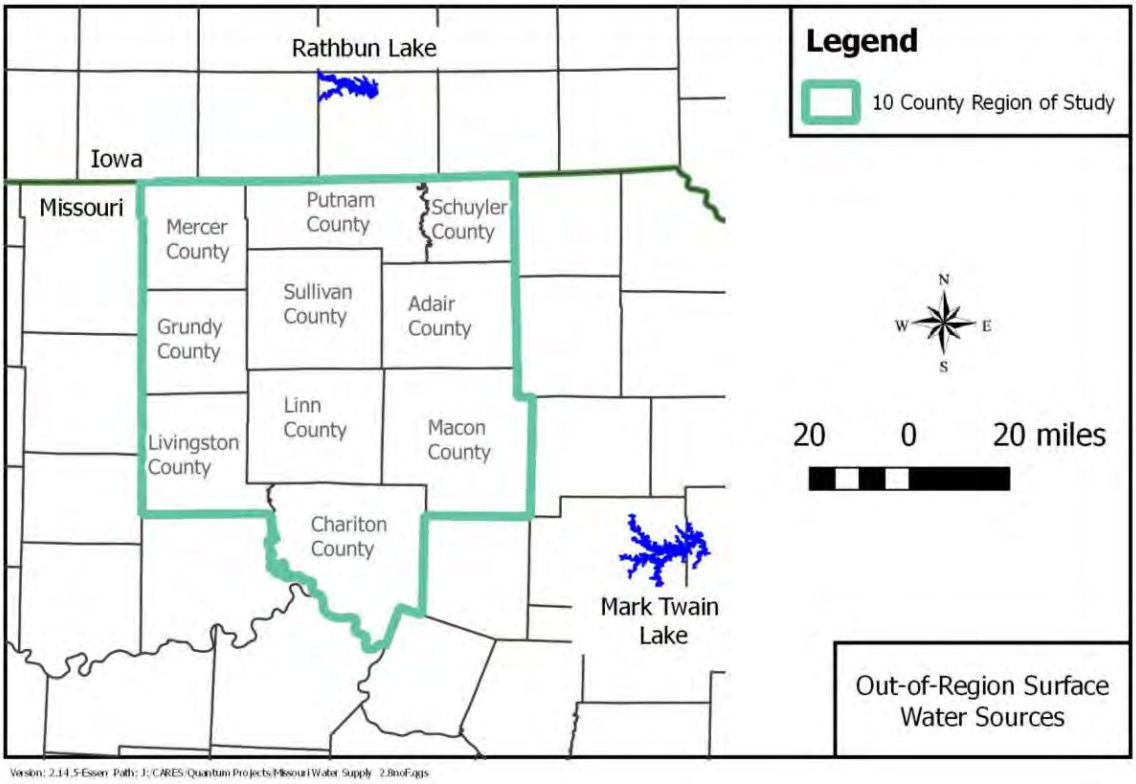
Figure 10: Groundwater Source Cluster Summary

Overview of Out-of-Region Cluster Evaluations

A total of three out-of-region suppliers provided 1.035 MGD of treated water within the 10-county study region in 2015. Both Rathbun Regional Water Association (OR-1) and Clarence Cannon Wholesale Water Commission (OR-2) provide treated surface water via direct wholesale connections. Livingston County PWSD #4 (OR-3) serves customers and is based within the region, but the groundwater wells are located in adjacent Daviess County. Wholesale customers of the Livingston County PWSD#4 are located in Daviess and Caldwell counties, neither of which are within the study region.

Given that the evaluation herein is for sources within the 10-county region of study, analysis of sources outside the region is irrelevant, except that there are communities within the study region depend on those sources for water daily. The underlying assumption is that out-of-region sources will be able to provide the current quantity of water into the future.

Figure 11, below, shows the proximity of the out-of-region surface water sources for OR-1 and OR-2 to the 10-county region.

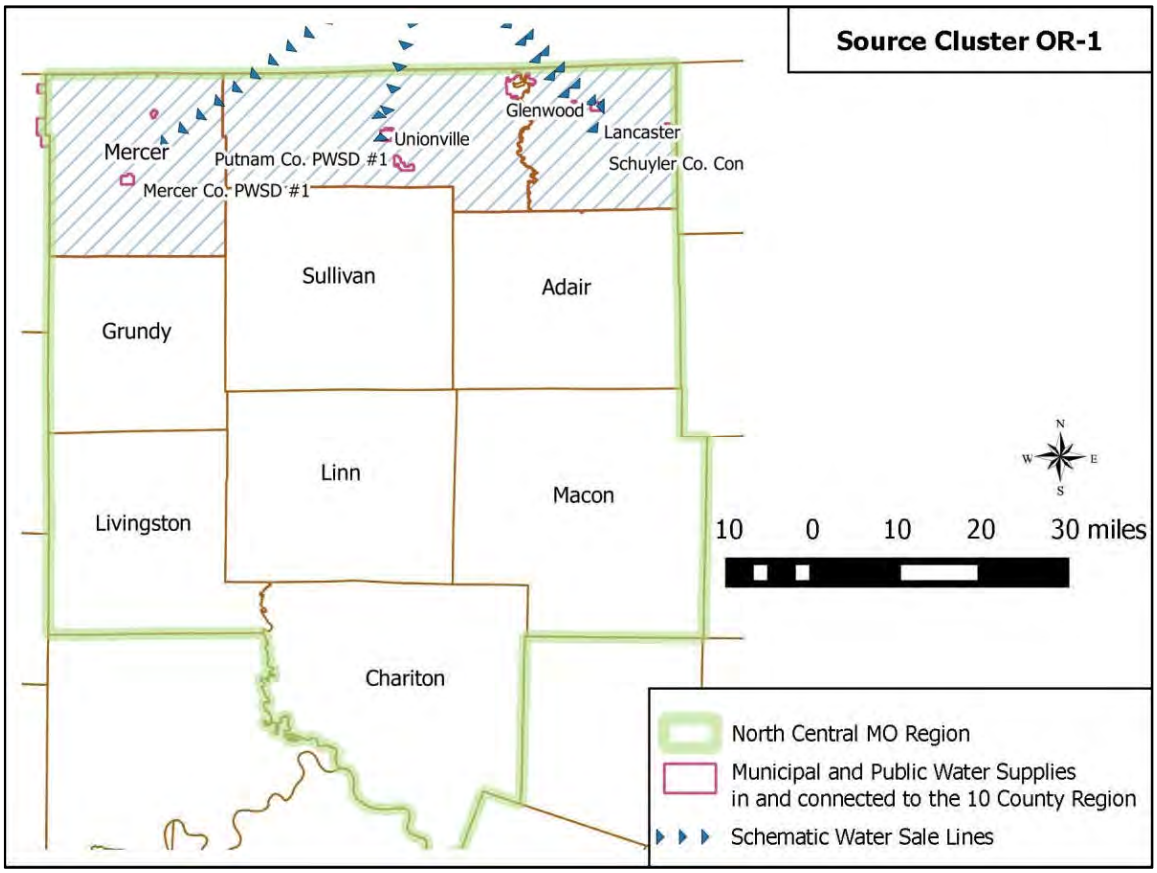


The following out-of-region cluster reports provide information about the systems dependent on the sources from outside of the region. Specific information in regard to drought resistance of those specific sources would have required extensive understanding, cooperation, and research to analyze each regional supply, their demands, and effecting conditions. This was additional research was beyond the scope of this evaluation.

Out-of-Region Reports OR-1 to OR-3

Cluster OR-1

Source Inadequate



The U.S. Army Corps of Engineers built Rathbun Lake in 1970 as a flood control, recreation, and water supply reservoir. Initially 6,680 acre-feet of the total drinking water allocation of 15,000 acre-feet, was contracted to the Rathbun Regional Water Association who treats the surface water supply. The remaining 8,320 acre-feet were designated as a first right of refusal for Rathbun Regional Water Association, who supplies treated water to over 14 Iowa counties and four Missouri counties.

An important note about OR-1 is that Rathbun Regional Water Association is located in Iowa. Water conveyance across state lines is explicitly listed in 455B.266 Priority Allocation which states:

"2. Notwithstanding a person's possession of a permit or the person's use of water being a nonregulated use, the department may suspend or restrict usage of water by category of use on a local or statewide basis in the following order:

a. Water conveyed across state boundaries.
b. Water used primarily for recreational or aesthetic purposes.
c. Uses of water for the irrigation of any general crop.
d. Uses of water for the irrigation of any specialty crop.
e. Uses of water for manufacturing or other industrial processes.
f. Uses of water for generation of electrical power for public consumption.
g. Uses of water for livestock production.
h. Uses of water for human consumption and sanitation supplied by rural water districts, municipal water systems, or other public water supplies. (Iowa 2016)"

Mr. John Glenn of Rathbun Regional Water Association spoke about the drought of 2012 in an April 2013 article of Wallaces Farmer, stating, "RRWA's water treatment plant averaged 7.5 million gallons per day last summer with the peak day producing 10.2 mgd, quite a feat considering the plant's designed capacity is only 8 mgd. Peak demand is strongly tied to livestock use. "Livestock use accounted for up to one-half of RRWA peak water

demand last summer," says Glenn. "More than 70 new service connections for livestock were installed in 2012, up from the five-year average of 20 per year (Chester 2013)."

At that time a second water treatment facility was under construction and Glenn was quoted again in the December 2013 Wallace Farmer, saying: "We are now able to supply more than14 million gallons of water daily to customers, almost double our capacity before this project," says Glenn. "This additional supply of drinking water is essential for RRWA to be able to support continued economic and community development efforts across our service territory (Chester 2013b)."

From that same article "Marty Braster, RRWA environmental specialist, says based on previous growth trends and water usage per meter, RRWA is now well prepared to meet the projected demand of peak daily use of 14 million gallons a day by 2035.(Chester 2013b)."

In 2015, Rathbun Regional Water Association provided 0.557 MGD of treated water, or approximately 47 percent of the total 1.175 out-of-region water. Given following list of factors it is reasonable to categorize OR-1 as an inadequate source for Missouri communities:

- Peak demands due to drought were 36 percent above normal demand in 2012
- Rathbun is part of community development and economic growth to over 14 counties in Iowa
- Availability of water during extreme drought depends upon choices made by another state
- Restriction of water conveyance over a state boundary is the first legal priority in allocation

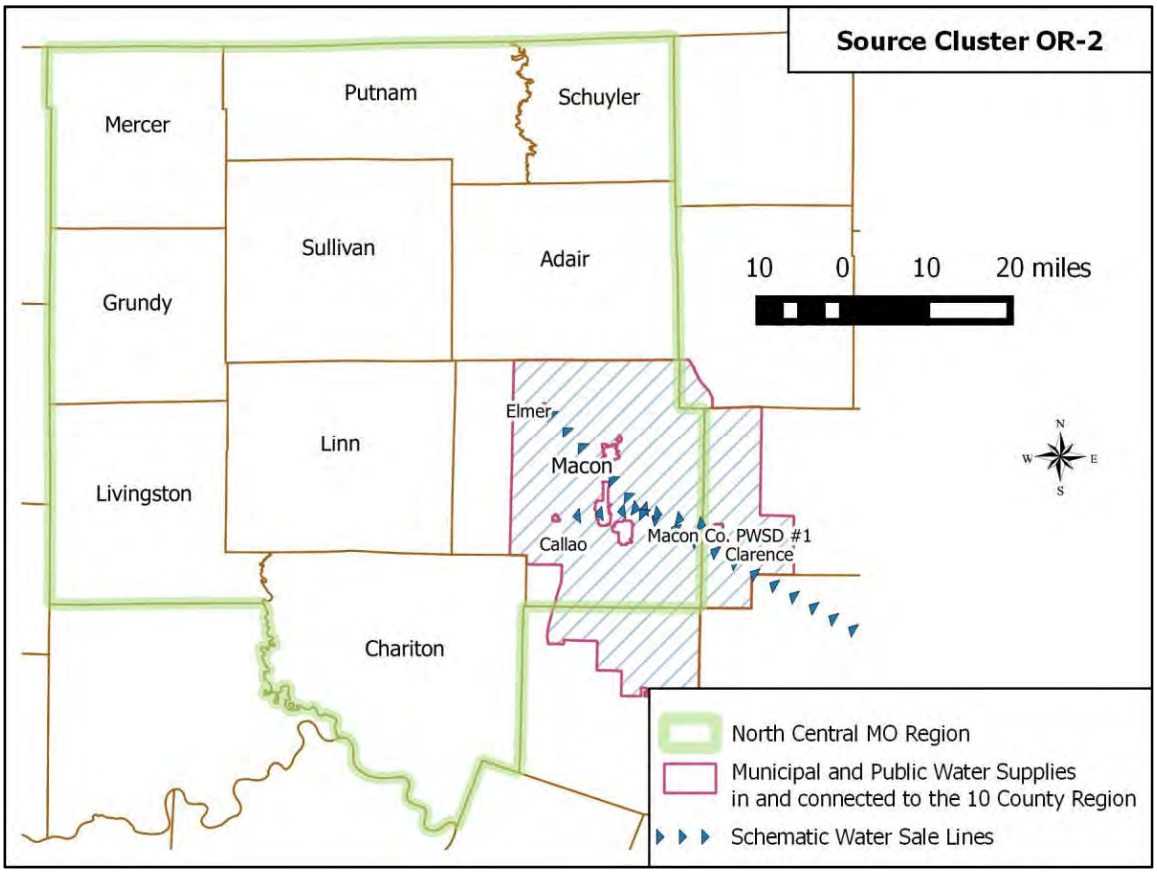
The impact of this inadequate source categorization is that nearly eight second and third tier systems will be without water, at current demand totaling 0.557 MGD. Therefore, Cluster OR-1 is identified as an inadequate source.

The Production and Demand table below details the Missouri communities dependent upon Rathbun for treated water. Note that Adair PWSD #1 is a third tier system to Rathbun and receives 0.25 percent of its total 0.463 MGD (or 0.001 MGD) from Rathbun. The systems listed below Adair PWSD#1 in this table do not receive water from Rathbun and were not included in the Cluster OR-1 map above.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
OR-1	Rathbun					0.557		
		Lancaster					100%	0.065
			Glenwood				100%	0.013
		Mercer County PWSD #1					95%	0.160
		Putnam County PWSD #1					32%	0.207
			Lake Thunderhead HOA				100%	0.021
		Schuyler County CPWSD #1					100%	0.266
			Downing				100%	0.026
			Adair PWSD #1				0.25%	0.463
				Brashear			100%	0.014
				LaPlata			100%	0.079
				Novinger			100%	0.026
				Macon County PWSD #1			1%	0.014
					Callao		100%	0.024
					Clarence		100%	0.065
					Elmer		100%	0.005

Cluster OR-2

Source Adequate



Clarence Cannon Wholesale Water Commission provides treated surface water from Mark Twain Lake in Ralls County Missouri. Mark Twain was constructed by the U.S. Army Corps of Engineers in 1983 on the Salt River to provide flood control, hydroelectricity, public water supply, recreation and navigation. Based on a three-party contract between the U.S. Army Corps of Engineers, the state of Missouri, and the Clarence Cannon Wholesale Water Commission, 20,000 acre-feet of the nearly 400,000 acre-feet within the beneficial use pool, was designated for drinking water supply.

In 2015, the Clarence Cannon Wholesale Water Commission provided 0.278 MGD to the 10-county study region, as detailed in the Production and Demand table below. Cluster OR-2 has an adequate source as determined by this evaluation.

The following excerpt is from the Mark Twain Lake Master Plan 2015 (USACE 2015):

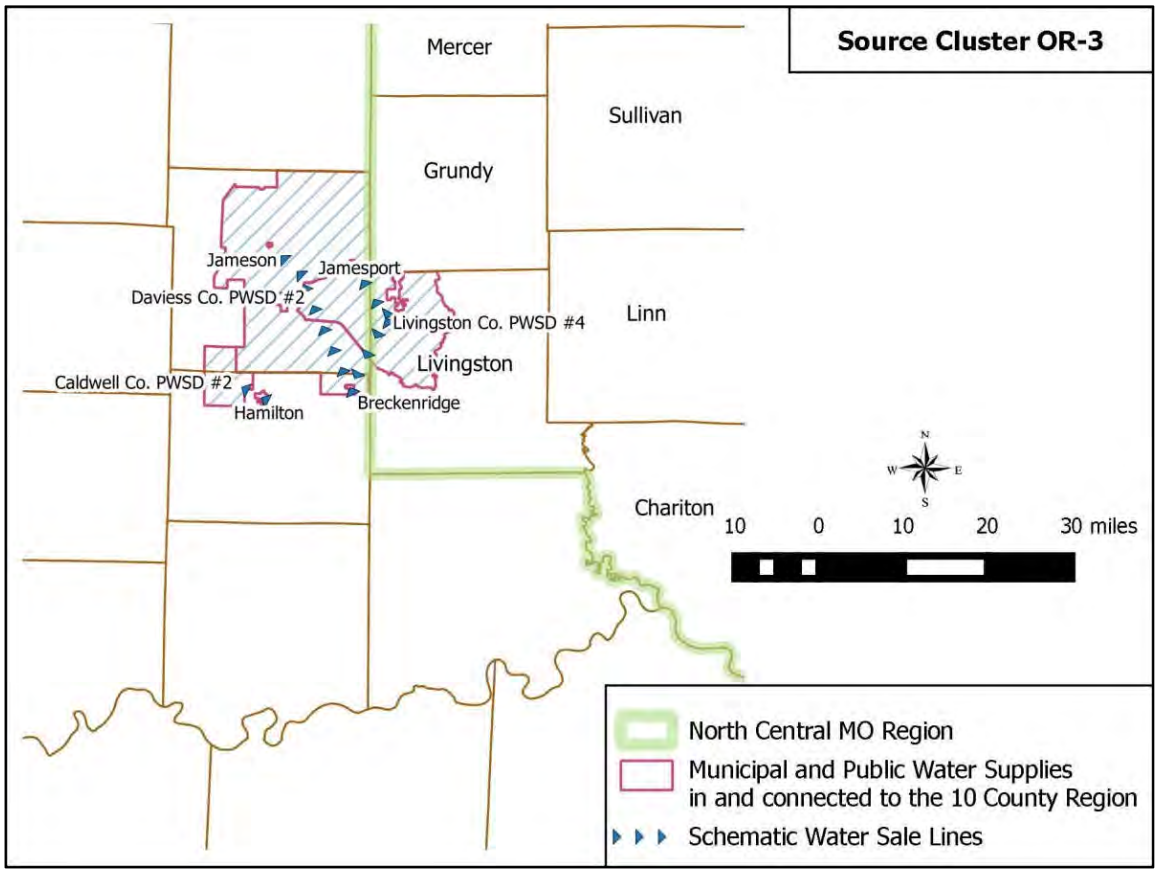
> "Water Treatment Plant, Clarence Cannon Wholesale Water Commission. This regional water treatment plant is located four miles west of Florida, Missouri off of State Highway U. This facility was constructed in 1991and1992. The production and sale of water to members began on June 16, 1992. The Clarence Cannon Wholesale Water Commission (CCWWC) entered into a three party contract with the US Army Corps of Engineers and the State of Missouri to purchase water storage space in Mark Twain Lake. The contract allows for removal of a maximum of 16 million gallons of raw water per day with an allowance for a failure rate of 2 years out of every 100 years for not being able to supply the full 16 million gallons per day. The CCWWC owns the rights to 5.0 million gallons of storage space, while the remaining 11.0 million gallons of water per day are available to them through contract with the State of Missouri. The CCWWC facilities consists of a 4.5 million gallons per day surface water treatment plant, which uses

flocculation, sedimentation, and filtration to purify raw water to acceptable standards for drinking purposes. In addition to the main facilities, the infrastructure consists of 325 miles of transmission mains, four booster pumping stations, a raw water intake structure located on the North Fork Branch of Mark Twain Lake, and daily storage space for 4.5 million gallons of drinking water. The CCWWC currently serves potable water for use by 15 cities, 14 counties, 9 water districts and 72,942 people. Expansion is underway to serve additional customers.″

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
OR-2	Clarence Cannon					0.278		
		Macon County PWSD #1					18%	1.523
			Callao				100%	0.024
			Clarence				100%	0.080
			Elmer				100%	0.005

Cluster OR-3

Sources Adequate



Livingston County PWSD #4 provides groundwater via three wells located in Daviess County, Missouri. Daviess County is not within the 10-county study region; therefore, this cluster is considered out-of-region. The water district serves customers in both Livingston and Daviess counties, and it also wholesales water to customers in Caldwell and Daviess counties. MDNR well data show that two glacial alluvial wells drilled in the 1970s yielded approximately 200 gpm each of water for the system. In 2010, a new well was located in the nearby Grand River alluvium and is recorded to have a yield of 500 gpm. This new source brought new customers in 2014 when Breckenridge, Missouri and Jamesport, Missouri chose to close their surface water treatment plants. The Production and Demand table below details the 0.340 MGD of treated water produced in 2015 and the communities reliant upon it. Only the 0.200 MGD of the produced water is considered consumption by the district customers within the 10 county region. The other supply goes to communities outside the region and is not included in the summary calculations. Cluster OR-3 is identified as an adequate source given its history and reliability.

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
	Livingston Co. PWSD 4					0.340		0.200
		Jamesport					100%	0.040
		Daviess PWSD #2					40%	0.100
			Jameson				100%	0.006
			Breckenridge				100%	0.001
			Hamilton				22%	0.050
				Caldwell Co. PWSD #2			100%	

Summary of Out-of-Region Cluster Evaluations

An important note about OR-1 is that Rathbun Regional Water Association is located in Iowa and water conveyance across state lines is explicitly listed in Iowa Administrative Code (IAC) 567-subrule 52.10(2) which states:

> "2. Notwithstanding a person's possession of a permit or the person's use of water being a nonregulated use, the department may suspend or restrict usage of water by category of use on a local or statewide basis in the following order: a. Water conveyed across state boundaries."

Rathbun Regional Water Association provided 0.557 MGD of treated water, or approximately 47 percent of the total 1.035 MGD out-of-region water in 2015. Given that the availability of water during extreme drought depends upon choices made by another state, it is reasonable to categorize OR-1 as an inadequate source. This is explained in the Cluster OR-1 report. The impact of this categorization is that nearly eight second and third-tier systems will be without water, at current demand totaling 0.557 MGD.

A complete listing of the Out-of-Region System Cluster Production & Demand Table from 2015 is located in Appendix L. Figure 12, below, shows clusters with inadequate sources in red and those with adequate sources in green. Each segment of the pie corresponds to a water producer from outside the 10-county region. The size of each segment is proportionate to the average daily demand supplied by each system to the region, shown as the value at the end of the labels in MGD.

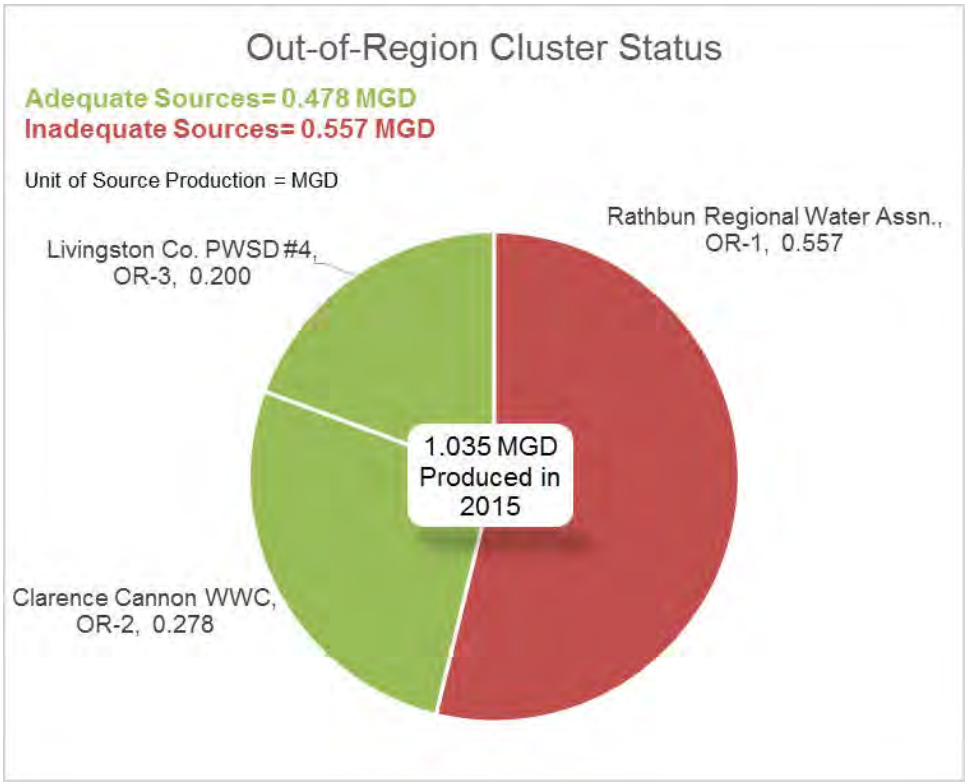


Figure 12: Out-of-Region Cluster Status

Summary of Findings

The evaluation, herein, included surface water and groundwater sources serving communities the in the north-central Missouri 10-county region of study including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties. By evaluating clusters of drinking water providers and their customers, the determination of sufficient, reliable raw water for the 10 county region, as a whole, was possible. The analysis was based upon the following assumptions:

- Current daily raw water demands remain constant
- DOR recharge conditions
- 50 years of sediment loading for surface water systems
- Water sources are sized according to current MDNR design requirements
- Geologic and hydrogeological evidence
- Local history and information specific to water supply

The clusters were divided into three subsets, surface water clusters (SW-1 through SW-6), groundwater clusters (GW-1 through GW-9) and out-of-region clusters (OR-1 through OR-3). These 18 clusters, comprised of 19 water producers provided 13.723 MGD of treated water within the 10-county region in 2015 (this quantity does not include impending demand from Kraft-Heinz). Figure 13, below, summarizes the production from the individual cluster reports by out-of-region and source water type.

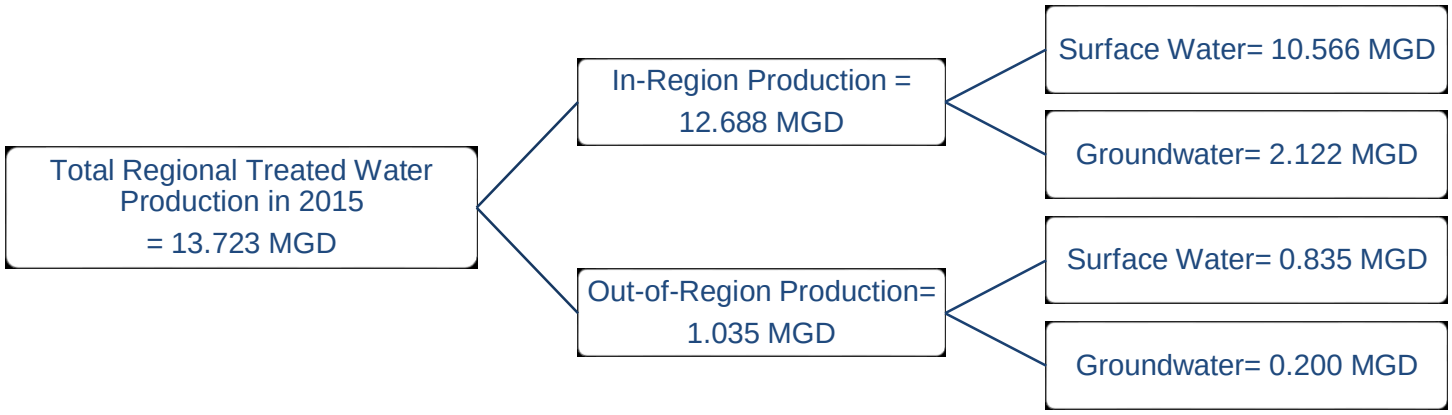
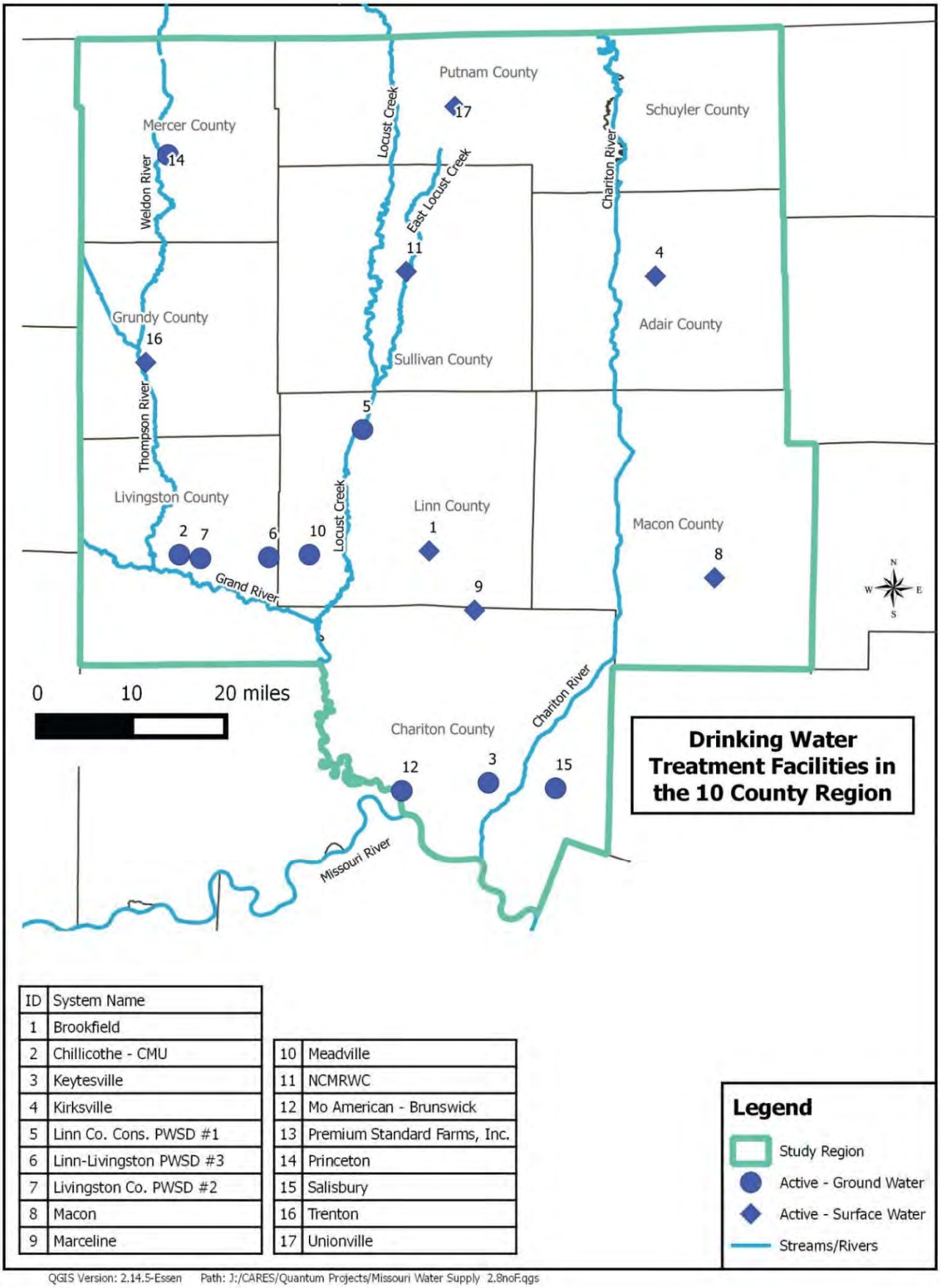


Figure 13: 2015 Water Provided to 10-county region

Figure 14, summarizes the type of source water in respect to the total amount of treated water produced for the 10-county region in 2015.

Figure 14: Total Water Produced in 10-county region in 2015.

Figure 15, below, details the current location and source water type of the active public water systems in the 10-county region of study. Note that out-of-region sources are not depicted on this figure. Additionally, six of the 10-counties have one source of water and Schuyler County did not have any PWSs produce water in 2015.



ID	System Name
1	Brookfield
2	Chillicothe - CMU
3	Keytesville
4	Kirksville
5	Linn Co. Cons. PWSD #1
6	Linn-Livingston PWSD #3
7	Livingston Co. PWSD #2
8	Macon
9	Marceline
10	Meadville
11	NCMRWC
12	Mo American - Brunswick
13	Premium Standard Farms, Inc.
14	Princeton
15	Salisbury
16	Trenton
17	Unionville

Figure 15: Active Public Drinking Water Treatment Facilities in 10 county region.

As noted in Figure 4 and Appendix C, 28 systems have ceased water treatment activities in the 10-county region since 1980. This regionalization or aggregation of systems is because of reduced source water yield, increasing water quality standards, and expense of maintaining a degrading facility. The reduction in number of water suppliers has placed a strain on more reliable sources within the region, pushing some past a reliability threshold during DOR conditions.

The surface water cluster evaluation determined that five of the six clusters had inadequate sources during a DOR. When these inadequate sources dry up during the drought, they are no longer able to provide any water, until a rainfall event occurs which may allow them to supply a small quantity of water. The cumulative total of treated water demand for these four clusters, given 2015 demands, is 8.406 MGD. This number includes the 0.350 MGD impending demand of the Kraft-Heinz expansion.

The groundwater cluster evaluation determined that 6 of the 9 clusters had inadequate sources based on historical data of wells in the region. In the event of a DOR, their capacity to produce water can be expected to decrease, because they are all based on shallow aquifers. The extent of this decrease is unknown, but once such systems run short of water, they will be inclined to purchase water elsewhere and once they start doing that, it is not likely in their interest to continue producing water once they are connected to larger producers. The cumulative total of treated water demand for these six clusters, given 2015 normal demands, is 0.563 MGD.

The out-of-region cluster evaluation determined that one of the three clusters (a surface water source) had an inadequate source given a dependability question in regards to inter-state conveyance. The total of treated water demand for this cluster is 0.557 MGD.

The cumulative total of inadequate sources serving the 10-county region, based on current treated water normal demand, is 9.526 MGD. The cumulative total was calculated by summing the 2015 treated water demand from those systems determined to have a deficit during the evaluation (including 0.35 MGD from the Kraft-Heinz expansion). Converting this total to raw water requires adding 10 percent or 0.953 MGD, which increases the total regional deficit to 10.479 MGD, based on current demands. Figure 16, below, displays the summary of information from the cluster evaluation sections and displays all of the evaluated clusters proportional to one another. This Regional Source Water Cluster Status graph represents all 18 clusters and 19 water producers in the region.

2015 Treated Water Demand Data and used in Figure 16.

2015 Treated Water Demand Data	Demand on Inadequate Sources (MGD)	Demand on Adequate Sources (MGD)	Total Treated Water Demand in 2015 (MGD)
Surface Water	8.623	2.778	11.401
Groundwater	0.563	1.759	2.322
Total	9.186	4.537	13.723

In the 10-county region of study 13 of the 18 clusters, or 14 of the 19 water producers, have inadequate sources of raw water supply. These 13 producers were responsible for 67 percent (9.186 MGD of the 13.723 MGD) of the water supplied to the region in 2015.

In Figure 16, the Surface Water Cluster Status graphic summarizes the five clusters or six producers who have inadequate sources of raw water supply. Overall these producers were responsible for 63 percent (8.623 MGD of the 13.723 MGD) of the total water supplied to the region. In Figure 16, the Groundwater Cluster Status graphic summarizes the six of the 10 clusters which have inadequate sources of raw water supply. Overall these producers were responsible for 13 percent (1.759 MGD of the 13.723 MGD) of the total water supplied to the region.

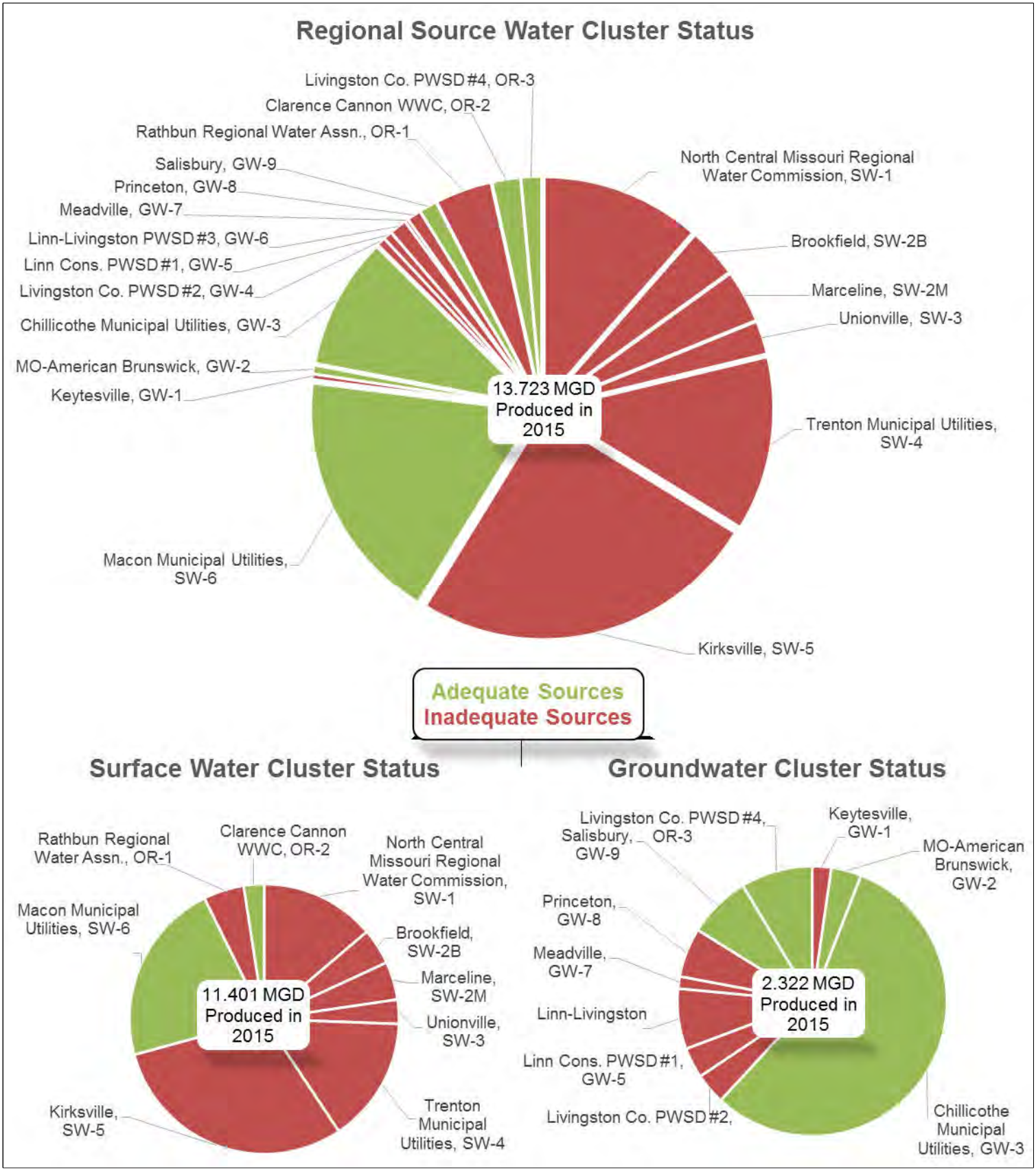
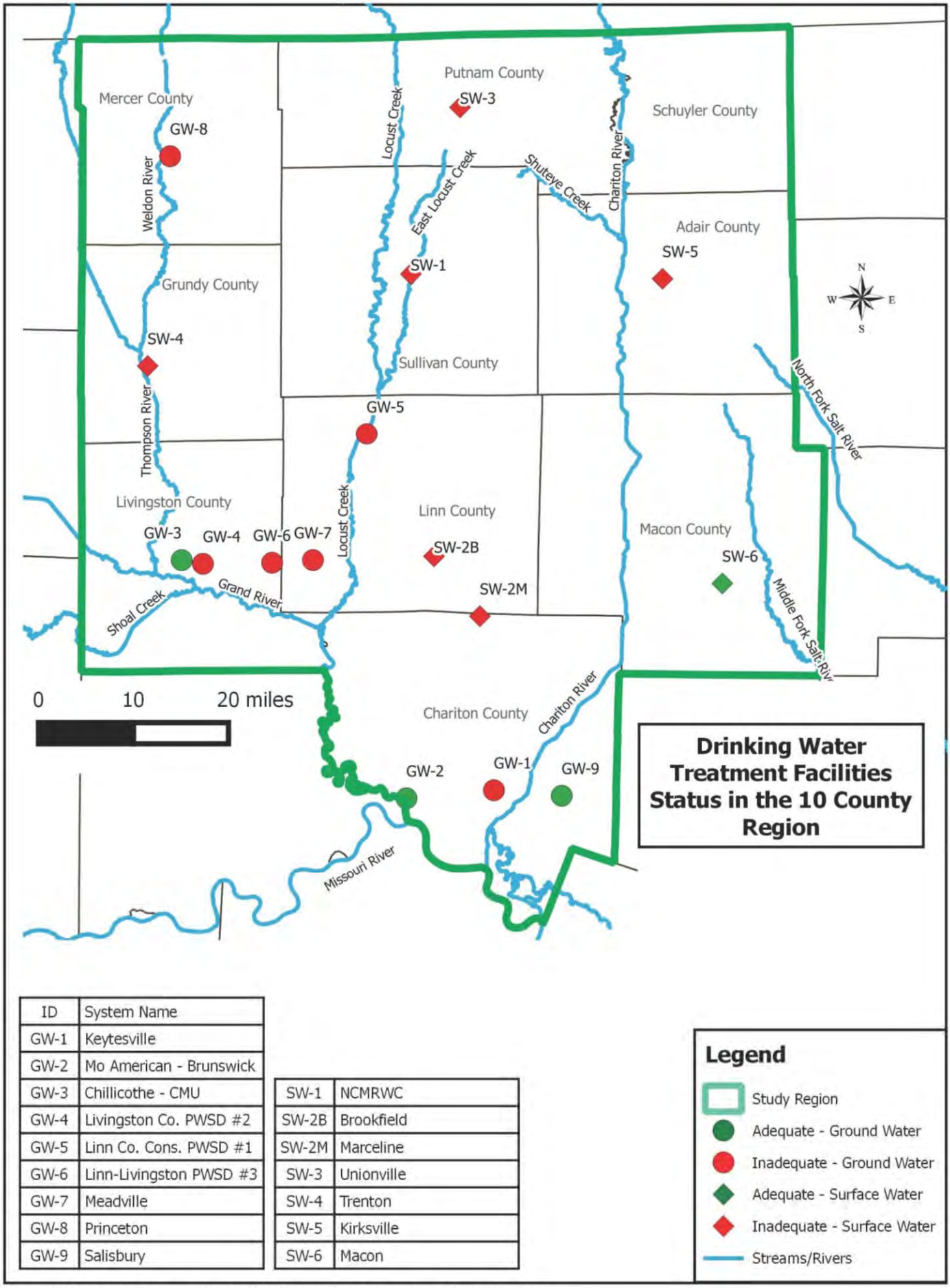


Figure 16: Summary of Cluster Status and Percent Production

Figure 17 displays on a map the evaluated clusters and summarizes the determination of their sources as adequate or inadequate.



ID	System Name
GW-1	Keytesville
GW-2	Mo American - Brunswick
GW-3	Chillicothe - CMU
GW-4	Livingston Co. PWSD #2
GW-5	Linn Co. Cons. PWSD #1
GW-6	Linn-Livingston PWSD #3
GW-7	Meadville
GW-8	Princeton
GW-9	Salisbury

SW-1	NCMRWC
SW-2B	Brookfield
SW-2M	Marceline
SW-3	Unionville
SW-4	Trenton
SW-5	Kirksville
SW-6	Macon

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Figure 17: Status of Public Drinking Water Treatment Systems in 10-county region.

Conclusion

There is a well-documented lack of adequate source water in north-central Missouri. Communities that developed sources, for their own current and future use, are rapidly becoming unintended regional systems as neighboring communities sources continue to deteriorate. The neighboring systems with inadequate sources become dependent upon and place unplanned burden on adequate sources. The result, as shown by the analysis herein, is a 10-county region of north-central Missouri now at risk of running out of water during severe drought conditions. The risk of insufficient water has an impact on community and economic growth.

If a new source(s) is not developed prior to another severe drought event, like that experienced in the 1950s, there will be significant and detrimental impacts made to the communities that call north-central Missouri home. This rural region of Missouri helps provide agri-goods to not only Missouri, but also to surrounding states; therefore, the threat of a no water scenario for 63 percent of users within the region has more broad effect. The impact of wide-spread water shortages on the health and safety of the local population is indisputably negative.

Correcting the 9.186 MGD deficit of inadequate sources by developing new sources will help secure the status quo. New water sources will need to be sized to allow for the support of regional economic growth of existing businesses, as well as for new businesses. Former MDNR Director, Sarah Parker-Pauley, is quoted saying, “Where there is water, there are communities. This is no coincidence” (Pauley 2016).

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Appendices

A. Regional Map

B. Letter from Well Driller

C. Listing of Closed Systems

D. Map of Closed Systems

E. Map of Treatment Facilities

F. Table of Closed Wells

G. Surface Water Supply Table

H. Stream Low Flow Table

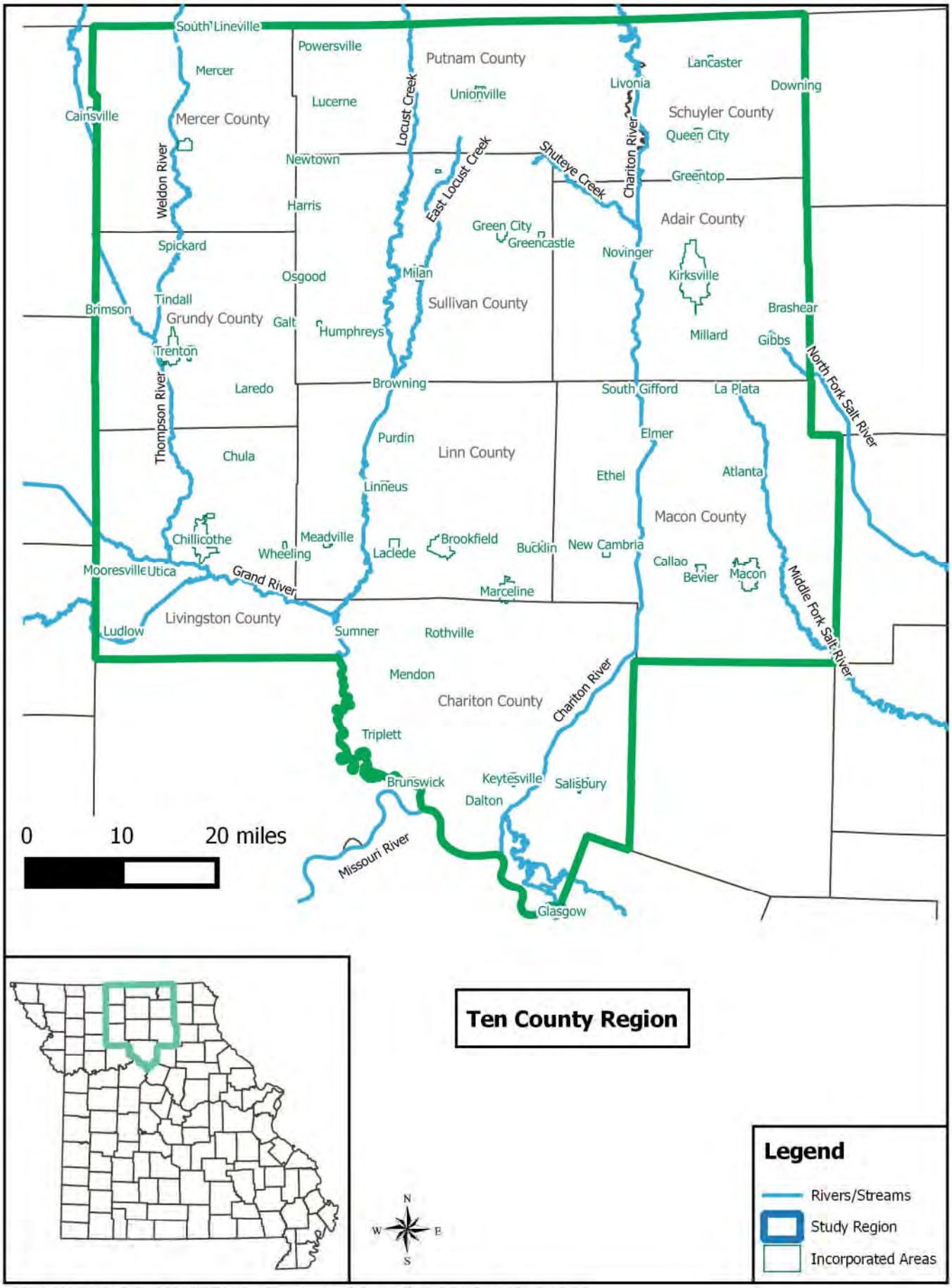
I. Treatment Plant Status

J. Surface Water Cluster Production & Demand Table

K. Groundwater Cluster Production & Demand Table

L. Out-of-Region Cluster Production & Demand Table

A. Regional Map



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B. Letter from Well Driller

Brotcke Well & Pump

November 25, 2003

Mr. Don Miller
Linn County PWSD No.1
PO Box 111
Purdin, Missouri 64674

RE: Hydrologic Study

Dear Mr. Miller:

Brotcke Well & Pump is performing a Hydrologic Engineering Study for Linn County CPWSD No. 1. The purpose of the Engineering Study is to locate a well that will have a safe yield of 50 GPM or more. Eleven test holes were completed in this phase of the investigation. They are located along Locust Creek. Presented on the attached map are the locations of the eleven TH. They were located with a hand held GPS device. Therefore their location is approximate. Also presented is our interpretation of the location of previous test-holes. The location and results were obtained from your files.

During test hole drilling soil samples were obtained during the performance of the Standard Penetration Test. This procedure uses a 2-inch split-spoon sampler. Representative samples from the split spoon were placed in glass jars and returned to our laboratory, where the samples were used to edit the Field Boring Logs. Copies of the Boring Logs are enclosed.

We don't feel a suitable formation for a well to produce at least 50 GPM has been encountered. The best TH was TH-9-03. This site at best would be equivalent to your Well No. 3. We do not feel a sustainable 50 GPM well can be constructed at this location.

A summary of previous exploration and current test holes are presented on the enclosed attachment. Where we had ground elevation, the bottom of the aquifer elevation is presented. We understand your best well is located at TH-3-97. As shown, the bottom of the aquifer is about elevation 10 feet. This compares favorably with the Well No. 1 which is at TH-1-66, the bottom elevation is 12 feet. Because of the accuracy in this type work, this elevation should be considered equal. As indicated, the locations are shown on the enclosed site sketch.

After reviewing the TH completed during this phase of study and previous work, we suggest additional exploration be performed. One area which has never been explored is West of Locust Creek. Test hole 4-89 was very poor, but it may be beneficial to explore both North and South of that location.

Brotcke Well & Pump Inc.
Water Supply Services • Geo/Environmental Drilling
750 Merus Court • P.O. Box 1168 • Fenton, Missouri 63026 • (636) 343-3029 • 800-969-3029

A review of the other bottom elevations show all others are about 10 feet to 20 feet higher than the two best Wells, No. 1 and 4. Both are located near the existing water plant. Test Hole 2-97 shows potential for this deeper aquifer. The approximate location is shown on the site map. The test hole report shows 70 feet to the bottom of the aquifer. Depending on the ground elevation, the bottom could be at an elevation in the 10-foot neighborhood.

We recommend that a series of test holes be performed along a line North-South through 2-97. The bedrock valley is apparently very narrow and the TH should be closely spaced to gain the best chance of intersecting the deepest part of the valley.

Brotcke Well & Pump has enjoyed providing these water supply services for the Linn County CPWSD No. 1. For your records we have enclosed the following:

- Field Boring Logs on the eleven test holes.
- Location sketch.
- Test hole summary.

If you have any questions, please do not hesitate to contact us.

Very truly yours,
BROTCKE WELL & PUMP INC.

Mike Thompson
Project Manager

MT/lmv
Enclosure
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Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-1-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-20-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: ☒ HSA ☒ CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	24	SILTY CLAY				
		S-1:	SPT	5-6.5	12"	2-3-4
		S-2: with some fine sand	SPT	16-11.5	14"	2-5-5
		S-3: fine sand layer	SPT	15-16.5	18"	1-3-3
		S-4: dark brown	SPT	20-21.5	16"	1-2-4
		S-5: gray	SPT	22.5-24	14"	1-2-3
24	32	FINE TO MEDIUM SAND				
		S-6:	SPT	25-26.5	12"	2-6-7
		S-7: with some coarse sand and few gravels	SPT	27.5-29	6"	9-6-14
		S-8: with some coarse sand and gravels	SPT	30-31.5	12"	6-15-16
32	38	CLAY/SHALE; gray				
		S-9:	SPT	32.5-34	5"	4-7-12
		S-10	SPT	35-36.5	5"	12-50-Refusal
		S-11:	SPT	37.5-39	5"	Refusal
	38	BOTTOM OF HOLE				

WATER LEVEL OBSERVATIONS

DURING DRILLING _____ FT.
AT COMPLETION _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.

NOTES

Piezometer Installed ☐ YES ☐ NO
Depth _____ Ft.
39° 58.73N
093° 12.18W

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-02-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-21-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	22	SILTY FINE SAND; brown				
		S-1:	SPT	5-6.5	14"	1-2-2
		S-2:	SPT	10-11.5	16"	1-2-2
		S-3: with some clay	SPT	15-16.5	16"	1-1-2
		S-4: Silty Fine Sand to Med. Sand with clay layer	SPT	18.5-20	10"	2-3-4
22	25	SANDY GRAY CLAY	SPT	23.5-25	10"	1-0-4
		S-5:				
25	35	FINE TO MEDIUM SAND				
		S-6: with coarse sand and trace gravel	SPT	28.5-30	6"	2-5-5
		S-7: with trace gravel and clay	SPT	33.5-35	8"	3-8-10
35	40	SHALE/CLAY				
		S-8:	SPT	38.5-40	12"	11-27-34
	40	BOTTOM OF HOLE				
		Drilled Through Some Wood @ 20' ±				

WATER LEVEL OBSERVATIONS

DURING DRILLING _____ FT.
AT COMPLETION _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.

NOTES

Piezometer Installed ☐ YES ☒ NO
Depth _____ Ft.
39° 58.71N
093° 12.22W

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-03-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-21-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	11	SILTY CLAY; brown				
		S-1:	SPT	5-6.5	14"	2-1-1
		S-2: with fine sand	SPT	10-11.5	14"	2-1-1
11	28.5	FINE SAND				
		S-3:	SPT	15-16.5	14"	2-3-3
		S-4:	SPT	18.5-20	6"	1-2-2
		S-5: with some medium sand and Clay Layer	SPT	23.5-25	8"	1-1-2
		S-6: with some medium sand, Small Clay Layer @ 28.5	SPT	28.5-30	6"	3-6-7
28.5	40	SHALE/CLAY				
		S-7:	SPT	33.5-35	6"	7-11-11
		S-8:	SPT	38.5-40	10"	22-Refusal
	40	BOTTOM OF HOLE				
		@				

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-04-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-22-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: ☒ HSA ☒ CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	20	SILTY FINE SAND				
		S-1:	SPT	5-6.5	14"	3-4-4
		S-2:	SPT	10-11.5	16"	1-3-3
		S-3: with medium sand	SPT	15-16.5	12"	1-2-2
		S-4: with some clay	SPT	18.5-20	8"	1-1-1
20	30	FINE TO MEDIUM SAND				
		S-5:	SPT	23.5-25	10"	1-5-6
		S-6:	SPT	28.5-30	10"	2-4-4
30	35	SHALE/CLAY				
		S-7:	SPT	33.5-35	14"	12-24-Refusal
	35	BOTTOM OF HOLE				

WATER LEVEL OBSERVATIONS			
DURING DRILLING			FT.
AT COMPLETION			FT.
AFTER		HRS	FT.
AFTER		HRS	FT.
AFTER		HRS	FT.

NOTES Piezometer Installed ☐ YES ☐ NO

Depth _____ Ft.

39° 58.62N

093° 12.31W

Medium & Coarse Gravel to 33.5'

Wood @ 25'

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-05-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-22-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows N/6"
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	
0	11	CLAY				
		S-1:	SPT	5-6.5	14"	1-1-2
		S-2: with silty fine sand	SPT	10-11.5	16"	2-1-1
11	34	FINE TO MEDIUM SAND				
		S-3:	SPT	15-16.5	16"	1-1-2
		S-4: with trace silt	SPT	18.5-20	8"	1-1-1
		S-5: with coarse sand	SPT	23.5-25	5"	2-3-4
		S-6: with some coarse Sand, 2" Clay Layer	SPT	28.5-30	12"	4-4-7
34	35	SHALE/CLAY				
		S-7:	SPT	33.5-35	10"	8-22-REFUSAL
	35	BOTTOM OF HOLE				

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-06-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-22-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	11	SILTY CLAY				
		S-1:	SPT	5-6.5	12"	3-3-3
		S-2:	SPT	10-11.5	12"	2-2-3
11	21	FINE SILTY SAND				
		S-3: with trace clay	SPT	15-16.5	14"	2-1-1
		S-4:	SPT	18.5-20	6"	1-1-1
21	33	FINE TO MEDIUM SAND				
		S-5: with some clay and trace gravel	SPT	23.5-25	10"	2-1-2
		S-6: with coarse sand	SPT	28.5-30	8"	3-5-9
33	35	SHALE/CLAY				
		S-7:	SPT	33.5-35	2"	23 -
	35	BOTTOM OF HOLE				

WATER LEVEL OBSERVATIONS

DURING DRILLING _____ FT.
AT COMPLETION _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.

NOTES

Piezometer Installed ☐ YES ☒ NO
Depth _____ Ft.
39° 58.55N
093° 12.40W

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-07-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-23-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows N/6"
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	
0	11	SILTY CLAY				
		S-1:	SPT	5-6.5	10"	3-3-3
		S-2:	SPT	10-11.5	18"	2-2-2
11	21	CLAYEY FINE SAND				
		S-3:	SPT	15-16.5	16"	1-1-1
		S-4:	SPT	18.5-20	8"	3-2-2
21	33	FINE TO COARSE SAND WITH TRACE GRAVEL				
		S-5: with some clay	SPT	23.5-25	10"	3-6-7
		S-6:	SPT	28.5-30	14"	5-12-14
33	33.5	SHALE/CLAY				
		S-7:	SPT	33.5-35	6"	Refusal
	33.5	BOTTOM OF HOLE				

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-08-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-27-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: ☒ HSA ☒ CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows N/6"
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	
0	11	SANDY CLAY				
		S-1:	SPT	5-6.5	14"	3-6-5
		S-2:	SPT	10-11.5	14"	3-3-1
11	37	FINE TO MEDIUM SAND				
		S-3: with some silt	SPT	15-16.5	14"	1-1-2
		S-4: with trace silt and gravel	SPT	18.5-20	12"	3-4-11
		S-5:	SPT	23.5-25	10"	2-3-5
		S-6: with coarse sand and gravel	SPT	28.5-30	4"	12-8-7
		S-7: with coarse sand and gravel	SPT	33.5-35	5"	9-3-3
37	50	SHALE/CLAY				
		S-8:	SPT	38.5-40	10"	3-7-8
		S-9:	SPT	43.5-45	8"	3-5-7
		S-10: with some sand	SPT	48.5-50	4"	3-5-7

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-09-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-28-03

Location Purdin, MO **Crew** M. Cox, M. Schaake

Drilling Method: ☒ HSA ☒ CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	17	CLAY				
		S-1:	SPT	5-6.5	12"	3-4-4
		S-2:	SPT	10-11.5	16"	2-2-2
		S-3: with fine sand	SPT	15-16.5	16"	1-2-2
17	10	FINE TO MEDIUM SAND				
		S-4: with some clay	SPT	18.5-20	14"	2-2-2
		S-5: with some clay	SPT	23.5-25	14"	1-2-3
		S-6:	SPT	28.5-30	14"	3-7-9
31	36	FINE TO COARSE SAND WITH GRAVEL				
		S-7:	SPT	33.5-35	16"	7-9-12
36	43	SHALE/CLAY				
		S-8:	SPT	38.5-40		Refusal
	43	BOTTOM OF HOLE				

Brotcke Well & Pump

FIELD BORING LOG

Boring No. TH-10-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-29-03

Location Purdin, MO **Crew** M. Cox & M. Schaake

Drilling Method: X HSA X CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	N/6"
0	21	CLAY				
		S-1:	SPT	5-6.5	12"	4-4-4
		S-2: with fine sand	SPT	10-11.5	16"	3-3-4
		S-3: with fine sand	SPT	15-16.5	16"	3-4-3
		S-4: with Fine Sand and Wood	SPT	18.5-20	16"	4-3-2
21	36	FINE SAND				
		S-5: with traces of Wood	SPT	23.5-25	12"	3-3-3
		S-6: with some med sand and trace clay	SPT	28.5-30	8"	5-8-9
		S-7: with some med. to coarse sand & Gravel	SPT	33.5-35	6"	8-13-17
36	40	SHALE/CLAY				
		S-8:	SPT	38.5-40	14"	13-17-30

WATER LEVEL OBSERVATIONS

DURING DRILLING _____ FT.
AT COMPLETION _____ FT.
AFTER _____ HRS FT.
AFTER _____ HRS _____ FT.
AFTER _____ HRS _____ FT.

NOTES

Piezometer Installed ☐ YES ☒ NO
Depth _____ Ft.
39° 58.37N
093° 12.57W

Brotcke Well & Pump

FIELD BORING LOG

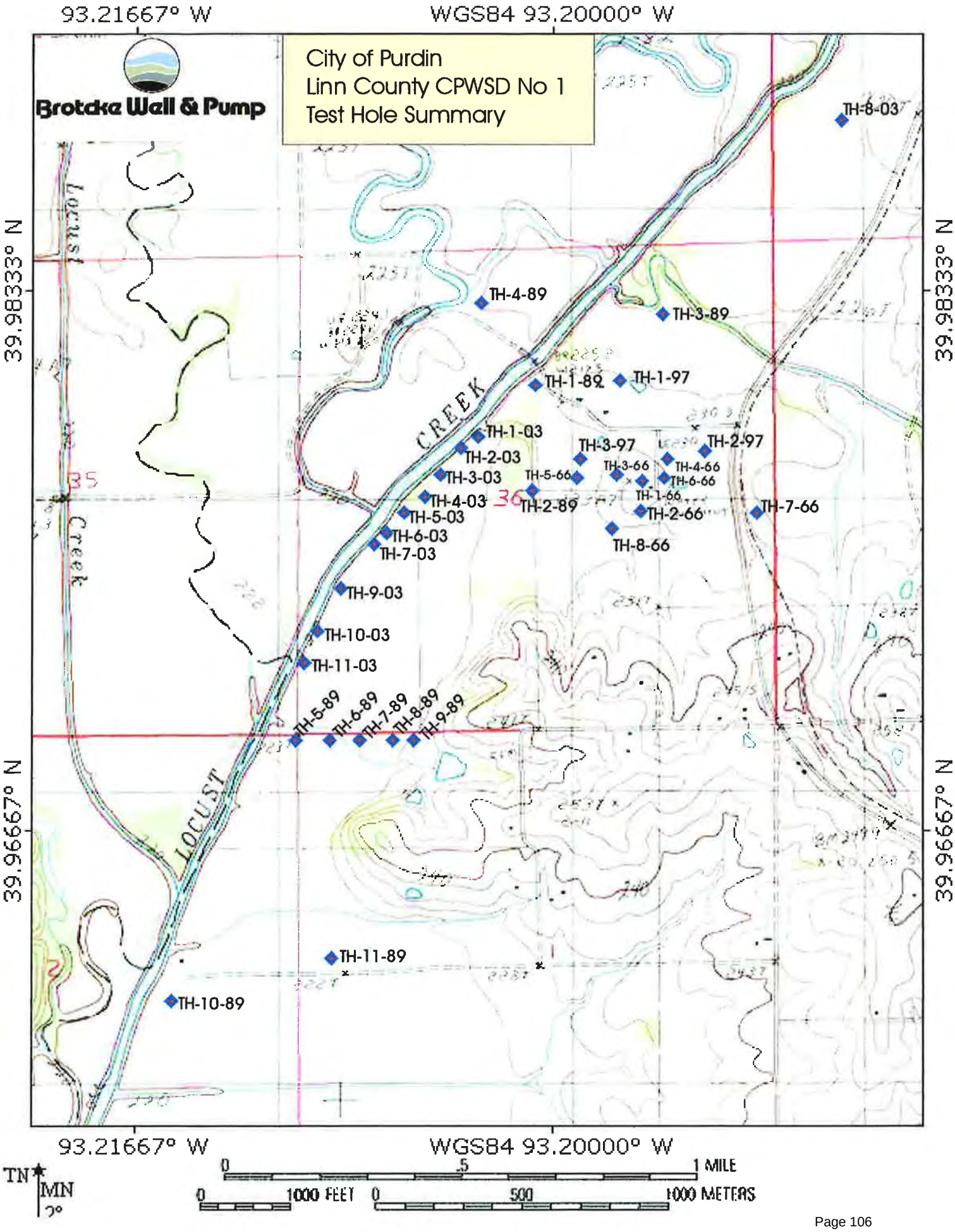
Boring No. TH-11-03

Project LINN CO. PWSD #1 **Job No.** 03286 **Date** 10-29-03

Location Purdin, MO **Crew** M. Cox & M. Schaake

Drilling Method: ☒ HSA ☒ CFA ☐ Rotary ☐ Rock Coring ☐ Drilling Fluid Bent. Mud

DEPTH, FT.			SAMPLE			SPT Blows N/6"
FROM	TO	DESCRIPTION	TYPE	DEPTH, FT.	RECOVERY	
0		CLAY				
		S-1:	SPT	5-6.5	12"	2-2-3
		S-2:	SPT	10-11.5	14"	1-1-2
		S-3:	SPT	15-16.5	20"	0-1-1
		S-4: with some fine sand	SPT	18.5-20	16"	1-3-3
21	33	FINE TO MEDIUM SAND				
		S-5: with trace clay	SPT	23.5-25	10"	1-1-3
		S-6: with trace clay and gravel	SPT	28.5-30	8"	1-2-4
33	35	SHALE/CLAY				
		S-7:	SPT	33.5-35	10"	7-9-13
	35	BOTTOM OF HOLE				


93.21667° W
WGS84 93.20000° W
Brotcke Well & Pump
City of Purdin
Linn County CPWSD No 1
Test Hole Summary
39.98333° N
39.96667° N
TH-8-03
TH-4-89
TH-3-89
TH-1-89
TH-1-97
TH-1-03
TH-2-03
TH-3-03
TH-4-03
TH-5-03
TH-6-03
TH-7-03
TH-9-03
TH-10-03
TH-11-03
TH-3-97
TH-2-97
TH-3-66
TH-4-66
TH-6-66
TH-5-66
TH-1-66
TH-2-89
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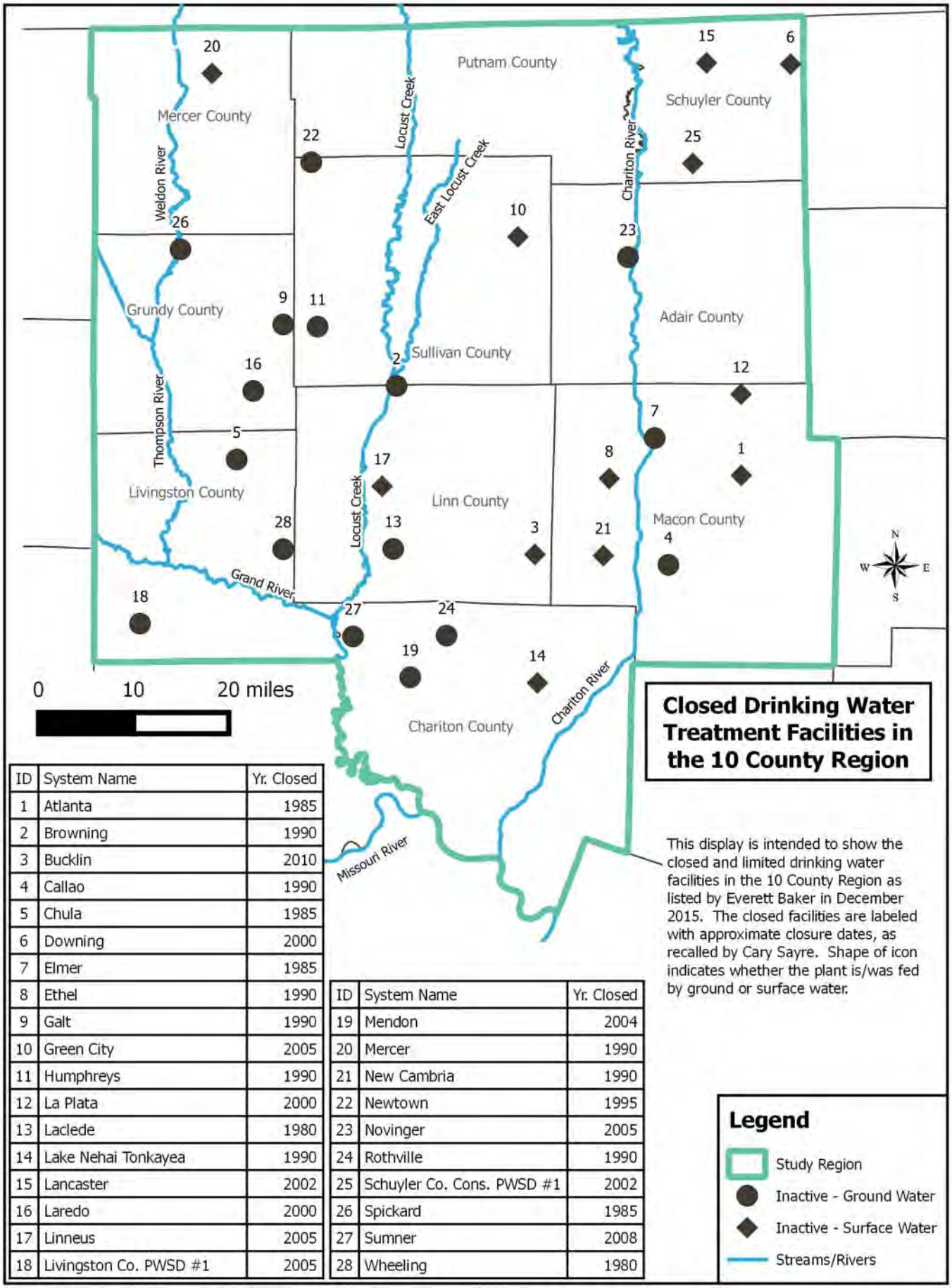
TH-7-66
TH-8-66
TH-5-89
TH-6-89
TH-7-89
TH-8-89
TH-9-89
TH-11-89
TH-10-89
CREEK
LOCUST
Locust
Creek
35
36
TN
MN
0°
0
.5
1 MILE
0
1000 FEET
0
500
1000 METERS

C. Listing of Closed Systems

Inactive Sources Within Clusters						
Current Cluster	2015 Treated Water Demand	Type	System Name	County	Source	Year of Closure
GW-3	0.077	Ground Water	Livingston PWSD #1	Livingston	Failed wells (declining yield, likely due to iron/silt, drilled approx. 28 test wells with low yield); closed plant; now purchase water from Chillicothe	2005
GW-4	0.197	Ground Water	Chula	Livingston	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Livingston #2	1985
GW-6	0.013	Ground Water	Laredo	Grundy	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Linn-Livingston #3	2000
GW-6	0.028	Surface Water	Linneus	Linn	Inadequate lake (heavily silted, high organic matter, supplemented with Locust Creek when dry); closed plant; now purchase water from Linn-Livingston #3	2005
GW-6	0.02	Ground Water	Wheeling	Livingston	Well (declining yield, likely due to iron/silt); closed plant; now purchase water from Linn-Livingston #3	1980
GW-8	0.024	Surface Water	Mercer	Mercer	Inadequate lake (shallow and heavily silted); closed plant; now purchase water from Princeton	1990
OR-1	0.026	Surface Water	Downing	Schuyler	Inadequate lake (shallow and heavily silted); closed plant; now purchase water from Schuyler CPWSD #1	2000
OR-1	0.065	Surface Water	Lancaster	Schuyler	Inadequate lake (shallow and heavily silted); closed plant; now purchase water from Rathbun	2002
OR-1	0.24	Surface Water	Schuyler CPWSD #1	Schuyler	Inadequate lake and treatment facility; closed plant; now purchase water from Rathbun and Putnam PWSD #1	2002
OR-3	0.04	Surface Water	Jamesport	Daviess	Inadequate lake (shallow and heavily silted); closed plant; now purchase water from Livingston #4	2010
OR-3	0.001	Surface Water	Breckenridge	Caldwell	Inadequate lake; supplemented from Grand River well; closed inadequate treament plant; now served water from Livingston #4	2014
SW-1	0.017	Ground Water	Browning	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1990
SW-1	0.122	Surface Water	Green City	Sullivan	Inadequate lakes to demand; single stage treatment facility became inadequate; closed plant; now purchase water from NCMRWC	2005
SW-1	0.007	Ground Water	Humphreys	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1990
SW-1	0.016	Ground Water	Newtown	Sullivan	Failed wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Sullivan PWSD #1	1995
SW-2	0.017	Surface Water	Bucklin	Linn	Inadequate lake (shallow and heavily silted); struggled with disinfection-by-products; closed plant; now purchase water from	2010
SW-2	N/A	Surface Water	Ethel	Macon	Inadequate lake (shallow and heavily silted); closed inadequate treatment plant; adsorbed by Chariton-Linn #3	1990
SW-2	0.031	Ground Water	Laclede	Linn	Failed shallow wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Brookfield	1980
SW-2	N/A	Surface Water	Lake Nehai Tonkayea	Chariton	Inadequate treatment plant; difficulty maintaining qualified operator; closed plant; adsorbed by Chariton-Linn #3	1990
SW-2	N/A	Ground Water	Mendon	Chariton	Failed shallow wells (declining yield, high in iron); closed plant; now purchase water from Chariton-Linn #3	2004
SW-2	N/A	Surface Water	New Cambria	Macon	Inadequate lake (shallow and heavily silted); closed inadequate treatment plant; adsorbed by Chariton-Linn #3	1990
SW-2	N/A	Ground Water	Rothville	Chariton	Failed shallow wells (declining yield, high in iron); closed plant; adsorbed by Chariton-Linn #3	1990
SW-2	N/A	Ground Water	Sumner	Chariton	Failed shallow wells with declining yield; closed plant; adsorbed by Chariton-Linn #3	2008
SW-4	0.021	Ground Water	Galt	Grundy	Failed shallow wells (declining yield, high in iron); closed plant; now purchase water from Grundy PWSD #1	1990
SW-4	0.028	Ground Water	Spickard	Grundy	Failed shallow wells (declining yield); closed plant; now purchase water from Linn-Livingston #3	1985
SW-5	0.079	Surface Water	La Plata	Macon	Inadequate lakes; closed inadequate treament plant; now purchase water from Adair PWSD #1	2000
SW-5	0.026	Ground Water	Novinger	Adair	Failed shallow wells (declining yield); closed plant; now purchase water from Adair PWSD #1	2005
SW-6	0.02	Surface Water	Atlanta	Macon	Inadequate lake; struggled with disinfection-by-products; closed plant; now purchase water from Macon	1985
SW-6	0.024	Ground Water	Callao	Macon	Failed shallow wells (declining yield); closed plant; now purchase water from Macon PWSD #1	1990
SW-6	0.005	Ground Water	Elmer	Macon	Failed shallow wells (declining yield, likely due to iron/silt); closed plant; now purchase water from Macon PWSD #1	1985

D. Map of Closed Systems



ID	System Name	Yr. Closed
1	Atlanta	1985
2	Browning	1990
3	Bucklin	2010
4	Callao	1990
5	Chula	1985
6	Downing	2000
7	Elmer	1985
8	Ethel	1990
9	Galt	1990
10	Green City	2005
11	Humphreys	1990
12	La Plata	2000
13	Laclede	1980
14	Lake Nehai Tonkayea	1990
15	Lancaster	2002
16	Laredo	2000
17	Linneus	2005
18	Livingston Co. PWSD #1	2005

ID	System Name	Yr. Closed
19	Mendon	2004
20	Mercer	1990
21	New Cambria	1990
22	Newtown	1995
23	Novinger	2005
24	Rothville	1990
25	Schuyler Co. Cons. PWSD #1	2002
26	Spickard	1985
27	Sumner	2008
28	Wheeling	1980

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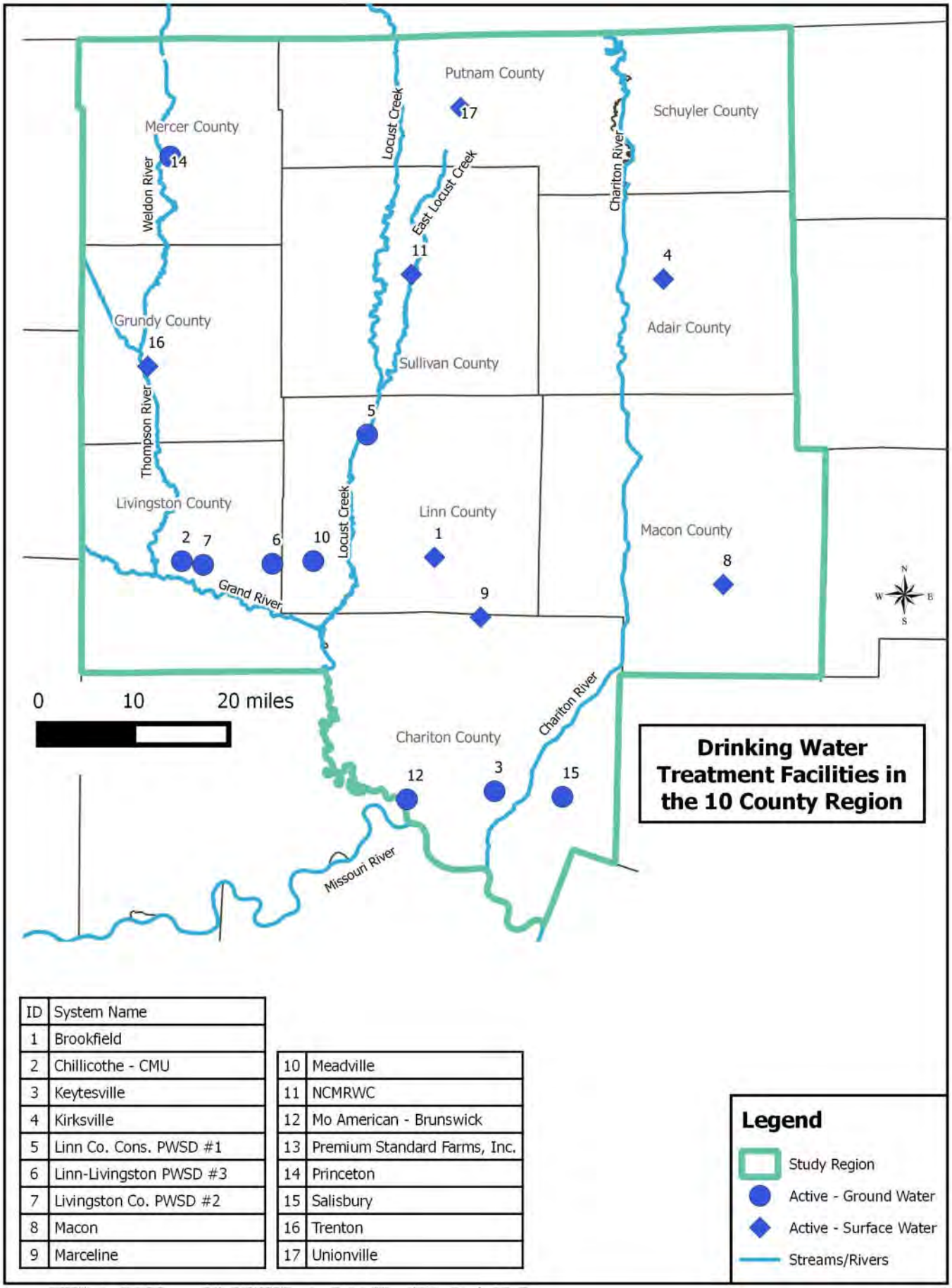
E. Map of Treatment Facilities



ID	System Name
1	Brookfield
2	Chillicothe - CMU
3	Keytesville
4	Kirksville
5	Linn Co. Cons. PWSD #1
6	Linn-Livingston PWSD #3
7	Livingston Co. PWSD #2
8	Macon
9	Marceline

10	Meadville
11	NCMRWC
12	Mo American - Brunswick
13	Premium Standard Farms, Inc.
14	Princeton
15	Salisbury
16	Trenton
17	Unionville

QGIS Version: 2.14.5-Essen Path: J:/CARES/Quantum Projects/Missouri Water Supply 2.8noF.qgs

F. Table of Closed Wells

Closed Wells in the 10 County Study Region
From MDNR Water Well Log Data Set

PWSSNAME	LOCALNAME	FED_TYPE	STATUS	DRILLDATE	ABAN	PLUG	MATERIAL	Form_TD	TOTDEPTH	STATICLEVE	YIELD	HEAD	DRAWDOWN
Novinger	Well #2, Old Well	C	Plugged	1977	0	1999	Unconsolidated	Alluvium	43	20	83	0	10
Chillicothe Municipal Utilities	Well #6 TEST HOLE	C	Abandoned	0	0	0	Unconsolidated	Glacial Deposits	135	0	0	158	0
Chillicothe Municipal Utilities	Well #7 TEST HOLE	C	Abandoned	0	0	0	Unconsolidated	Glacial Deposits	135	0	0	158	0
Keytesville	Well #2, T53N R18W Chariton (Sec 5)	C	Plugged	1959	0	2006	Unconsolidated	Alluvium	50	20	10	53	1
Keytesville	Well #3	C	Plugged	1986	0	2006	Unconsolidated	Alluvium	64	16	7	63	1
Keytesville	Well #1, T53N R18W Chariton (Sec 5)	C	Plugged	1936	0	2006	Unconsolidated	Alluvium	47	26	11	53	1
Lake Nehai Tonkayea	Chariton	NP	Inactive	1970	0	0	Unconsolidated	Alluvium	51	6	80	0	14
Linn-Livingston Co. PWSD #3	Well #2, New Well	C	Inactive	1982	0	0	Unconsolidated	Glacial Deposits	138	60	235	0	16
Livingston Co. PWSD #1	Well #1	C	Inactive	1967	0	0	Unconsolidated	NULL	0	24	104	0	22
Livingston Co. PWSD #1	Well #2 (WRC monitoring well)	C	Observation Well	1967	0	0	Unconsolidated	Glacial Deposits	79	7	100	0	60
Livingston Co. PWSD #1	Well #3	C	Inactive	1989	0	0	Unconsolidated	Glacial Deposits	83	27	114	0	0
Livingston Co. PWSD #2	Well #1	C	Inactive	1964	0	0	Unconsolidated	Glacial Deposits	181	91	94	0	68
Livingston Co. PWSD #2	Well #2	C	Inactive	1988	0	0	Unconsolidated	Glacial Deposits	139	53	240	0	110
Livingston County R-I School	Well #1, School Wellhouse	NTNC	Inactive	0	0	0	Unconsolidated	Glacial Deposits	65	0	0	0	0
Mendon	Well #1	C	Observation Well	1955	0	0	Unconsolidated	Alluvium	52	0	0	0	0
Mendon	Well #2	C	Inactive	1955	0	0	Unconsolidated	Alluvium	54	0	0	0	0
Novinger	Well #1	C	Plugged	1958	1976	1986	Unconsolidated	Alluvium	44	8	210	125	20
Novinger	Well #3, New Well	C	Plugged	1982	0	1999	Unconsolidated	Alluvium	43	29	83	0	8
Princeton	Well #3	C	Inactive	1971	0	0	Unconsolidated	Alluvium	38	15	133	132	14
Princeton	Well #1	C	Plugged	1973	0	2009	Unconsolidated	Alluvium	38	15	90	0	8
Princeton	Well #1, Old	C	Plugged	0	1995	1995	Unconsolidated	NULL	0	10	0	0	0
Princeton	Well #12	C	Plugged	0	1995	1995	Unconsolidated	NULL	0	10	0	0	0
Princeton	Well #13	C	Plugged	0	1995	1995	Unconsolidated	NULL	0	10	0	0	0
Princeton	Well #5	C	Plugged	0	0	2002	Unconsolidated	NULL	0	0	0	0	0
Princeton	Well #7	C	Plugged	1978	0	2002	Unconsolidated	Alluvium	42	13	100	100	13
Princeton	Well #2B	C	Plugged	1968	0	2002	Unconsolidated	Alluvium	41	14	100	100	30
Sumner	Well #1	C	Inactive	0	0	0	Unconsolidated	Glacial Deposits	75	0	0	0	0
Sumner	Well #2	C	Inactive	0	0	0	Unconsolidated	Glacial Deposits	35	0	0	0	0

This data is from http://drinkingwater.missouri.edu/gisdata/metadata/spwswell.html collected on 8/30/2016 by A. Jones

G. Surface Water Supply Table

Surface Water Supply(s) Within Cluster											
		Cluster Current Demand		Raw Water Yield: Without Pumping, With Sediment Loading							
Cluster	Lake/ Reservoir	Normal Treated (MGD)	Normal Raw (MGD)	Source Yield Capacity (MGD)	Cluster Yield Capacity (MGD)	Excess Capacity (Cluster Yield-Cluster Normal Raw Demand) MGD	Lake Purpose (S=water supply, R=recreation, C=flood control) in order of importance	Year Dam Built	Surface Area (acre)	Total Volume (ac.-ft.)	Water Supply Volume (ac.-ft.)
SW-1	Elmwood Reservoir	1.622	1.629	0.800	0.940	-0.689	S, R	1972	194.8	2503.2	2416.5
SW-1	Milan Lake (Golf Course)			0.140			S, R	1940	41.0	555.21	500.27
SW-2	Brookfield Lake	1.014	1.115	0.180	0.600	-0.515	S, R	1959	107.9	2070.3	1948.2
SW-2	Brookfield Reservoir			n/a			S				
SW-2	Old Marceline Lake			n/a			S				
SW-2	Marceline Lake (New)			0.420			S, R	1980	172.8	1990	1812
SW-3	Unionville Reservoir	0.33	0.363	0.200	0.200	-0.163	S, R	1941	73.5	620	430
SW-4	Trenton Lower Reservoir	1.78	1.958	0.000	0.000	-1.958	S				
SW-4	Trenton Upper Reservoir			0.000			S				
SW-5	Forest Lake*	2.51	2.76	2.691	4.040	-0.120	R, S	1951	585.2	12500	10,380
SW-5	Hazel Creek Lake*	1.27	1.40	1.349			R, S	1982	501.7	8680	7,230
SW-6	Long Branch Lake	2.5	2.75	3.400	3.400	0.650	C, S, R				

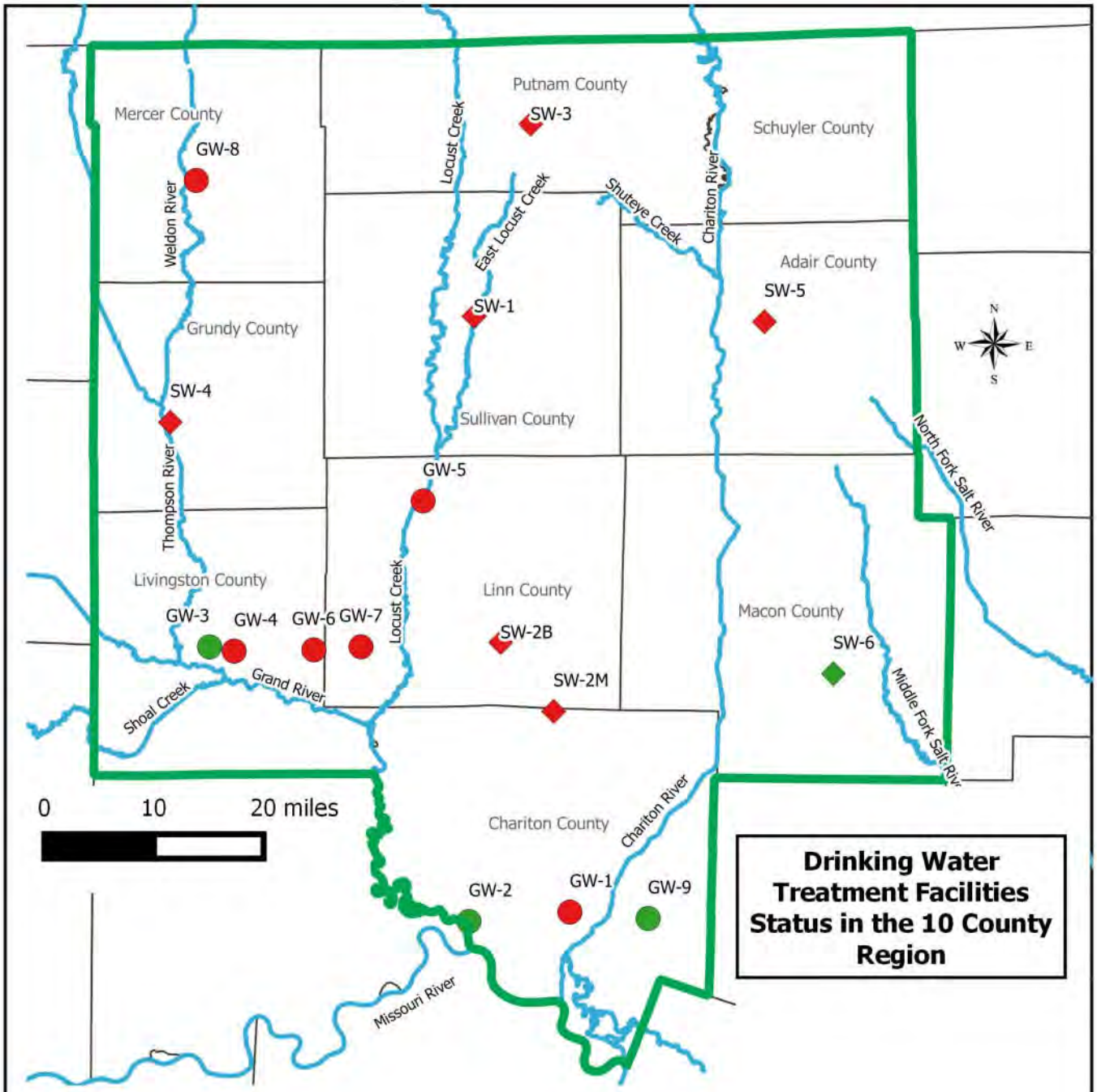
* Normal Treated Demands were proportionaly increased to account for the 0.35 MGD Kraft-Heinz expansion.

H. Stream Low Flow Table

Results from USGS Low Flow Equations* for Stream Intakes in 10 County Region									
				Inputs			Outputs		
Cluster	Supplier	PWSSID	Intake	Drainage Area (Mi^2)	Length (mi)	Stream Variable	7Q10 (MGD)	30Q10 (MGD)	60Q10 (MGD)
SW-1	NCMRWC	2021537	Locust Creek at Intake	217.63	44.08	0.745	0.264	0.568	0.921
SW-2	Marceline	2010497	Mussel Fork at Intake	146.7	55.6	0.695	0.100	0.229	0.284
SW-2	Brookfield	2010105	West Yellow Creek at intake	195.27	54.7	0.659	0.258	0.546	0.723
SW-4	Trenton	2010796	Thompson River at Intake	1722.3	155.46	0.714	6.268	8.673	12.949

* Computed Statistics at Streamgages, and Methods for Estimated Low-Flow Frequency Statistics and Development of Regional Regression Equations for Estimating Low Flow Frequency Statistics at Ungaged Locations in Missouri, USGS 2013

I. Treatment Plant Status



ID	System Name
GW-1	Keytesville
GW-2	Mo American - Brunswick
GW-3	Chillicothe - CMU
GW-4	Livingston Co. PWSD #2
GW-5	Linn Co. Cons. PWSD #1
GW-6	Linn-Livingston PWSD #3
GW-7	Meadville
GW-8	Princeton
GW-9	Salisbury

SW-1	NCMRWC
SW-2B	Brookfield
SW-2M	Marceline
SW-3	Unionville
SW-4	Trenton
SW-5	Kirksville
SW-6	Macon

Legend

- Study Region
- Adequate - Ground Water
- Inadequate - Ground Water
- Adequate - Surface Water
- Inadequate - Surface Water
- Streams/Rivers

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J. Surface Water Cluster Production & Demand Table

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
SW-1	North Central Missouri Regional Water Commission					1.572		n/a
		Green City					100%	0.122
			Green Castle				100%	0.034
		Milan					100%	0.180
		Sullivan County PWSD #1					100%	0.274
			Browning				100%	0.017
			Humphreys				100%	0.007
			Newtown				100%	0.016
		Premium Standard Farms (RAW Supply)						0.923
SW-2	Brookfield					0.494		0.376
		Laclede					100%	0.031
		Chariton-Linn PWSD #3					25%	0.351
			Bucklin				100%	0.017
			Mendon				100%	0.018
			Chariton PSWD #2				35%	0.049
	Marceline					0.52		0.257
		Chariton-Linn PWSD #3					75%	0.351
			Bucklin				100%	0.017
			Mendon				100%	0.018
			Chariton PSWD #2				35%	0.049
SW-3	Unionville					0.33		0.150
		Putnam County PWSD #1					68%	0.207
			Lake Thunderhead HOA				100%	0.021
			Adair PWSD #1				0.75%	0.463
				Brashear			100%	0.014
				LaPlata			100%	0.079
				Novinger			100%	0.026
				Macon County PWSD #1			1%	0.014
					Callao		100%	0.024
					Clarence		100%	0.065
					Elmer		100%	0.005
SW-4	Trenton Municipal Utilies					1.718		1.477
		Grundy County PWSD #1					100%	0.241
			Galt				100%	0.021
			Spickard				100%	0.028
SW-5	Kirksville					3.432		2.969
		Adair PWSD #1					99%	0.463
			Brashear				100%	0.014
			LaPlata				100%	0.079
			Novinger				100%	0.026
			Macon County PWSD #1				1%	0.014
				Callao			100%	0.024
				Clarence			100%	0.065
				Elmer			100%	0.005
SW-6	Macon					2.5		
		Atlanta					100%	0.020
		Bevier					100%	0.056
		Macon County PWSD #1					81%	1.232
			Callao				100%	0.024
			Clarence				100%	0.065
			Elmer				100%	0.005

K. Groundwater Cluster Production & Demand Table

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
GW-1	Keytesville					0.0530		0.031
		Chariton PWSD #2					45%	0.049
GW-2	Mo American Brunswick					0.0841		0.057
		Chariton PWSD #2					55%	0.049
GW-3	Chillicothe Municipal Utilities					1.3		0.893
		Livingston Co. PWSD #1					100%	0.077
		Livingston Co. PWSD #2					49%	0.151
		Chula					100%	0.016
		Livingston Co. PWSD #3 East					100%	0.197
		Hale					100%	0.043
GW-4	Livingston Co. PWSD #2					0.0865	51%	0.151
		Chula					100%	0.016
GW-5	Linn Consolidated PWSD #1					0.085		0.085
GW-6	Linn-Livingston PWSD #3					0.168062		0.107
		Laredo					100%	0.013
		Linneus					100%	0.028
		Wheeling					100%	0.020
GW-7	Meadville					0.0335		0.034
GW-8	Princeton					0.137		0.080
		Mercer					100%	0.024
		Mercer County PWSD #1					5%	0.033
GW-9	Salisbury					0.1750		0.175

L. Out-of-Region Cluster Production & Demand Table

2015-2016 Cluster Average Daily Production and Demand (Treated Water Quantities)								
Source Cluster	Tier System					MGD Produced	% purchase from supplier	Total MGD Consumed
	1st	2nd	3rd	4th	5th			
OR-1	Rathbun					0.557		
		Lancaster					100%	0.065
			Glenwood				100%	0.133
		Mercer County PWSD #1					95%	0.160
		Putnam County PWSD #1					32%	0.207
			Lake Thunderhead HOA				100%	0.021
		Schuyler County CPWSD #1					100%	0.266
			Downing				100%	0.026
			Adair PWSD #1				0.25%	0.463
				Brashear			100%	0.014
				LaPlata			100%	0.079
				Novinger			100%	0.026
				Macon County PWSD #1			1%	0.014
					Callao		100%	0.024
					Clarence		100%	0.065
					Elmer		100%	0.005
OR-2	Clarence Cannon					0.278		
		Macon County PWSD #1					18%	1.523
			Callao				100%	0.024
			Clarence				100%	0.080
			Elmer				100%	0.005
OR-3	Livingston Co. PWSD 4					0.34		0.200
		Jamesport					100%	0.040
		Daviess PWSD #2					40%	0.100
			Jameson				100%	0.006
			Breckenridge				100%	0.001
			Hamilton				22%	0.050
				Caldwell County PWSD #2			100%	

Appendix D

East Locust Creek Reservoir Water Budget Model

EAST LOCUST CREEK RESERVOIR
WATER BUDGET MODEL

PREPARED FOR

NORTH CENTRAL MISSOURI REGIONAL WATER COMMISSION

ALLSTATE
CONSULTANTS

STATE OF MISSOURI
JOHN L. HOLMES
NUMBER
E-29459
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MARCH 20, 2020

DRAFT

Contents

1.0 Introduction and background 1
1.1 Water Budget Model..... 1
1.2 Proposed East Locust Creek Reservoir 2
2.0 methods.....3
2.1 Rainfall 3
2.2 Watershed Runoff – Unit Runoff Method 4
2.3 Seepage Rate 8
2.4 Evaporation 9
2.5 Water Demand 10
2.6 Reservoir Stage Storage 11
2.7 Reservoir Stage Outflow.....12
2.8 In-Stream Flow Releases 13
2.8.1 Existing Stream Flow.....13
3.0 Results 15
3.1 General results 15
3.2 In-stream flow Implementation.....18
3.3 Reservoir Startup Scenarios.....21
3.4 Reservoir Fluctuation.....24
3.4.1 Operational Levels 24
3.4.2 Flood Levels.....26
4.0 Conclusions 26
5.0 References 28

List of Figures

Figure 1. Surrogate Gage Selection for Watershed Runoff
Figure 2. Runoff Records from Three Gages Used in Unit Runoff Analysis
Figure 3. Pan Evaporation Gage Selection
Figure 4. ELCR Elevation Area Curve
Figure 5. ELCR Elevation Volume Curve
Figure 6. Gage Data - East Locust Stream Gage near Boynton
Figure 7. Flow Duration Curve – East Locust Creek – Period of Record
Figure 8. Annual Flow Duration Curves – East Locust Creek
Figure 9. Annual Total Volumes of Reservoir Inputs
Figure 10. Annual Total Volumes of Reservoir Outputs

Figure 11. Annual Total Volumes of Reservoir Inputs and Outputs
Figure 12. Projected Lake Level at Steady Demand of 7 MGD
Figure 13. Flow Duration Curves – Estimated Pre and Post Reservoir
Figure 14. Reservoir Level During Startup Scenarios
Figure 15. Estimated Time to Fill vs. Average Palmer Drought Severity Index
Figure 16. Proposed East Locust Creek Reservoir – Estimated Reservoir Levels
Figure 17. Reservoir Level Frequency Diagram

List of Tables

Table 1. Water Budget Model Inputs.
Table 2. Short Listed Stream Gages
Table 3. Watershed Land Use (NLCD 2016).
Table 4. Evaporation Gage Stations
Table 5. Reservoir Seepage Rates
Table 6. Stage Outflow Data
Table 7. In-Stream Flow Orifice Details
Table 8. Time Required to Fill Reservoirs under Various Scenarios
Table 9. Maximum WBM Reservoir Level Drop Rates
Table 10. Maximum WBM Reservoir Level Rise Rates
Table 11. Reservoir Flood Levels

Appendix

A - Water Budget Model – Varying Water Supply Demand Rates
B – East Locust Creek Reservoir Hydraulics Report
C – East Locust Creek Reservoir Hydrology Report

Acronyms and Initialisms

Term	Definition
CFS	Cubic Feet per Second
EIS	Environmental Impact Statement
ET	Evapotranspiration
ELCR	East Locust Creek Reservoir
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MGD	Million Gallons per Day
NCMRWC	North Central Missouri Regional Water Commission
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
URM	Unit Runoff Method
WBM	Water Budget Model

1.0 INTRODUCTION AND BACKGROUND

The proposed East Locust Creek Reservoir (ELCR) project in Sullivan County Missouri will create a 2,328-acre multi-purpose reservoir designed to provide drinking water, recreation, and flood damage reduction for a 10-county region in north central Missouri. The reservoir is sized to provide 7 million gallons a day (MGD) to the 10-county region in north central Missouri. The reservoir is designed to provide a reliable drinking water source during the drought of record. The current proposed reservoir location, reservoir size, and the drinking water capacity of 7 MGD was established in 2007 in the "East Locust Creek Watershed Revised Plan and Environmental Impact Statement" (EIS) (NRCS 2007).

Because the 10-county area is one of the poorest regions in the state and because existing drinking water rates are among the highest in the state, the residents of the region currently pay an inordinately high percentage of their household income for drinking water. For this reason, it is also critical that the reservoir provide high quality recreational opportunities to help subsidize drinking water production. An important constraint in designing recreational opportunities that will attract consumers to the reservoir is an understanding of how the lake levels will fluctuate through typically varying weather patterns.

1.1 Water Budget Model

The ELCR water budget model is intended to estimate the amount of drinking water the proposed ELCR can provide during a drought equivalent to the drought of record while considering watershed runoff, rainfall, downstream flows, seepage, and evaporation and without excluding the other two project purposes (recreation and flood damage reduction). In the absence of reliable predictions of future rainfall, runoff, evaporation rates, etc, a water budget model relies on historical climate records to simulate reservoir operations during past conditions with an assumption that future conditions will be similar to past conditions. As such, the model cannot predict conditions on any particular day, but can provide information about the range of conditions that may be encountered.

The NRCS model, Reservoir Operation Study Program TR-19 (RESOP) was developed by the Soil Conservation Service in the 1960s to determine the storage requirements necessary to meet supply-demand relationship (NRCS 1967). In other words, it was developed to produce a water budget model.

NRCS used RESOP to develop the original ELCR water budget model for the 2007 EIS (NRCS 2007). This RESOP model used climatological data from 1951-1992 as the proxy for future conditions. The RESOP model was a monthly water budget model that considered seepage, evaporation, rainfall, runoff, 0.5 CFS in-stream flow, and 7 MGD in water use.

This current water budget model, referred to hereafter as the Water Budget Model (WBM) is intended to update the previous NRCS RESOP model to include the additional 25 years of records now available and to gain a better understanding of daily reservoir fluctuation. An improved understanding of daily reservoir fluctuations is needed to make sure that the reservoir design

facilitates reservoir operation during normal, wet and dry periods.

The project team determined that a daily model with additional years of data, would be helpful to:

- Extend the results to consider 25 additional years of information
- Gain a better understanding of the reservoir level fluctuations for optimal design
- Provide additional information for the Supplemental Environmental Impact Statement
- Consider in-stream flow capabilities on a daily basis. (The term “in-stream flow” is intended to be synonymous with the terms “ecological flows” or “environmental flows” which have all been used by various parties to describe the water that is released through the dam to maintain the downstream reach of East Locust Creek.)

Because the RESOP model is based on a monthly time step, it could not provide daily results. Accordingly, a spreadsheet (the WBM) was developed to replicate the RESOP model calculations, but on a daily time step basis. This WBM uses historical data (1950-2017) along with projected watershed, reservoir and water supply conditions to simulate the reservoir water level fluctuation caused by natural, water supply and in-stream flow withdrawals from ELCR.

The WBM is not intended to modify the original 7 MGD estimate of the reservoir firm yield or the size of the reservoir. It does not provide any improved accuracy in estimating firm yield during the design drought (the drought of the 1950s). Rather, it provides additional years of record and details of daily fluctuation to help plan reservoir design and operations.

1.2 Proposed East Locust Creek Reservoir

The proposed East Locust Creek Reservoir will consist of a multipurpose reservoir with a zoned earth dam and a drainage area of approximately 21,000 acres, creating a reservoir surface area of approximately 2,328 acres at normal pool elevation of 922.3 feet, MSL. Watershed land use is described in Table 3. The proposed reservoir spillway is a two-stage labyrinth weir with the first stage at normal pool and the second stage at the 25-year flood level. There is no auxiliary or emergency spillway as the principal spillway is designed to handle all events up to the probable maximum precipitation (PMP) storm. Approximately 10 feet below normal pool will be a passive in-stream flow orifice system that will pass 0.5 cubic feet per second (CFS) to the existing stream below the reservoir (on average). The orifices will pass flow at diminishing rates as the reservoir drops until they cease when the lake falls below the orifice elevations..

2.0 METHODS

The WBM uses historical data (1950-2017) with projected reservoir, in-stream flow and water supply conditions to simulate the reservoir water level fluctuation caused by natural, water supply and in-stream flow withdrawals from ELCR. This approach provides a range of conditions typical for this region to help us to understand reservoir levels but does not predict any particular temporal sequence of events. In other words, it can't be used to predict conditions at any particular time and it can't be used to model a progression of water demand unless we assume an exact repeat of past history. Further, it does not account for climate change.

The inflow to the reservoir consists of direct rainfall on the reservoir and runoff from the East Locust Creek watershed. Outflow from the reservoir consists of seepage, evaporation, outflow through the two-state labyrinth weir, water supply demand, and through the passive in-stream flow system. Based on the inflows and outflows, the WBM calculates the modeled reservoir level for each day.

The model inputs and data sources for the WBM consist of water exchange within the reservoir watershed system, based on factors that add or deduct from the reservoir's water supply. These inputs are listed in Error! Reference source not found. and further described below.

Table 1. Water Budget Model Inputs.

Model Input	Data Source
Rainfall	Historic rain gage data near ELCR. (Green City, Milan (preferentially in that order))
Watershed Runoff	Historic stream gage data. (Locust Creek at Linneus, Medicine Creek Near Galt, South Fork Chariton (preferentially in that order))
Seepage Rate	NRCS (NRCS 2007) and DNR (MDNR 2013)
Evaporation	Historic regional pan evaporation gages as described in Section 2.4.
Water Demand	Varies as described for each scenario.
Reservoir Stage Storage	2008 and 2017 LIDAR Data (Surdex 2009) (Woolpert 2017)
Reservoir Stage Outflow	Hydraulics Report (Appendix B).
In-Stream Flow Releases	Varies as described for each scenario.

2.1 Rainfall

Rain gage data was used to model the quantity of direct rainfall on the reservoir surface. The rainfall that falls on the rest of the watershed is included in the measured watershed runoff, so the rain gage data is not used to calculate watershed runoff.

Rain gages within 11 miles of the reservoir were investigated to determine which gages could

provide continuous data for the full period of modeling from gages closest to the reservoir watershed. Of the five evaluated, it was determined that the combination of the two closest gages, Green City 5 N gage (6.6 miles from watershed center) and Mo Milan gage (8.08 miles from watershed center), provided a continuous period of record over the modeled time frame. Data from the Green City 5 N gage was used when available and data from the Mo Milan gage was used to fill in any gaps. The Green City 5 N gage was installed in June of 2006, so the Mo Milan Gage provided the bulk of the data.

2.2 Watershed Runoff – Unit Runoff Method

The Unit Runoff Method (URM) estimates watershed flow into the reservoir based on measured runoff per unit area at nearby stream gages. The URM is based on the measured runoff per unit area at an existing stream gage for each day during the period of record. This runoff per unit area is then applied directly to the watershed area for the proposed reservoir (less the area of the reservoir surface for each day) to determine a volume of watershed runoff into the reservoir. Because the gage data reflects both base flow and storm runoff, the application of this method includes both the base flow and storm runoff merged as watershed runoff. So, no independent estimate of base flow is necessary for the model.

For example, on January 1, 1950, USGS Gage #06901500 reported an average daily flow of 1510 CFS. Dividing this flow into the watershed area (550 mi^2) and making appropriate simple conversions indicates that the flow represented 0.102 inches of runoff averaged over the watershed. This 0.102 watershed inches was applied to the watershed area for the proposed reservoir (29.2 mi^2) to estimate the watershed runoff volume that would have flowed into the reservoir on that day (158.9 ac-ft (or 80.1 CFS)).

To determine the best gage(s) to use for this purpose, stream gages within 50 miles of the watershed centroid with drainage area between 10 and 600 square miles were evaluated to find the most suitable watershed for determining the unit runoff. Consideration was given to similarity of drainage area size, degree of existing impoundment, distance of the gage watershed centroid from the ELCR watershed centroid, and period of record available during the modeled time frame. Of the 21 gages found, 10 were pre-screened out due to insufficient period of record or because they were just downstream of existing major impoundments. Eleven gages were short listed as shown in Figure 1. From this set, two gages stood out due to their proximity to the reservoir and were selected as potential sources of runoff data. However, the combination of these two gages did not provide a complete record of runoff for the period modeled so a third gage was necessary. While the Medicine Creek near Laredo Gage would have been the most appropriate third gage due to location and shape, its data gaps coincided with the gaps in the two primary gage records. Details of the 11 short listed gages are presented in Table 2.

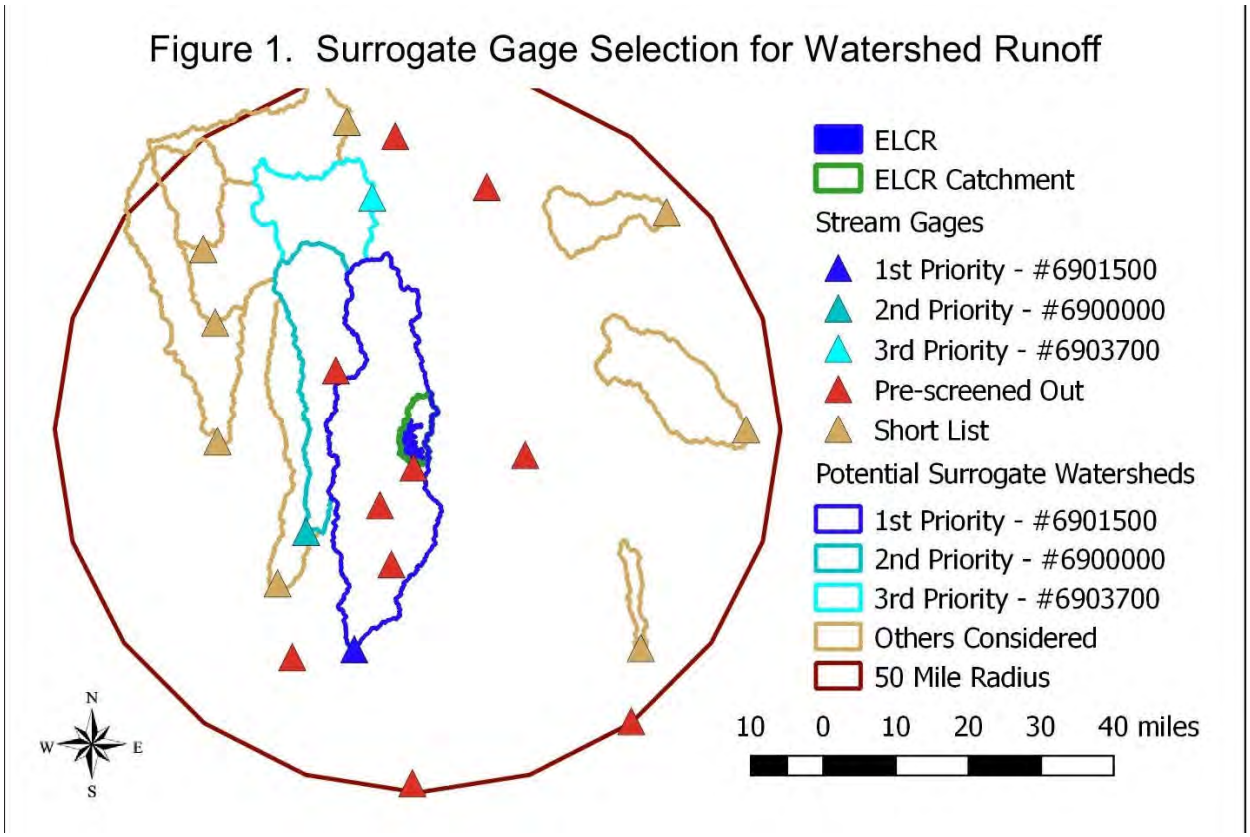


Table 2. Short Listed Stream Gages				
Gage	Drainage Area (mi^2)	Distance (Watershed Centroid to ELCR Catchment Centroid) (mi)	Relevant Period of Record (years)	Priority
6901500 Locust Creek near Linneus, MO	550	5.8	68	1
6900000 Medicine Creek near Galt, MO	225	16.9	40	2
6903700 South Fork Chariton River near Promise City, IA	168	33.3	52	3
6900050 Medicine Creek near Laredo, MO	355	16.0	17	NA

Table 2. Short Listed Stream Gages				
Gage	Drainage Area (mi^2)	Distance (Watershed Centroid to ELCR Catchment Centroid) (mi)	Relevant Period of Record (years)	Priority
5497500 Middle Fabius River near Baring, MO	185	35.6	11	NA
6906150 Long Branch Creek near Atlanta, MO	23	37.2	22	NA
6899000 Weldon River at Mill Grove, MO	494	37.4	23	NA
5494300 Fox River at Bloomfield, IA	88	38.3	65	NA
6898500 Weldon River near Mercer, MO	246	39.1	28	NA
6903400 Chariton River near Chariton, IA	182	44.8	68	NA
6898400 Weldon River near Leon, IA	104	45.2	33	NA

The two primary gages are Locust Creek near Linneus (#06901500) and Medicine Creek near Galt, MO (#06900000) and the third gage on the South Fork of Chariton River near Promise City, IA (#06903700). Because the Locust Creek gage watershed includes the ELCR catchment, it is selected as the unit runoff source whenever it has valid data. Likewise, the Medicine Creek near Galt data is used when Locust Creek gage doesn't have data and the S. Fork Chariton data fills in the remaining data gaps. Figure 2. graphically represents the availability of data from these gages. Table 3 compares the land use in the respective watersheds to the land use in the ELCR watershed.

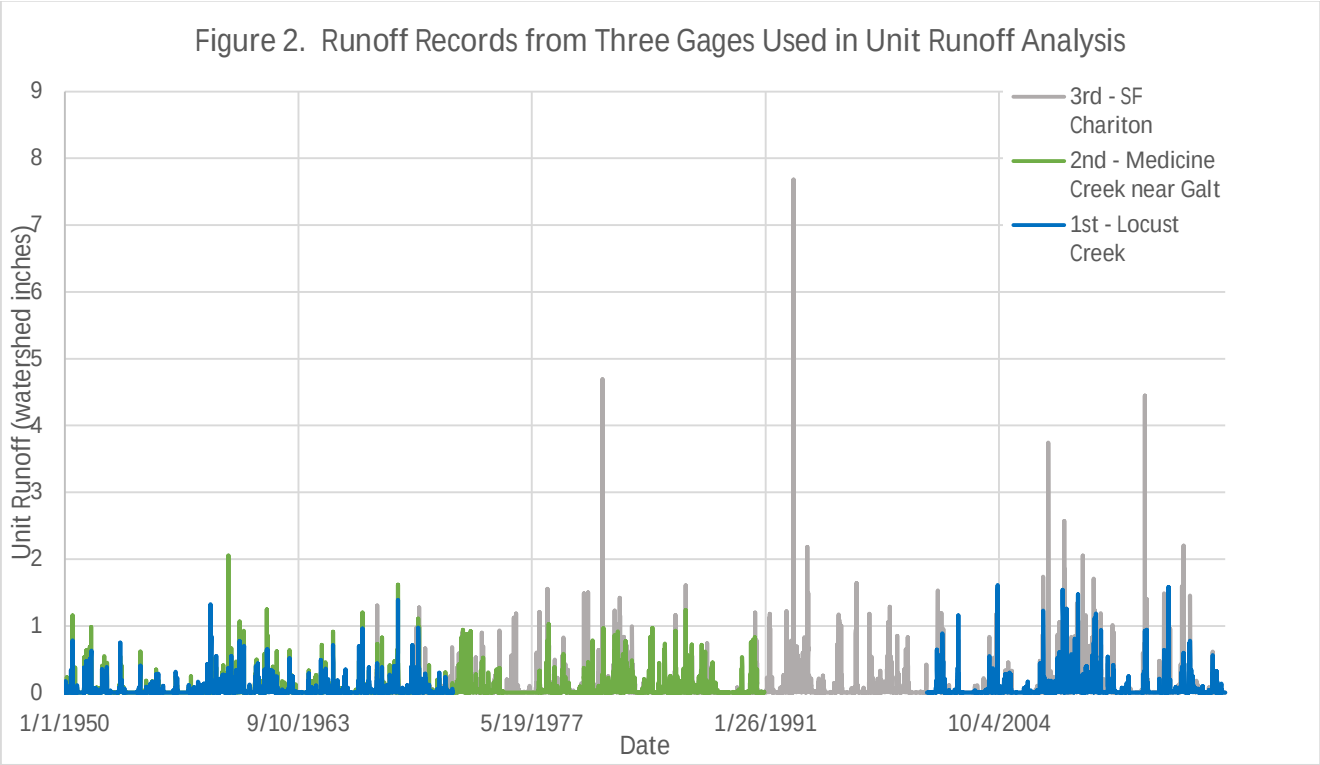


Figure 2. Runoff Records from Three Gages Used in Unit Runoff Analysis
Unit Runoff (watershed inches)
9
8
7
6
5
4
3
2
1
0
1/1/1950
9/10/1963
5/19/1977
1/26/1991
10/4/2004
Date
3rd - SF Chariton
2nd - Medicine Creek near Galt
1st - Locust Creek

Table 3. Watershed Land Use (2016 NLCD).

NLCD Class	Land Use	Linneus #6901500	Medicine Creek Near Galt #6900000	S. Fork Chariton near Promise City #6903700	ELCR Catchment (above pool)
		Land Use Percentage (%)			
11	Open Water	0.7%	0.4%	0.7%	0.8%
21	Developed, Open Space	2.8%	2.6%	2.8%	3.5%
22	Developed, Low Intensity	0.7%	0.9%	1.4%	0.6%
23	Developed, Medium Intensity	0.1%	0.1%	0.1%	0.0%
24	Developed, High Intensity	0.0%	0.0%	0.0%	0.0%
31	Barren Land (Rock/Sand/Clay)	0.0%	0.0%	0.0%	0.0%
41	Deciduous Forest	19.7%	16.1%	11.0%	21.3%
42	Evergreen Forest	0.3%	0.3%	0.1%	0.5%
43	Mixed Forest	5.5%	3.4%	0.8%	7.1%
52	Shrub/Scrub	0.3%	0.2%	0.1%	0.2%
71	Grassland/Herbaceous	0.6%	0.5%	0.3%	0.5%
81	Pasture/Hay	51.6%	50.0%	39.6%	60.3%
82	Cultivated Crops	15.6%	23.2%	41.6%	5.0%
90	Woody Wetlands	1.9%	1.9%	1.2%	0.1%
95	Emergent Herbaceous Wetlands	0.2%	0.2%	0.4%	0.0%
	Total	100.0%	100.0%	100.0%	100.0%

2.3 Seepage Rate

The seepage from the reservoir varies with the surface area of the lake. Table 4 lists the lake surface area and the seepage rate for the lake. The seepage rate table for ELCR was provided by NRCS and is consistent with seepage values used for Elmwood Reservoir and Lake Thunderhead in the 2013 MDNR Water Supply Study (MDNR 2013).

Table 4. Seepage Values

Lake Surface Area (acres)	Seepage (inches/day)	Seepage (inches/month)
2100 and above	0.100	3.0
1100 to 2100	0.067	2.0
1100 and below	0.033	1.0

2.4 Evaporation

The evaporation from the reservoir was simulated using the pan evaporation data from gages throughout the region and the daily calculated reservoir surface area. The evaporation gages near ELCR are listed below in Table 5:

Table 5. Evaporation Gage Stations.

Station	Distance from ELCR Catchment Centroid	Period of Record	Comments
Rathbun Dam, IA US (USC00136910)	34.5	1970-Present	
Mo Spickard 7 W (USC00237963)	34.5	1957-1993	Not used – data quality concerns.
Mo Long Branch Rsvr. (USC00235050)	50.2	2011-Present	
Mo New Franklin 1W (USC00236012)	92.4	1956-2016	
Mo Clarence Cannon Dam (USC00231600)	94.1	1996-1997	Not Used– insufficient data
Columbia 9 WNW, MO US	98.6	1944-1953	
Norwich Experimental Farm, IA US	115	1937-1970	
Smithville Lake (USC00237862)	102	1985-Present	Not used – data quality concerns.
Ames 3 SW, IA US	118	1893-1964	
Iowa City, IA US	120	1950-Present	
Mo Lakeside (Lake of the Ozarks) (USC00234694)	149	1931-1990	
St. Louis Washington University, MO US	187	1938-1957	

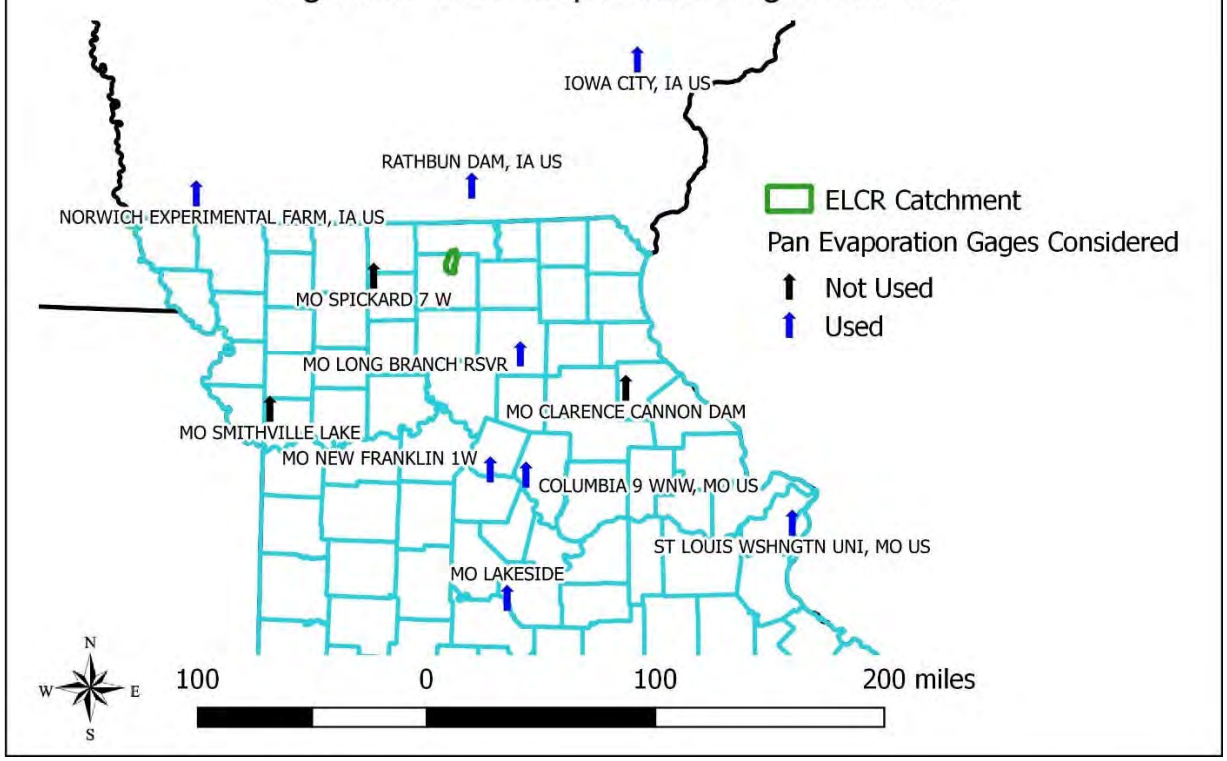
Because the records were often missing within the reported period of record, it was necessary to find multiple stations to ensure some data was available. The model used the average of all gages with data for each individual day.

There were some dates for which none of these stations had data. In that case, the average pan

evaporation value for that day of the year was used. The average pan evaporation for the day of the year was calculated by averaging all values at all stations in every year there was data for that day.

The pan evaporation coefficient of 0.76 was used to convert the pan evaporation values from the National Oceanic and Atmospheric Administration (NOAA) gages to the free water surface of the reservoir (NOAA 1982). The pan coefficient of 0.76 was selected based on DNR's WBM of Elmwood Reservoir (4 miles from ELCR) (DNR 2013). Figure 3 shows the locations of the pan evaporation gages considered and used.

Figure 3. Pan Evaporation Gage Selection

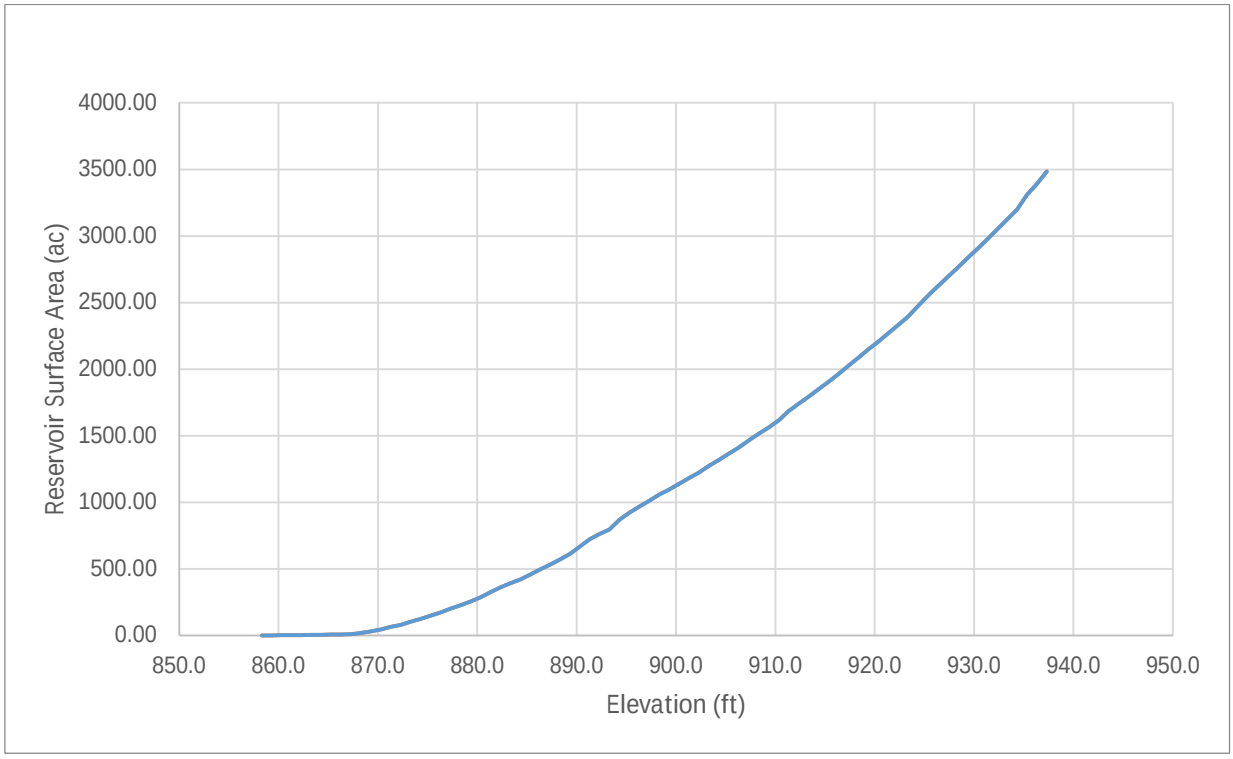


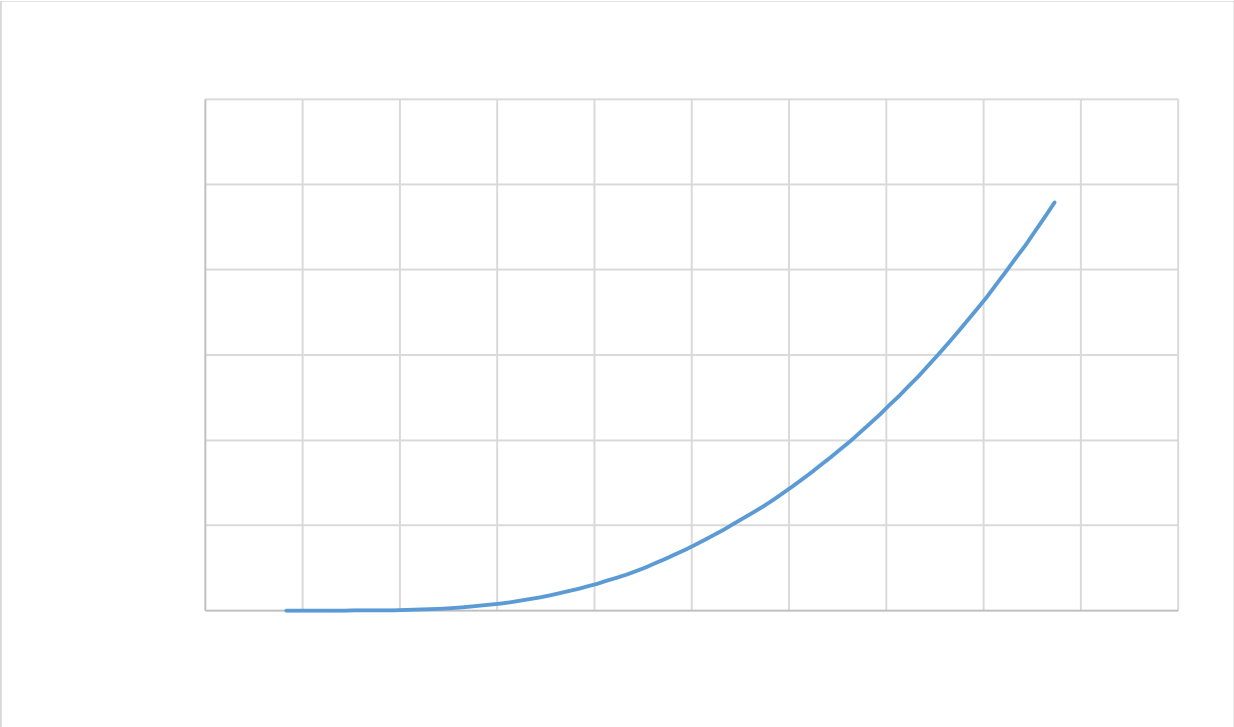
2.5 Water Demand

The reservoir is designed to be able to supply 7 MGD during the drought of record (NRCS 2003). The model was setup to be able to run various demand scenarios up to 7MGD. For basic sizing of the reservoir a constant demand of 7MGD is used. Appendix A contains a summary of results for other demand rates for use in understanding reservoir fluctuation and ecological flows during periods prior to when the full 7 MGD is being sold.

2.6 Reservoir Stage Storage

The reservoir stage storage data was created from LIDAR taken in 2008 and 2017. The 2017 LIDAR only includes the floodplains but is used to the extent possible with the 2008 data being used for higher elevations not covered by the 2017 data. Figure 4 displays the relationship of reservoir surface area to elevation and Figure 5 displays the relationship of total reservoir volume to elevation.





2.7 Reservoir Stage Outflow

The proposed reservoir spillway is a two-stage labyrinth weir with the first stage at normal pool and the second stage at the 25-year flood level. There is no auxiliary or emergency spillway as the principal spillway is designed to handle all events up to the probable maximum precipitation (PMP) storm. The reservoir stage outflow for the two stage spillway is described fully in appendix B. The stage discharge data from that report is compiled in Table 6.

Table 6. Stage Outflow Data

Elevation (ft)	Flow (CFS)	Description
922.3	0	1st Stage Weir
922.55	19	
922.8	59	
923.05	112	
923.3	179	
923.55	256	
923.8	342	
924.05	436	
924.3	536	
924.55	642	
924.8	753	2nd Stage Weir
924.9	762	

Table 6. Stage Outflow Data		
Elevation (ft)	Flow (CFS)	Description
925	780	
926.4	1501	
927.8	2730	
929.2	4152	
930.5	5491	
931.9	6887	
933.3	8235	
934.6	9469	
936	10817	2' Below Top of Dam

2.8 In-Stream Flow Releases

To maintain the stream below the dam, the reservoir will be configured to provide in-stream flow when the principal spillway is not active. This in-stream flow will be in addition to what passes through the spillway due to storm events and what seeps through the dam. The original Environmental Impact Study (NRCS 2006) assumed an average value of 0.5 CFS for in-stream flows. As discussed in Section 3.2, a passive system has been devised to produce at least an average of 0.5 CFS over the period of record given projected lake elevation and the results below reflect the presence of that system unless stated otherwise.

2.8.1 Existing Stream Flow

To provide a description of existing flows in East Locust Creek for comparison to post project flows, a USGS stream gage, #06901205, was constructed on East Locust Creek and began operation on September 30, 2013. The gage is about a mile downstream of the proposed dam and has a drainage area of 33.8 mi^2. The proposed reservoir has a drainage area of 32.5 mi^2. Figure 6 shows the mean daily discharge over the period of record.

The following flow duration curves were created from the gage data to illustrate the flow characteristics of East Locust Creek. Figure 7 shows the flow duration curve for the entire period of record and Figure 8 shows the flow duration curve separated by calendar year. Data over the period from 7/1/2014-6/30/2019 indicates that the gage records zero flow approximately 6% of days and less than 0.1 CFS approximately 15% of days. The median daily average discharge during this time period was 2.86 CFS.

Breaking down the flow data by year (Figure 8) reveals that in the 2018 the creek did not have any flow for 25% of the year and that in 2015 the creek had year round flow. Three out of five years had some periods with zero flow.

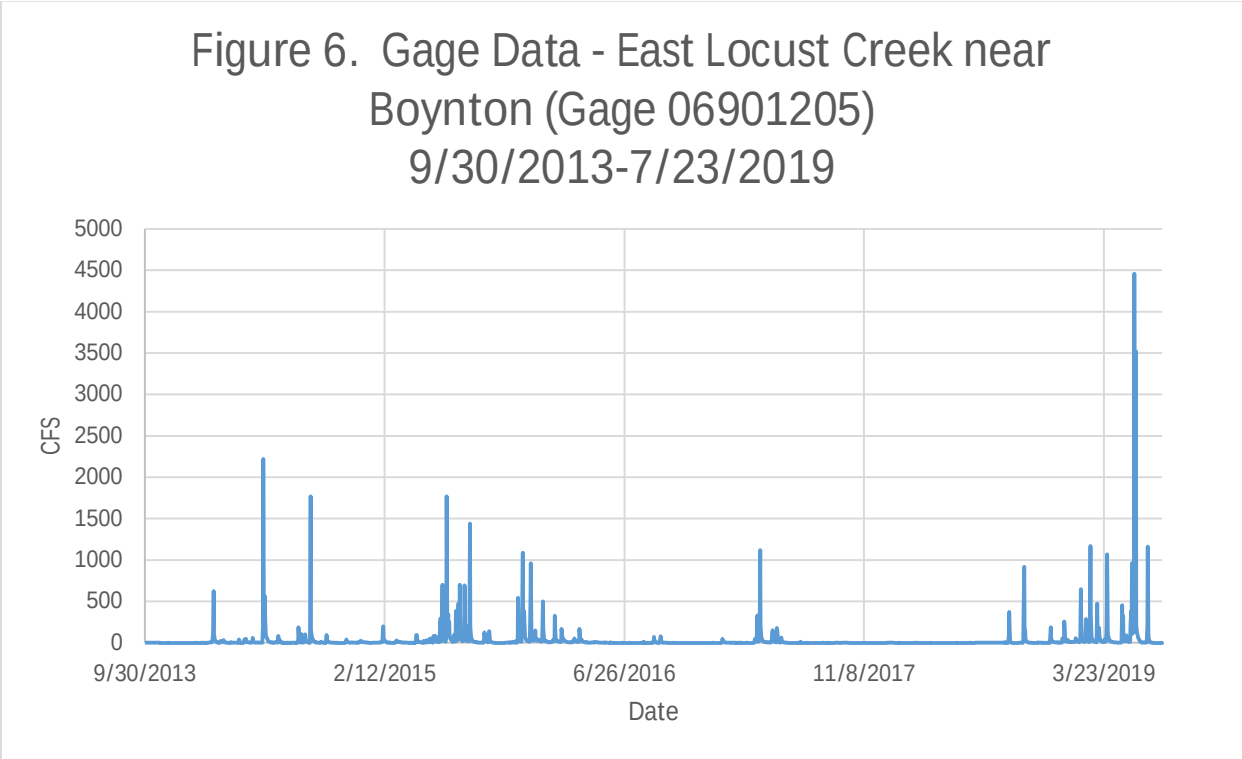
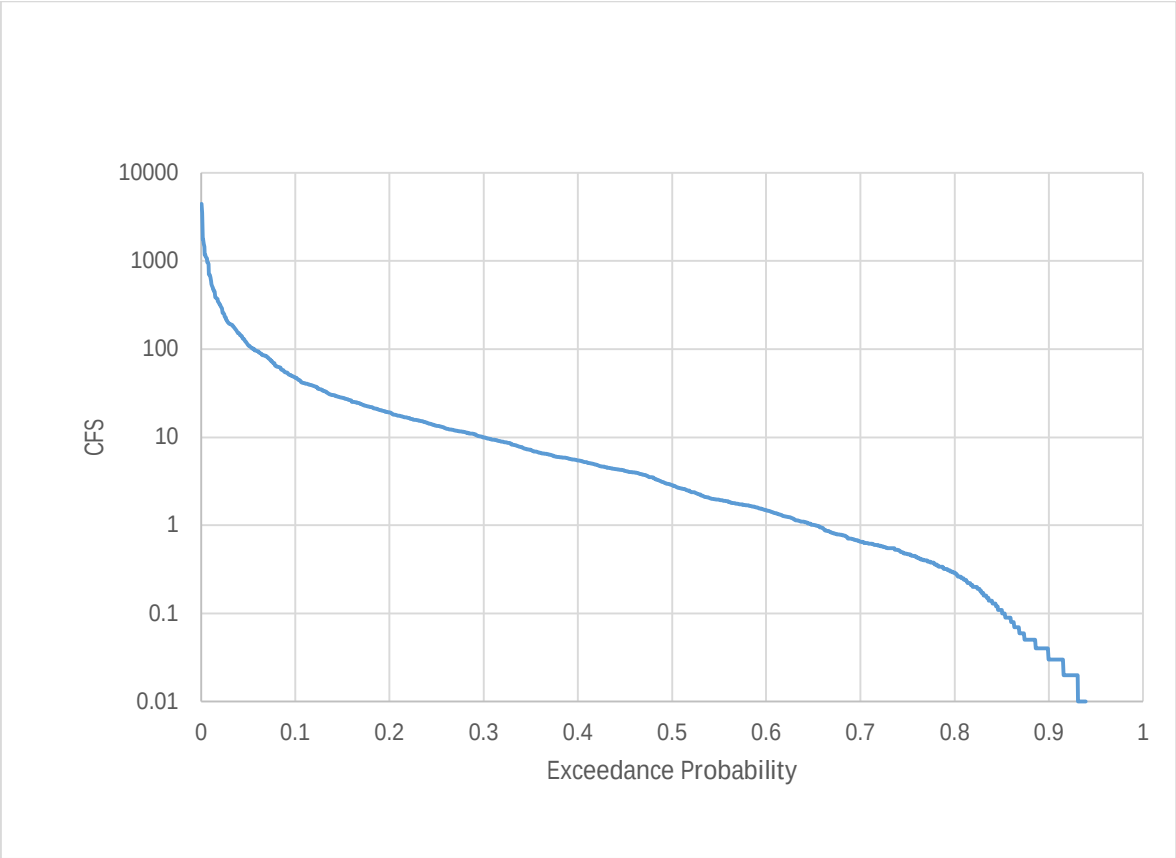


Figure 6. Gage Data - East Locust Creek near Boynton (Gage 06901205) 9/30/2013-7/23/2019
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
CFS
9/30/2013
2/12/2015
6/26/2016
11/8/2017
3/23/2019
Date


10000
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CFS
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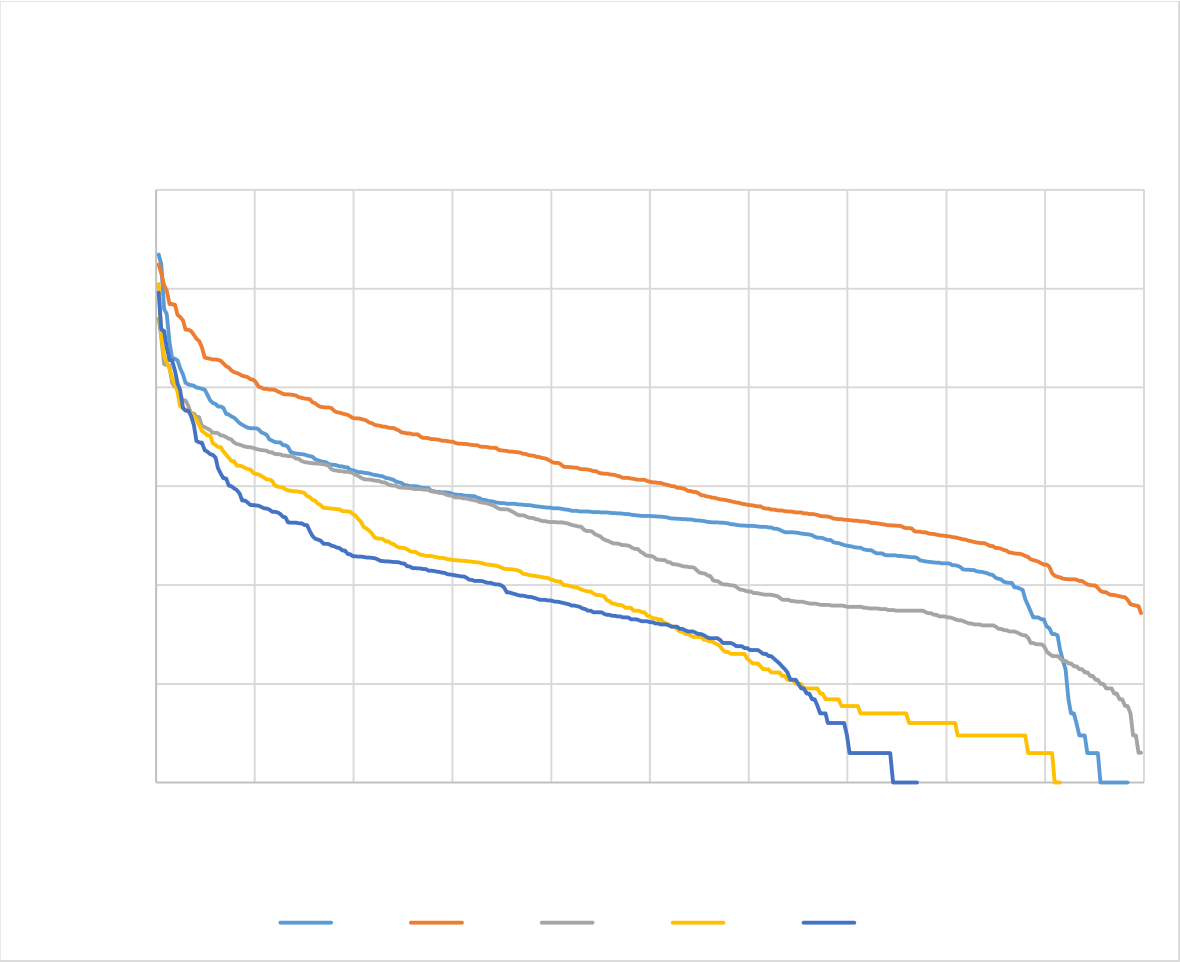
0.7
0.8
0.9
1
Exceedance Probability



3.0 RESULTS

The WBM was applied with varying assumptions and constraints to develop a better understanding of how the reservoir might operate, based on historical climate and conditions. Particularly the model was used to:

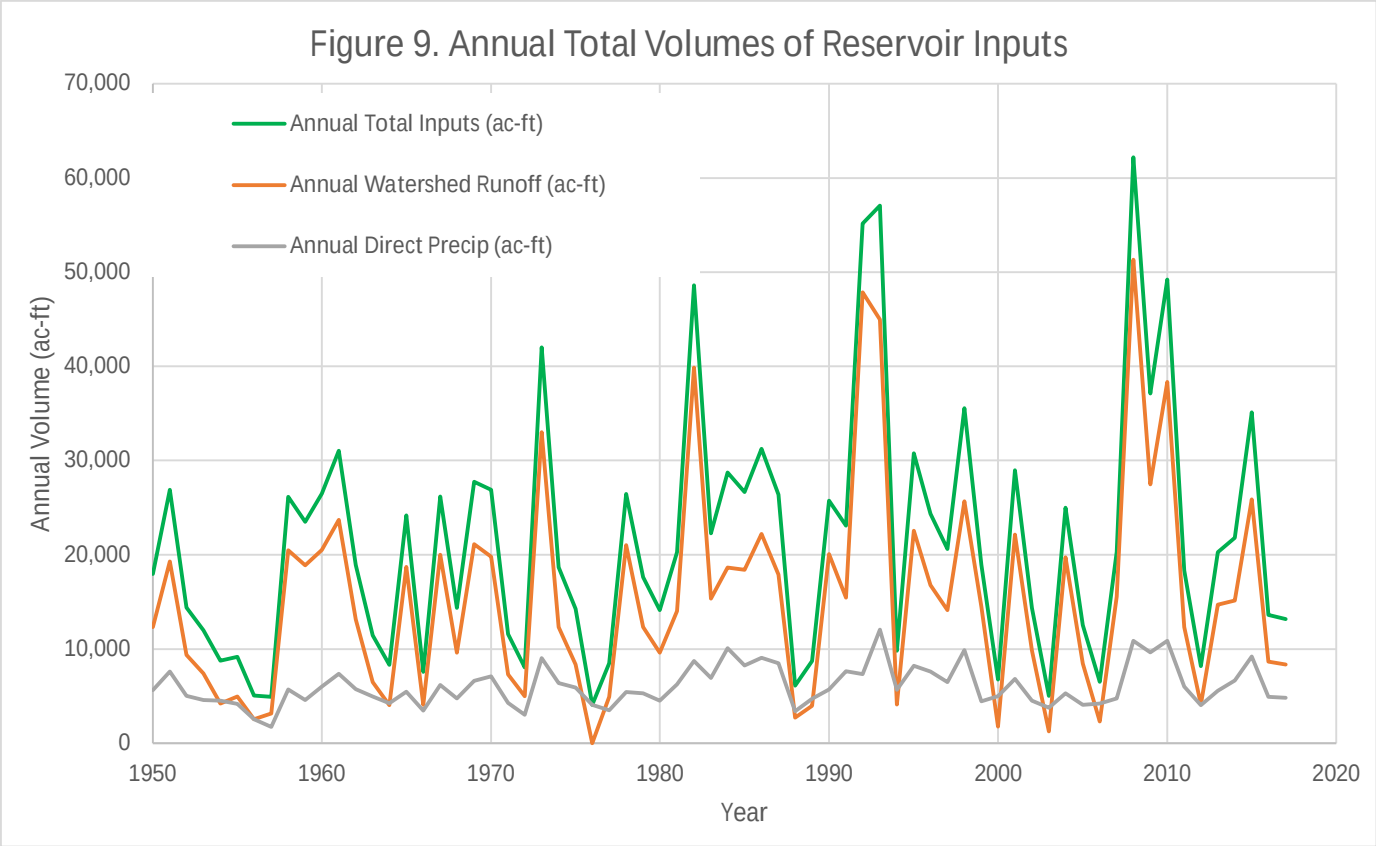
- Simulate flow conditions in East Locust Creek below the dam
- Estimate the time required to fill the reservoir once dam construction is complete
- Model how lake levels will tend to fluctuate after the reservoir is initially filled

3.1 General results

Figures 9-11 display the annual average values of the model inputs and outputs. As expected, the watershed runoff is the primary source of water into the reservoir, but direct rainfall on the

reservoir is also a significant source. The 7 MGD water supply demand is the largest steady outflow of water from the reservoir, although there are years when evaporation exceeds demand. Seepage is also a significant source of loss, especially in years when the reservoir is full. Spillway release is highly variable, reflecting the fact that the reservoir will often be below normal pool and many storms will add significant volumes of water to the reservoir without raising it to the level that allows spillway flow.

The average annual reservoir volume has been added to Figure 11 to provide a sense of scale for the total inputs and outputs from the reservoir. As can be expected, the inputs tend to be more variable while the outputs are dampened by reservoir storage.



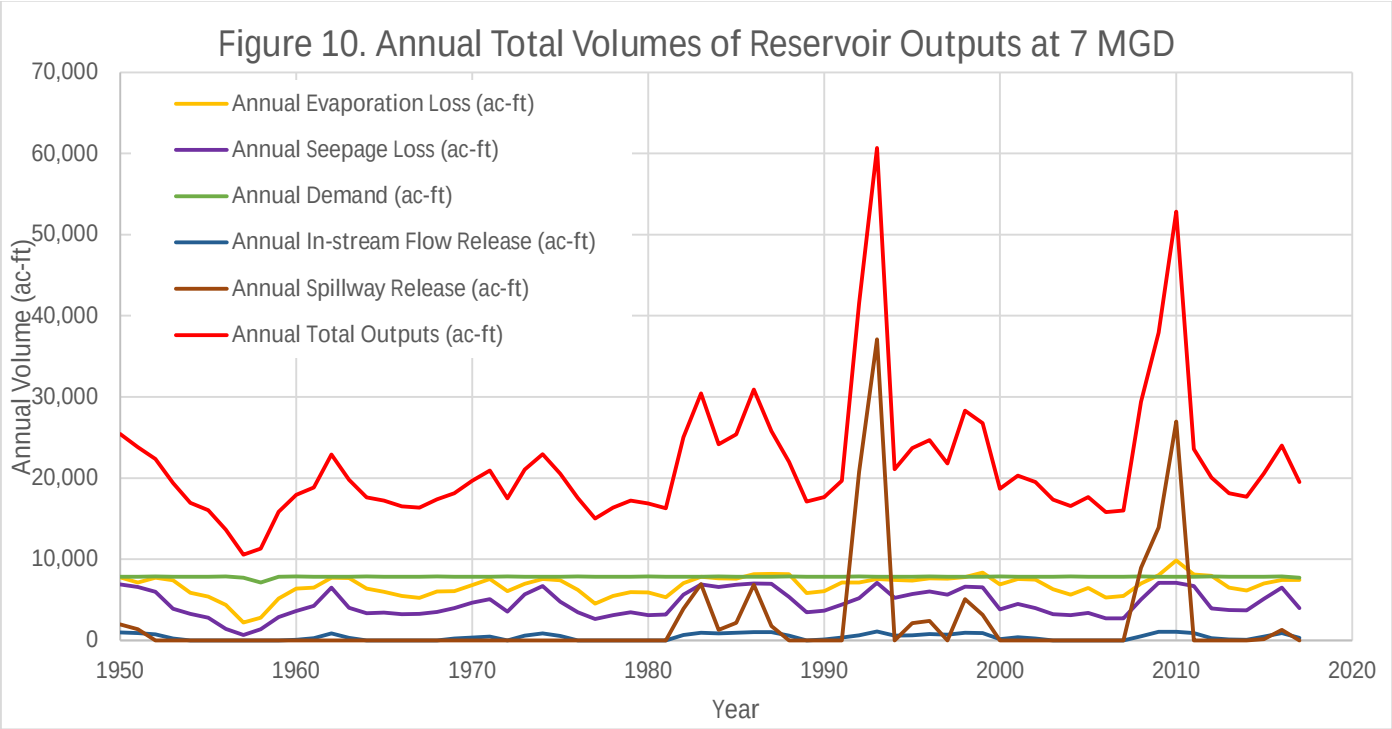


Figure 10. Annual Total Volumes of Reservoir Outputs at 7 MGD
Annual Evaporation Loss (ac-ft)
Annual Seepage Loss (ac-ft)
Annual Demand (ac-ft)
Annual In-stream Flow Release (ac-ft)
Annual Spillway Release (ac-ft)
Annual Total Outputs (ac-ft)
Annual Volume (ac-ft)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1950
1960
1970
1980
1990
2000
2010
2020
Year

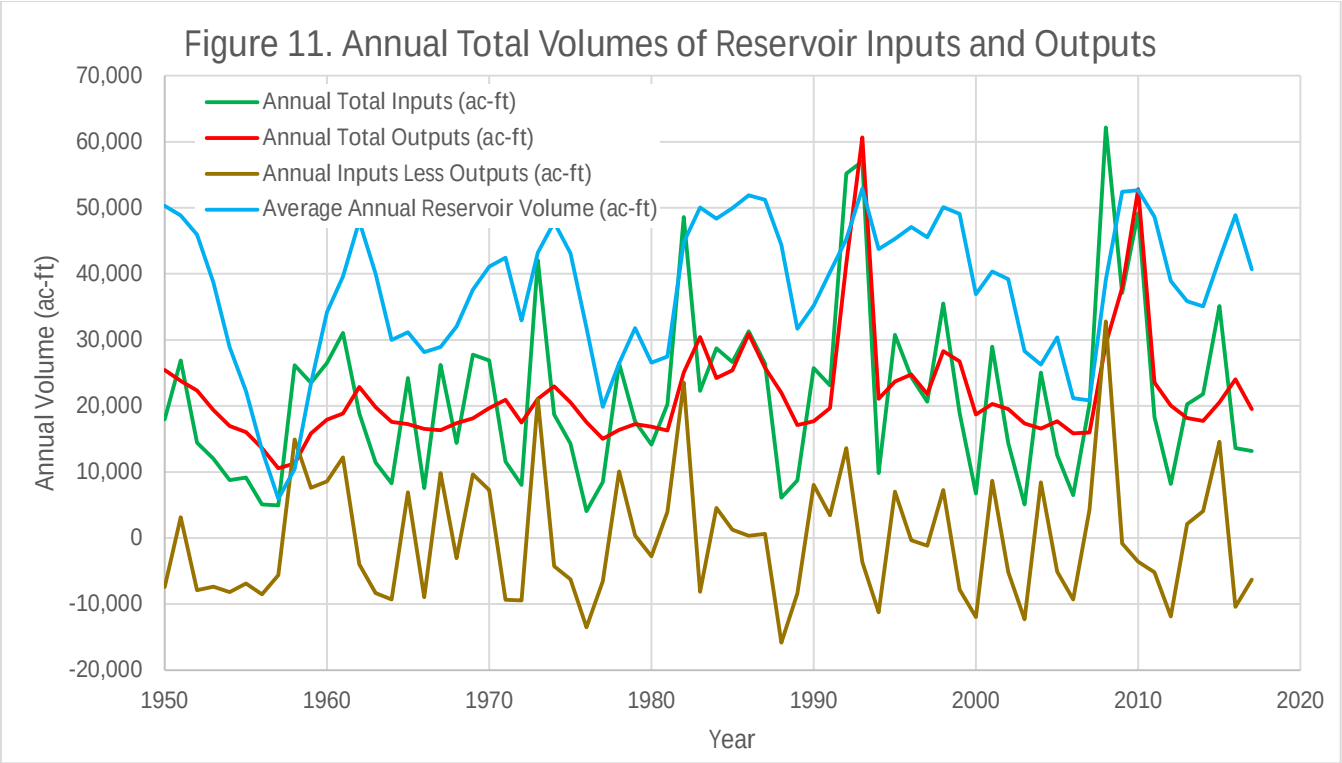
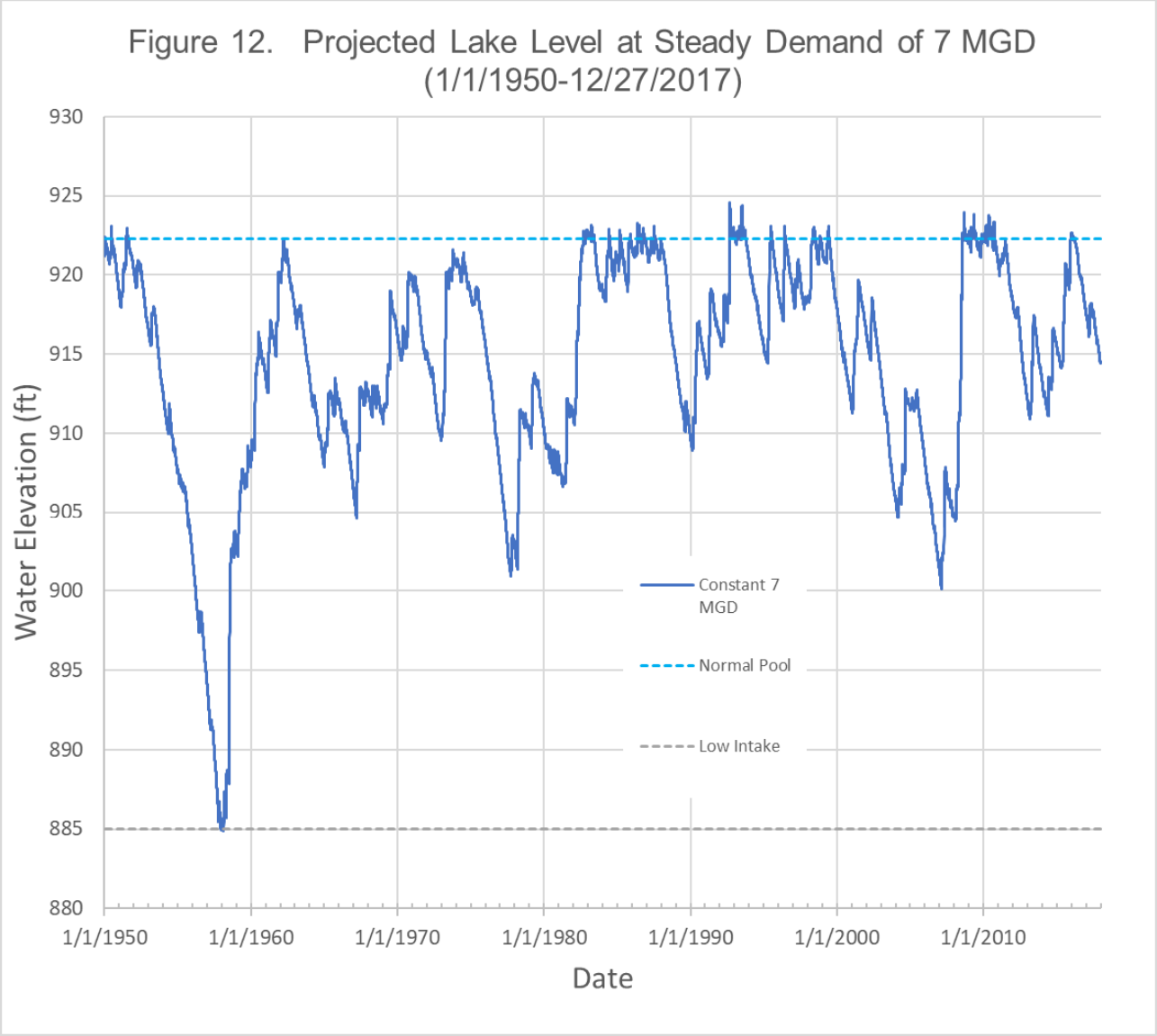


Figure 11. Annual Total Volumes of Reservoir Inputs and Outputs
Annual Total Inputs (ac-ft)
Annual Total Outputs (ac-ft)
Annual Inputs Less Outputs (ac-ft)
Average Annual Reservoir Volume (ac-ft)
Annual Volume (ac-ft)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
1950
1960
1970
1980
1990
2000
2010
2020
Year

Figure 12 shows the estimated reservoir level over the period of record for the full 7 MGD demand, starting with the reservoir full, and utilizing the proposed in-stream flow configuration. It shows that during the drought of record the lake level drops to the low intake level, confirming that the firm yield of the reservoir is 7 MGD given this configuration. Appendix A and Figure 16 below provide similar curves for other demand rates less than 7 MGD for use in estimating reservoir operations prior to when the full demand is developed.



3.2 In-stream flow Implementation

This study evaluated various options for passive orifices placed to provide an average in-stream

value of 0.5 CFS over the period of record.

The reservoir principal/auxiliary/emergency spillway is controlled by a labyrinth weir placed in the spillway (Appendix B). The weir wall is notched to 10' tall for the principal spillway and is 12.5' tall for the auxiliary/emergency spillway. Normal pool level is at elevation 922.3 and from normal pool to the 25-year level the principle spillway notch handles all storm flow. At the 25-year flood elevation (924.8') the auxiliary/emergency portion of the weir wall becomes active.

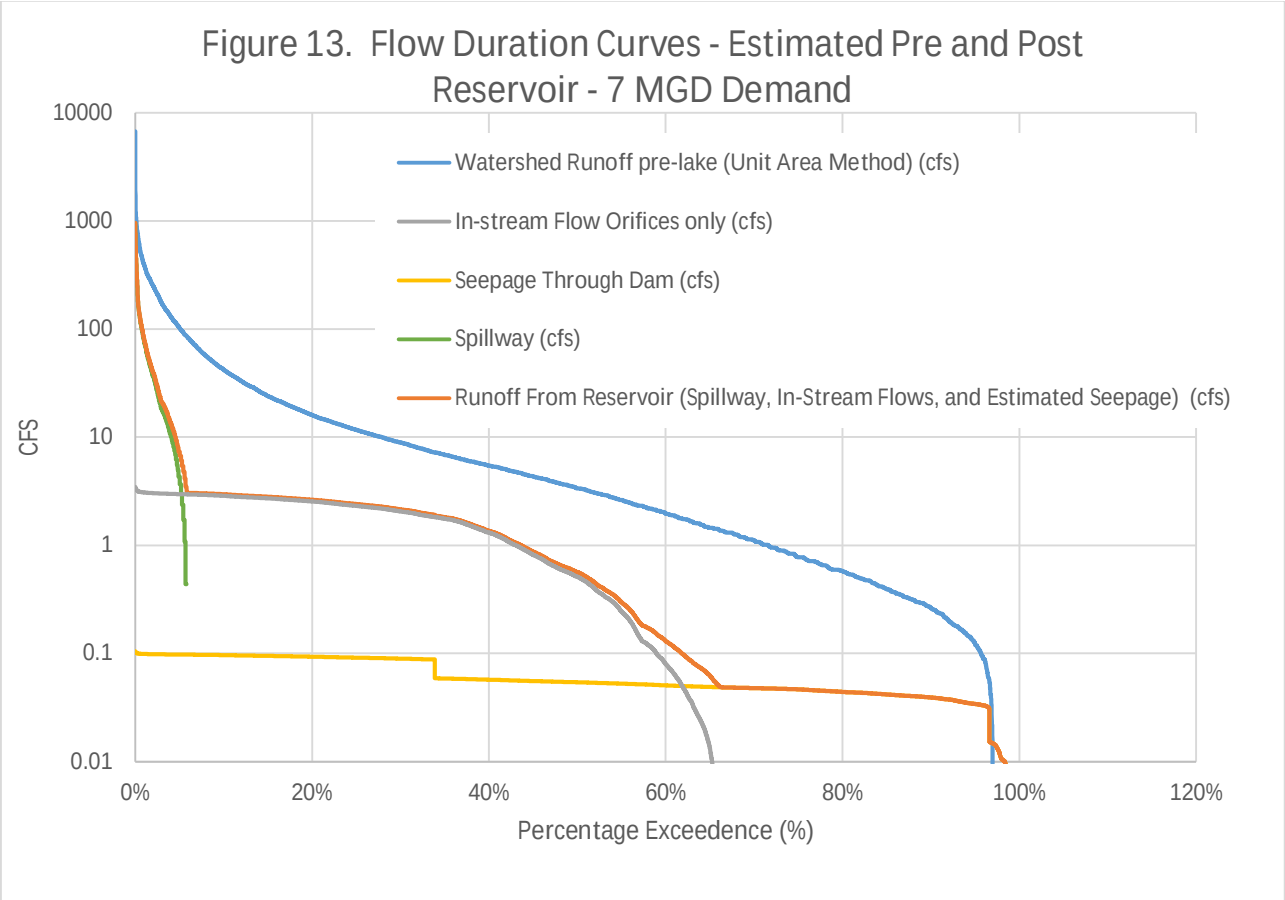
The proposed plan is to place orifices in the weir wall to provide in-stream flows. The orifices will be fitted with flanges so that orifice sizes can be modified in the future using an adaptive management approach. A configuration that is estimated by the model to provide 0.55 CFS of in-stream flow on average over the period of record at the full 7MGD demand is described in Table 7. In addition, there will be some seepage through the dam and abutments that will also contribute to in-stream flow. When the reservoir level drops below the elevation of 913' (9.3' below normal pool) the orifices will not allow any flow to pass, but seepage through the dam and abutments will continue. The low orifice elevation is set 0.7' above the base of the weir wall to allow space for the flange.

To provide some basis for comparison to existing conditions, the unit runoff method was applied to the entire East Locust Creek Reservoir watershed using the unit area flow from the stream gage system described above to develop the pre-lake watershed runoff curve shown in Figure 13. Based on the daily reservoir elevation calculated by the model over the 1950-2017 time frame with the full 7 MGD demand, the orifice equation was used to calculate daily flow through the in-stream flow orifice system and the spillway rating curve was used to calculate daily spillway flow. The seepage through the dam was estimated at 1% of the total seepage from the reservoir described in Section 2.3. Figure 13 also shows the resulting flow duration curve for East Locust Creek and the contributions from the proposed reservoir for the 1950-2017 time frame. Appendix A provides similar curves for other demand rates less than 7 MGD for use in estimating reservoir operations and stream flows prior to when the full demand is used.

The flow duration curves show that at most times there will be less water in the stream after the reservoir is built. This is not a surprising result because the reservoir is being built for water supply purposes and a significant amount of water will go to water supply. However, during the drier times, it will not be uncommon for the reservoir to pass some water downstream when there wouldn't have been water without the dam. The curves also show that the reservoir will reduce the volume of flooding that is passed downstream during large storm events.

Table 7. In-Stream Flow Orifice Details

Reservoir Elevation (ft)	Feature	Flow through Orifice System at Reservoir Elevation (CFS)
924.8’	Auxiliary/Emergency Spillway	1.77
922.3’	Principal Spillway	1.49
917’	2 – 2.5” diameter orifices	0.52
915’	2 – 2” diameter orifices	0.15
913’	1 – 1.5” diameter orifices	0
912.3’	Bottom of weir wall, spillway floor	0



The impacts on the stream below the dam will be most noticeable near the dam and will recede further downstream as the reservoir watershed becomes a smaller fraction of the overall watershed. At 5.39 miles downstream from the dam the Elmwood Branch brings the drainage area up to 49.3 square miles, but it also adds the relatively reliable 1.5 CFS flow of treated process water from the Smithfield pork processing plant. According to the 2019 MDNR Stream Classification data set, East Locust Creek becomes perennial just downstream of this point.

At 20.9 miles downstream is the confluence with Little East Locust Creek and the total drainage area is 121 square miles and the reservoir drainage area is 27% of the watershed. At 22.8 miles downstream from the dam East Locust Creek pours into Locust Creek and the total drainage area below the confluence is 380 square miles and the reservoir drainage area is 8.5% of the total watershed. By the time Locust Creek reaches Pershing State Park, the first downstream recreational access to a stream, the reservoir is only 6% of the total watershed.

3.3 Reservoir Startup Scenarios

Several model scenarios were run to evaluate the range of possibilities for time to fill the reservoir based on the precipitation conditions throughout the period of record. These scenarios were run by setting the reservoir volume to zero at various scenario start dates to see how long it takes to recover to full pool under the conditions at that time. To capture the likely range of water demand during the filling period, startup scenarios were run at both 0 MGD and 3 MGD demand. Given the time it will take to expand the water supply system to reach the additional customers, it is unlikely that the water demand will exceed 3 MGD during the filling period. Table 8 describes the scenarios and lists the time required to fill the reservoir under the evaluated scenarios. The average monthly Palmer Drought Severity Index (PDSI) for north eastern Missouri is also included for the time of filling to provide a quantitative description of conditions at the time. To simulate in-stream flows during the reservoir startup scenarios it was assumed that steps would be taken to produce an average of 0.5 CFS of in-stream flow per day during filling, even when the reservoir level is below the passive in-stream flow orifices. The in-stream flow release during reservoir filling is anticipated as a step taken to avoid an initial possible multiyear dry period for the stream. Figure 14 shows the reservoir level over time for these various scenarios. Figure 15 compares the filling time to the average PDSI during the filling time.

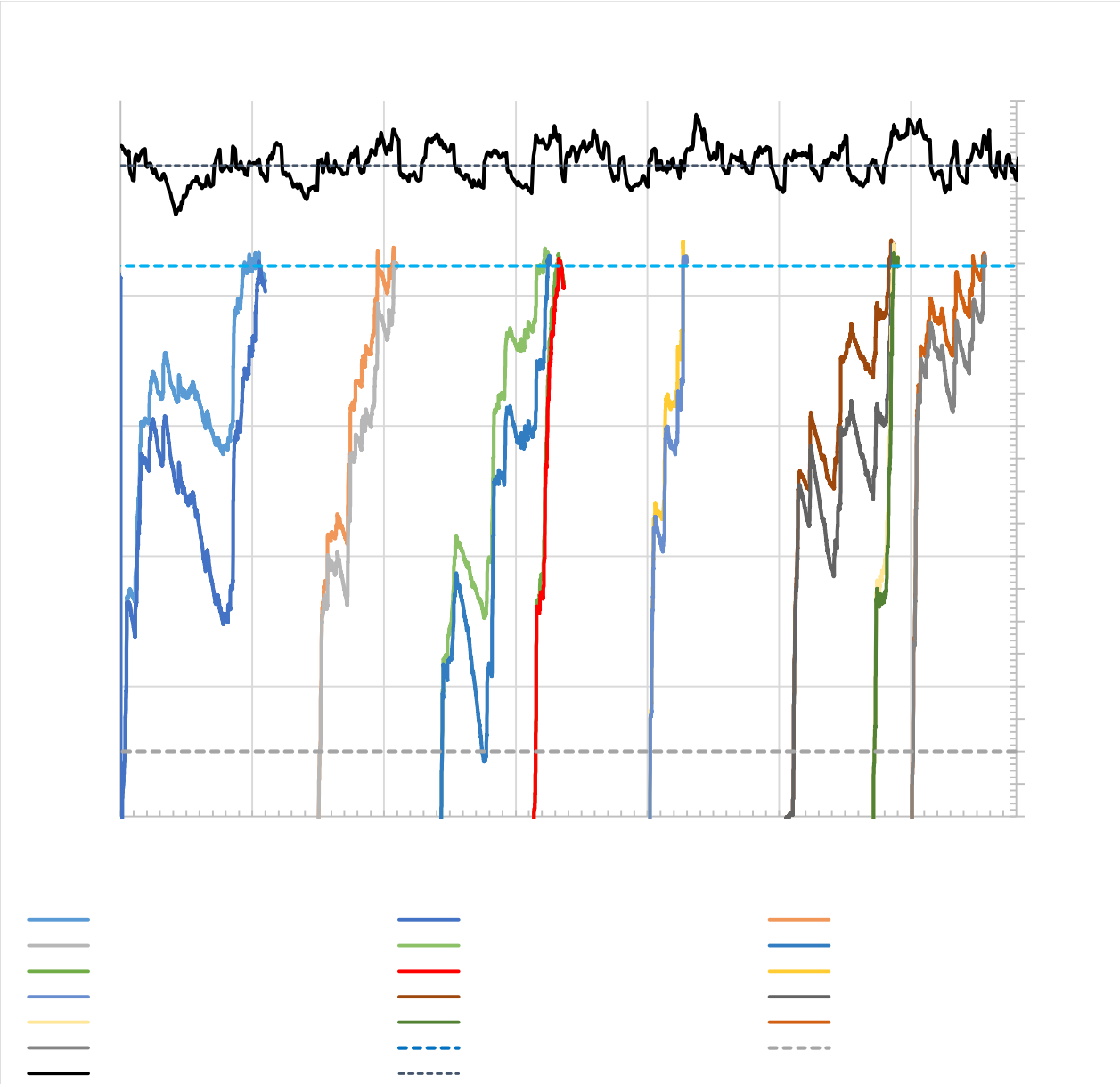
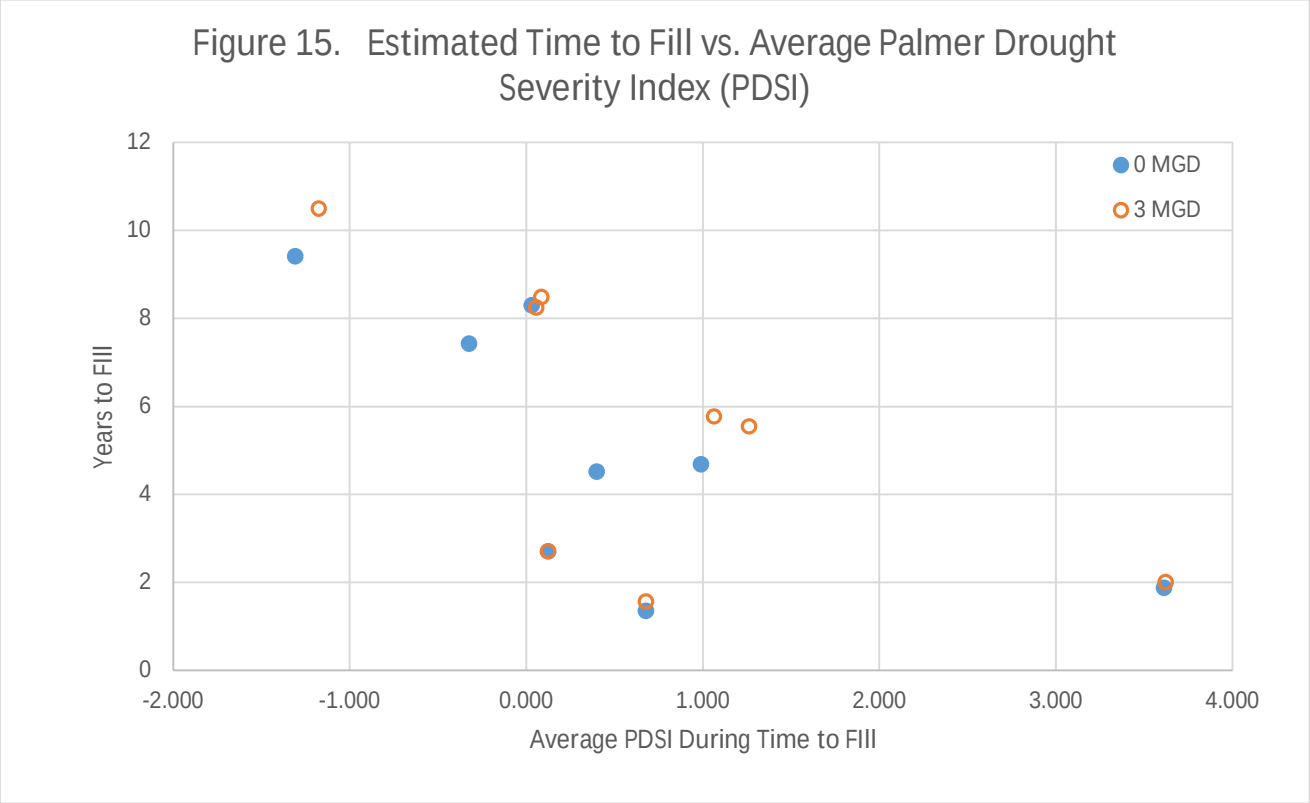


Table 8. Time Required to Fill Reservoir under various scenarios				
Start Date	Scenario Description	Average PDSI* during filling period @0 MGD (and @3MGD)	Years To Fill	
			@ 0 MGD Demand	@ 3 MGD Demand
1/1/1950	Drought of Record	-1.310 (-1.175)	9.41	10.50

Table 8. Time Required to Fill Reservoir under various scenarios				
Start Date		Average PDSI*	Years To Fill	
			@ 0 MGD Demand	@ 3 MGD Demand
1/1//1965		0.400 (1.063)	4.52	5.77
3/1/1974		-0.325 (0.057)	7.43	8.25
4/1/1981	Wettest Period in 1900s	3.613 (3.622)	1.88	2.01
1/1/1990		0.123 (0.123)	2.70	2.71
1/1/2000	Drought of early 2000s	0.031 (0.085)	8.30	8.49
2/19/2007	Recovery from dry years	0.678 (0.678)	1.36	1.57
1/1/2010		0.989 (1.261)	4.69	5.55

* Palmer Drought Severity Index



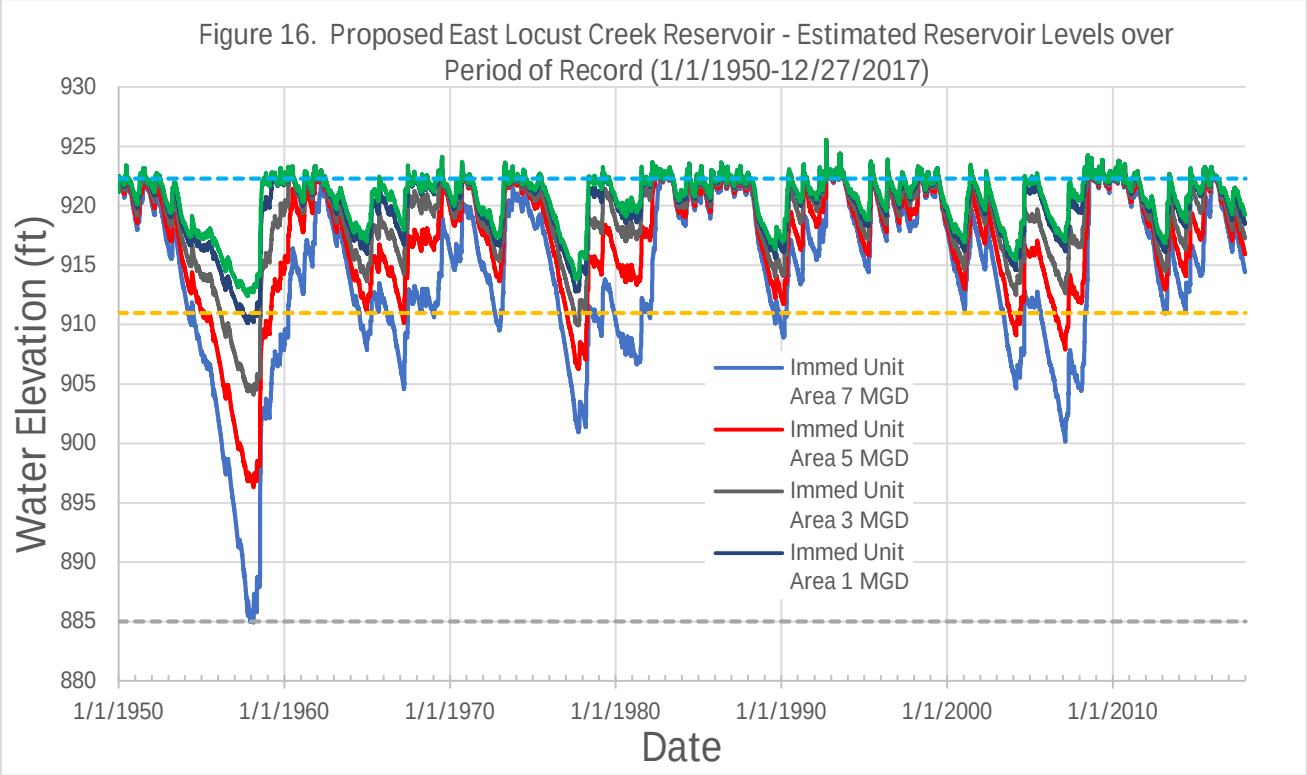
3.4 Reservoir Fluctuation

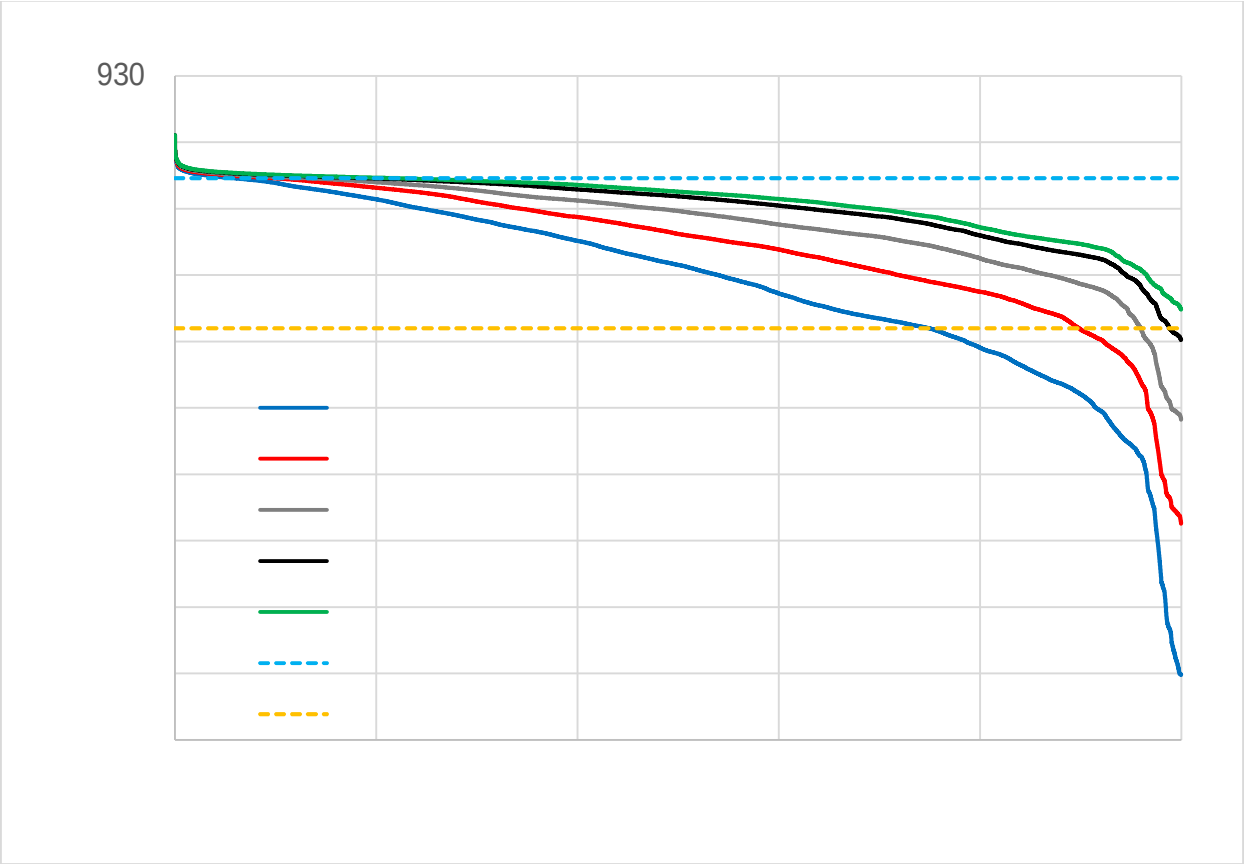
3.4.1 Operational Levels

Operational level simulations were run by setting the reservoir level to normal pool at the beginning of 1950 and running the model for the period of record. In-stream flows were included in these simulations based on the orifice system described above and all other inputs and outputs were as described in Section 2. However, the water supply demand was varied from 0 to 7 MGD to provide insight into how the reservoir levels might fluctuate at any given demand because the full 7 MGD demand could take anywhere from 10-30 years to develop. Consideration was given to modeling a ramp up in demand, but such modeling would only be valid if climactic conditions repeated the exact temporal patterns in the period of record.

Figure 16 provides the model results over the period of record for the range of demands from 0 MGD to 7 MGD. Figure 17 shows the results in the form of a reservoir level frequency diagram.

A main goal of completing this analysis is to set an operational level to which the reservoir facilities will be designed. Given the model results, it seems appropriate to design the reservoir facilities to operate normally for 75% of the time when the reservoir is providing 7 MGD. This equates to a reservoir level of 911'. At this elevation, the reservoir surface area would be 1,710 acres. Below this level, recreational activities on the lake can still be allowed but with restrictions and cautions.





Model predicted maximum rates of reservoir level drop were evaluated to determine whether there is cause for concern about slope failures for embankments or shoreline around the reservoir. Rates were calculated by subtracting each day from the previous day to find the maximum reservoir level drop over a single day. The rate of drop was also averaged over 7, 14, 30, 90, and 180 days and over 1, 3 and 5 years to find the highest extended period of reservoir level drop. The maximum drop rates are provided in Table 9. Not surprisingly, the shorter duration drops all start when the reservoir is above normal pool (922.3').

Table 9. Maximum WBM Reservoir Level Drop Rates

Time Period	1 Day	7 Days	14 Days	30 Days	90 Days	180 Days	1 Year	3 Years	5 Years
Starting Date	7/6/1993	7/25/1993	7/25/1993	9/16/1992	7/16/1957	4/25/1957	10/22/1956	10/23/1954	10/22/1952
Ending Date	7/7/1993	8/1/1993	8/8/1993	10/16/1992	10/14/1957	10/22/1957	10/22/1957	10/22/1957	10/22/1957
Starting Elev. (ft)	924.3	924.4	924.4	924.6	889.4	891.8	896.2	908.9	917.8
Ending Elev. (ft)	924.0	923.0	922.6	922.7	885.8	885.5	885.5	885.5	885.5
Total Drop (ft)	0.3	1.3	1.8	1.9	3.5	6.2	10.7	23.4	32.2
Rate (in/day)	3.9	2.3	1.5	0.7	0.5	0.4	0.4	0.3	0.2

A similar analysis was conducted to determine the maximum rates of rise. Results are presented in Table 10.

Table 10. Maximum WBM Reservoir Level Rise Rates									
Time Period	1 Day	7 Days	14 Days	30 Days	90 Days	180 Days	1 Year	3 Years	5 Years
Starting Date	9/14/1992	7/14/1958	7/14/1958	7/14/1958	7/2/1958	2/2/2008	5/3/1958	5/2/1958	10/22/1957
Ending Date	9/15/1992	7/21/1958	7/28/1958	8/13/1958	9/30/1958	7/31/2008	5/3/1959	5/1/1961	10/22/1962
Starting Elev. (ft)	918.3	888.7	888.7	888.7	887.9	904.4	885.8	885.8	885.5
Ending Elev. (ft)	923.4	897.5	897.7	901.7	902.6	922.6	907.0	916.7	919.1
Total Rise (ft)	5.1	8.9	9.0	13.1	14.8	18.2	21.2	30.9	33.6
Rate (in/day)	61.2	15.2	7.7	5.2	2.0	1.2	0.7	0.3	0.2

3.4.2 Flood Levels

The determination of flood levels for the reservoir are described in Appendix C, East Locust Creek Reservoir Hydrology Report. The watershed and proposed dam were modeled using the United States Department of Agriculture (USDA) SITES program, version 3.5. Per the guidance in the Natural Resources Conservation Service Technical Release 60, “Earth Dams and Reservoirs” issued July, 2005 (TR-60), and the National Engineering Handbook (NEH), Part 630 - Hydrology, USDA NRCS, version 2010. The report includes analysis of reservoir flood levels based on an assumption that the reservoir starts out full when flood events occur. Table 11 summarizes the flood elevations documented in Appendix C and applies the stage storage information described in Section 2.6 to estimate the area flooded. If a flood event occurs when the reservoir level is below normal pool, the flood elevation and area flooded will be lower than reported.

Table 11 Reservoir Flood Levels			
Annual Exceedance Probability (%)	Return Period (Yrs)	Elevation (ft)	Area (ac)
Normal Pool		922.30	2,328
100%	1	923.35	2,396
50%	2	923.59	2,416
20%	5	924.03	2,452
10%	10	924.44	2,484
4%	25	924.90	2,519
2%	50	925.53	2,565
1%	100	925.97	2,595
Top of Dam		938	3,580

4.0 Conclusions

Based on the assumptions and historical conditions used in this model, it appears that the proposed reservoir level will fluctuate significantly, but in addition to being able to provide 7 MGD will be able to sustain the other two major project purposes which are:

- Provide reservoir based recreational opportunities
- Provide flood damage reduction benefits

In addition, the reservoir will be able to provide in-stream flows with an average value of 0.5 CFS over a range of historical conditions like those from the years 1950 through 2017.

The reservoir should be designed to function normally when the reservoir is down to an elevation of 911 feet. However, this should be considered a general guiding principle not a hard and fast rule. Some situations may warrant designing for lower water. For example, a boat ramp that facilitates emergency operations might be extended to be useable when the lake is below normal operating level. Likewise, for some situations it might be acceptable to design to higher levels. There would be no point in improving an entrance to a shallow cove to provide boat access to elevation 911' if the bottom of the cove is at 912'.

5.0 REFERENCES

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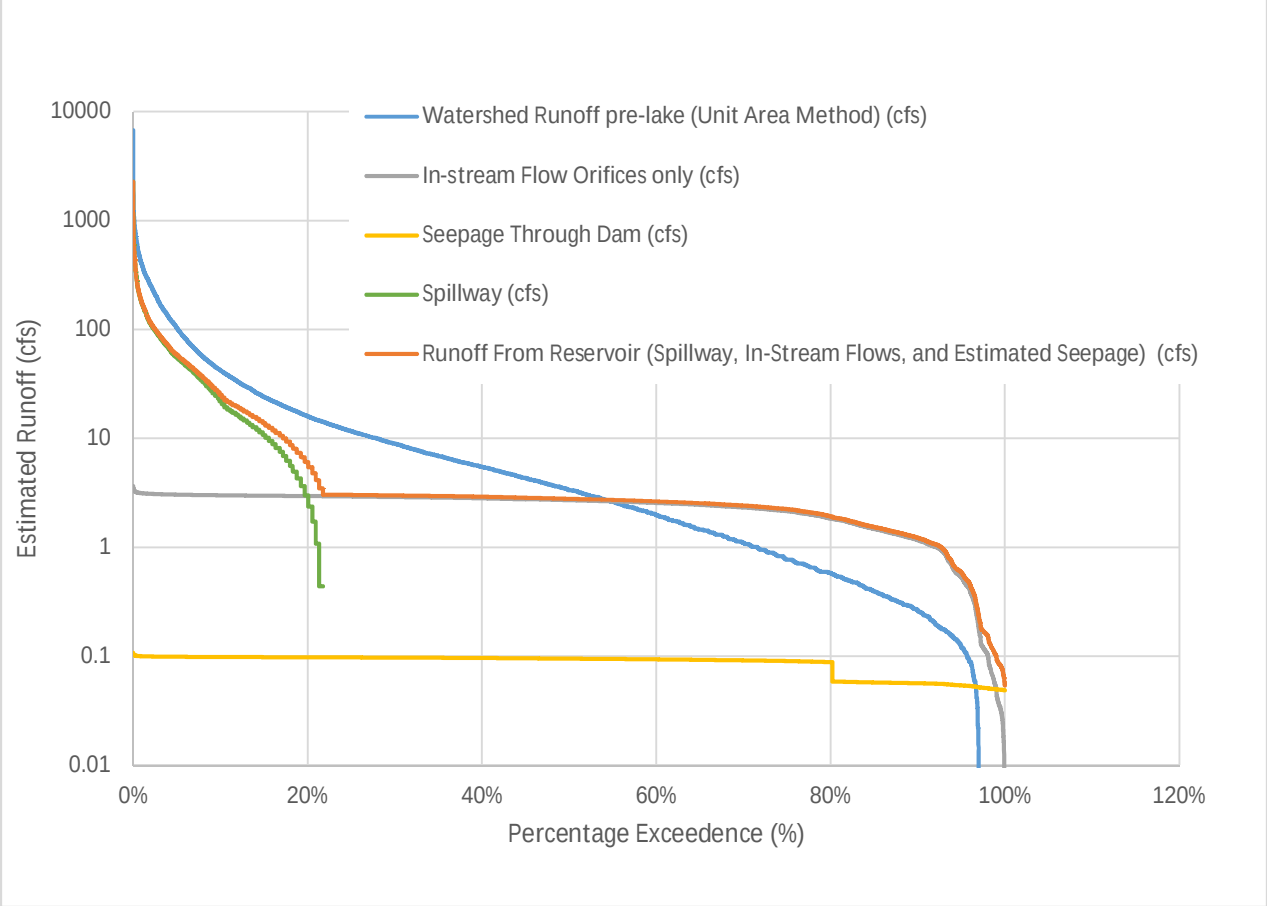
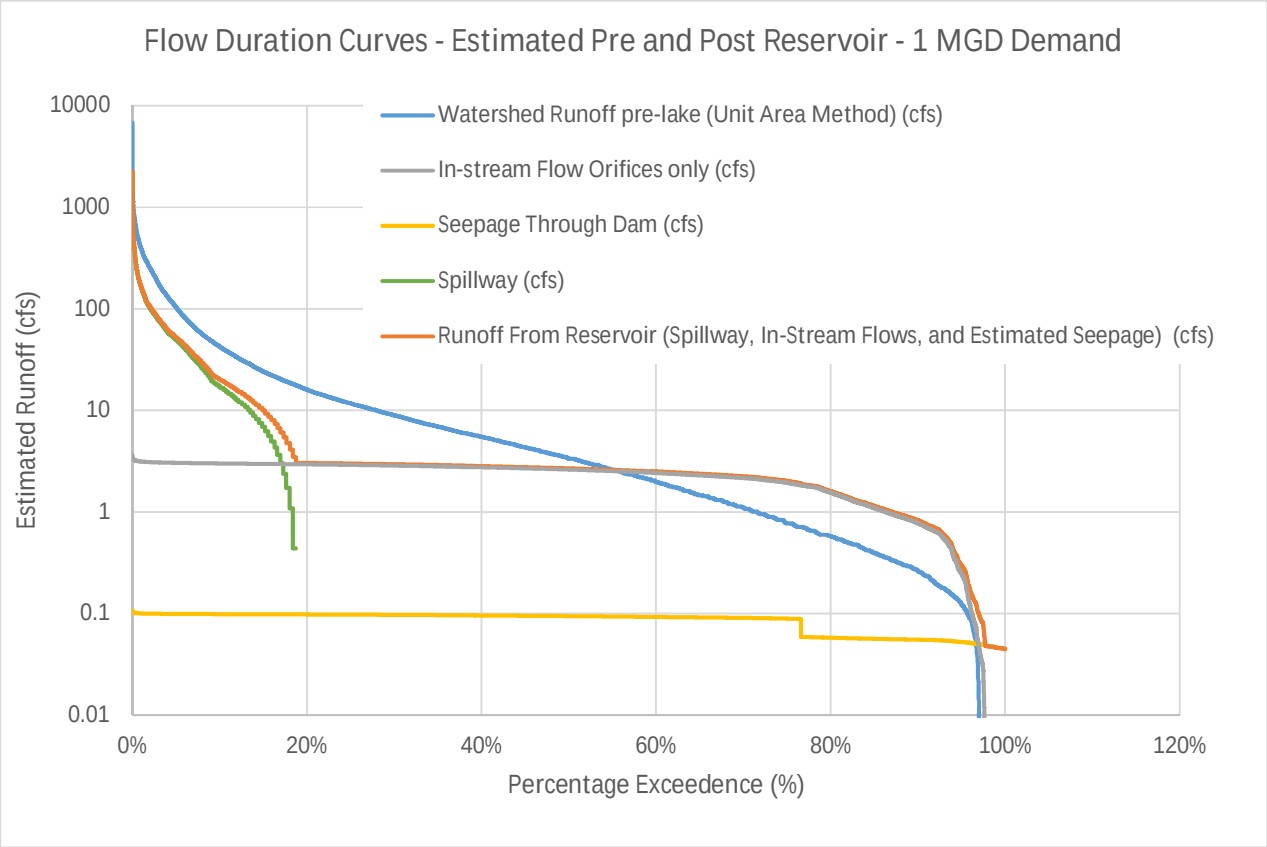
East Locust Creek Reservoir Water Budget Summary

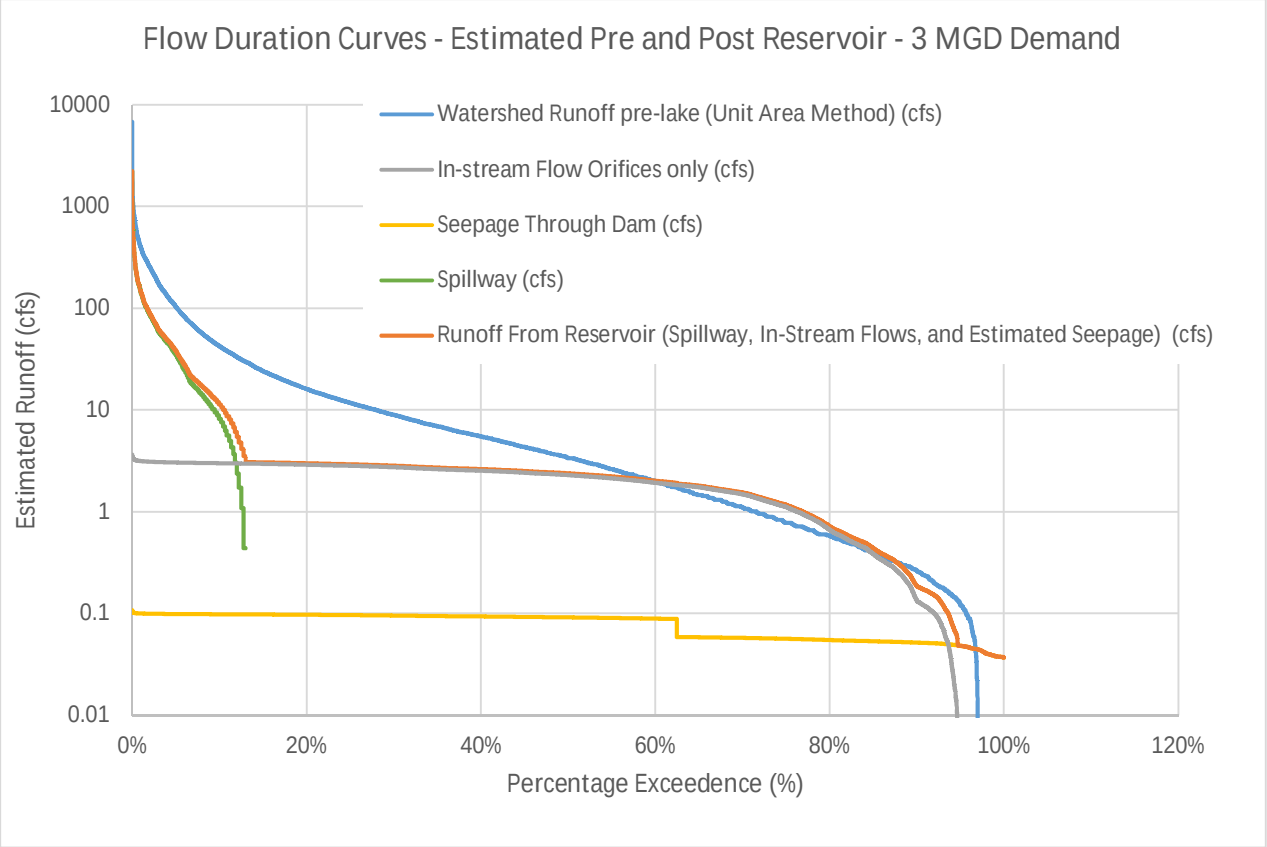
Appendix A.

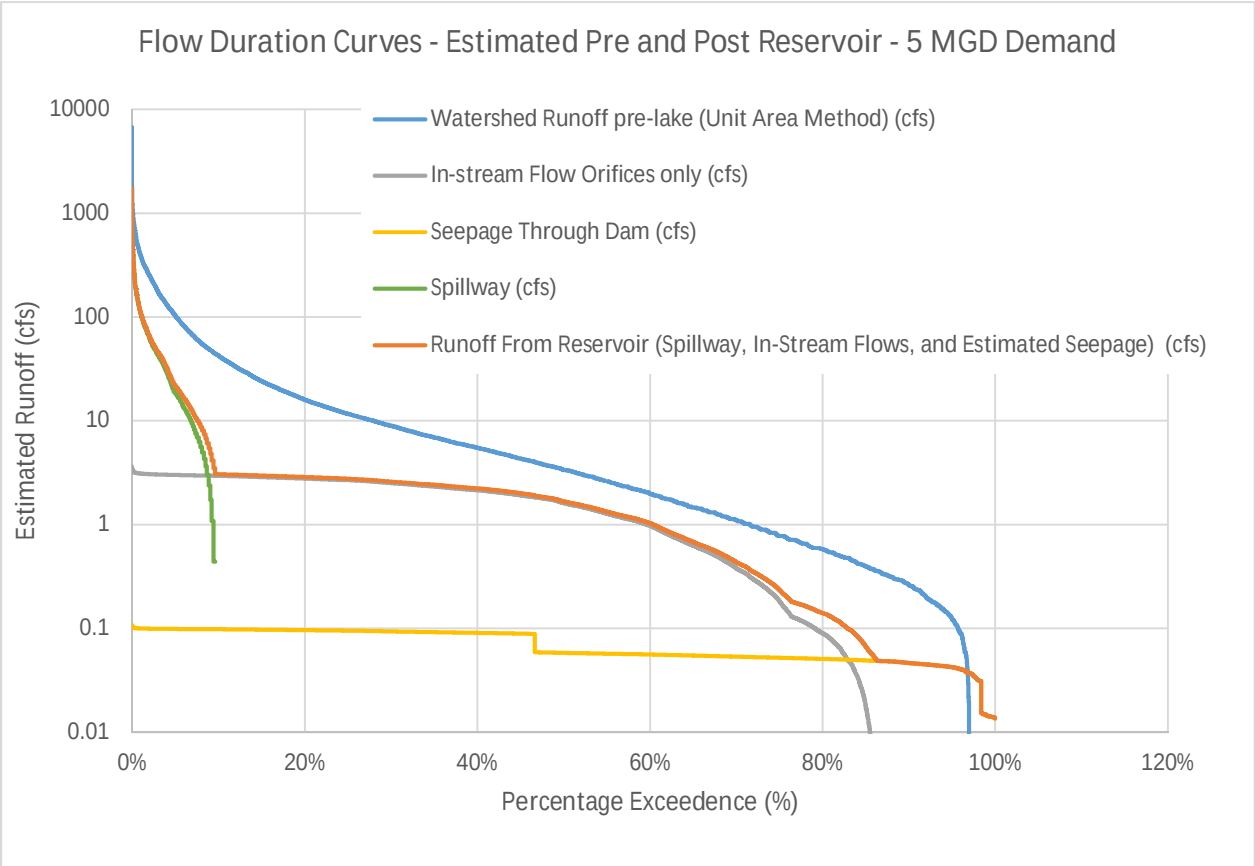
WBM Results at Varying Water Supply Demand Rates

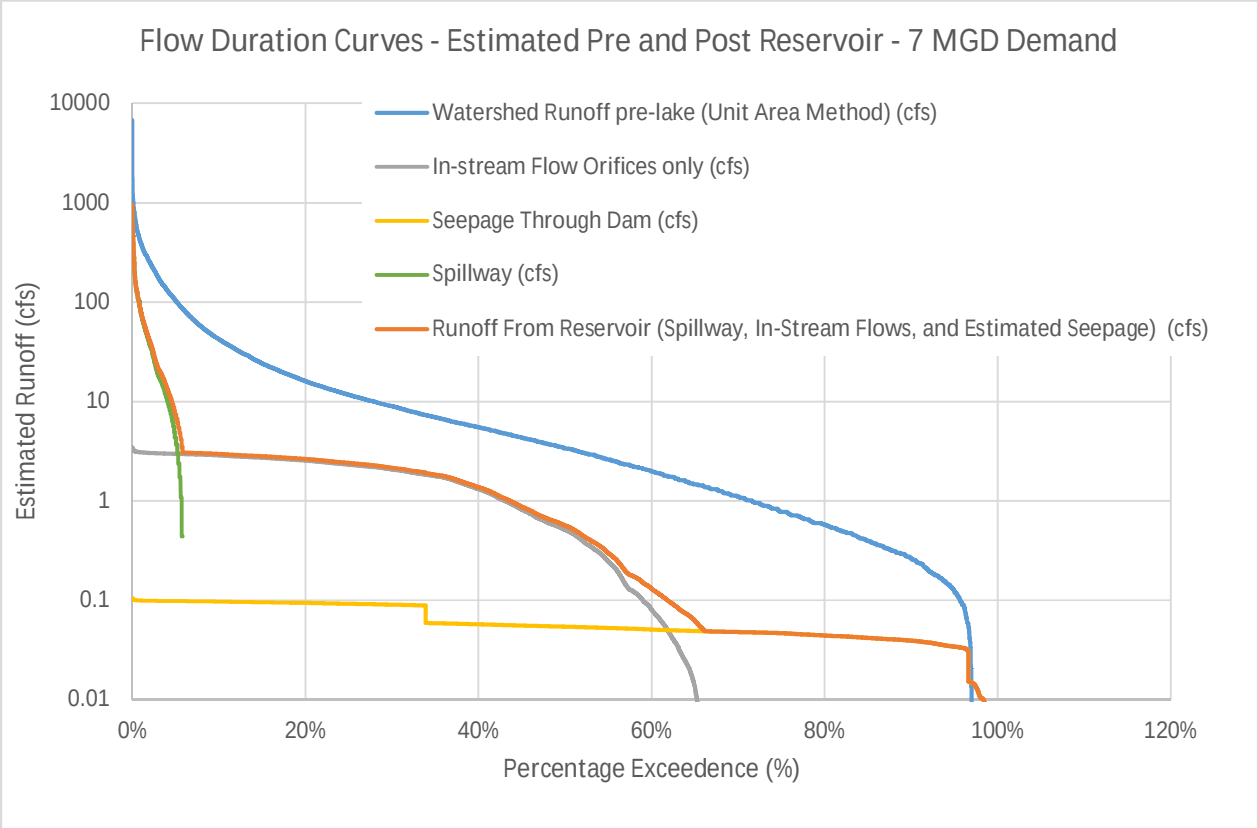
Flow Duration Curves



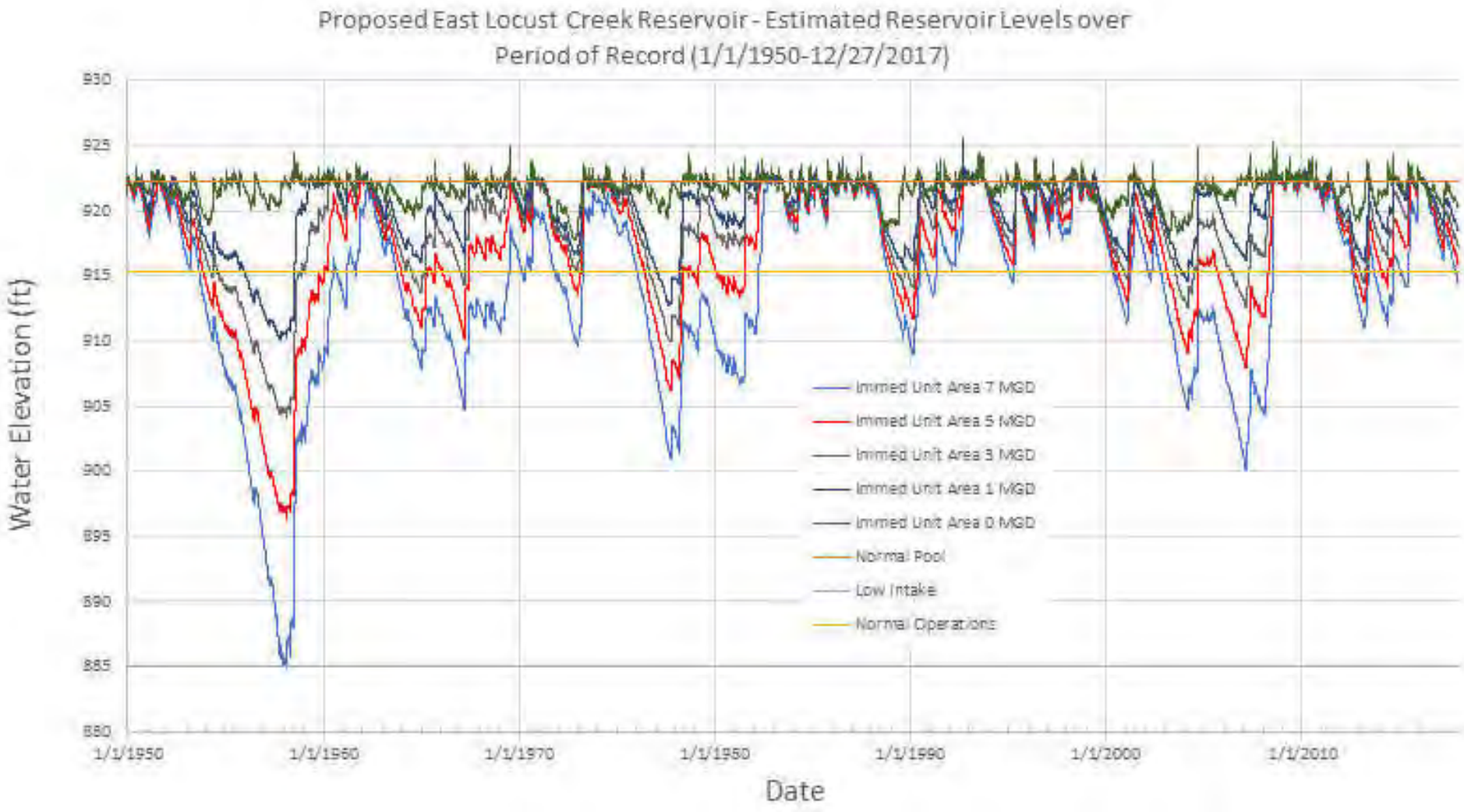

Flow Duration Curves - Estimated Pre and Post Reservoir - 1 MGD Demand
Watershed Runoff pre-lake (Unit Area Method) (cfs)
In-stream Flow Orifices only (cfs)
Seepage Through Dam (cfs)
Spillway (cfs)
Runoff From Reservoir (Spillway, In-Stream Flows, and Estimated Seepage) (cfs)
Estimated Runoff (cfs)
10000
1000
100
10
1
0.1
0.01
0%
20%
40%
60%
80%
100%
120%
Percentage Exceedence (%)


Flow Duration Curves - Estimated Pre and Post Reservoir - 3 MGD Demand
Watershed Runoff pre-lake (Unit Area Method) (cfs)
In-stream Flow Orifices only (cfs)
Seepage Through Dam (cfs)
Spillway (cfs)
Runoff From Reservoir (Spillway, In-Stream Flows, and Estimated Seepage) (cfs)
Estimated Runoff (cfs)
10000
1000
100
10
1
0.1
0.01
0%
20%
40%
60%
80%
100%
120%
Percentage Exceedence (%)


Flow Duration Curves - Estimated Pre and Post Reservoir - 5 MGD Demand
Watershed Runoff pre-lake (Unit Area Method) (cfs)
In-stream Flow Orifices only (cfs)
Seepage Through Dam (cfs)
Spillway (cfs)
Runoff From Reservoir (Spillway, In-Stream Flows, and Estimated Seepage) (cfs)
Estimated Runoff (cfs)
10000
1000
100
10
1
0.1
0.01
0%
20%
40%
60%
80%
100%
120%
Percentage Exceedence (%)


Flow Duration Curves - Estimated Pre and Post Reservoir - 7 MGD Demand
Watershed Runoff pre-lake (Unit Area Method) (cfs)
In-stream Flow Orifices only (cfs)
Seepage Through Dam (cfs)
Spillway (cfs)
Runoff From Reservoir (Spillway, In-Stream Flows, and Estimated Seepage) (cfs)
Estimated Runoff (cfs)
10000
1000
100
10
1
0.1
0.01
0%
20%
40%
60%
80%
100%
120%
Percentage Exceedence (%)

Reservoir Levels



East Locust Creek Reservoir Water Budget Summary

Appendix B.

East Locust Creek Reservoir Hydraulics Report

EAST LOCUST CREEK RESERVOIR
HYDRAULICS REPORT

PREPARED FOR

NORTH CENTRAL MISSOURI
REGIONAL WATER COMMISSION

MILAN, MISSOURI

STATE OF MISSOURI
BRIAN H. LADD
NUMBER
PE-2014012020
5-31-17
PROFESSIONAL ENGINEER

May 2017

Olsson Associates Project No. A11-1513

OLSSON ASSOCIATES

Table of Contents

1.0 Dam Outflow Structure 1
1.1 Previously Completed Design 1
1.2 Design of Outflow Structure 1
1.2.1 Design References 2
1.2.2 Proposed Outflow Structure 2
1.2.3 Storm Routing 5
2.0 Spillway Chute and Stilling Basin 5
2.1 Previously Completed Design 5
2.2 Proposed Spillway Chute 5
2.3 Proposed Stilling Basin 6
2.4 Proposed Channel Downstream of Stilling Basin 6

List of Tables

Table 1. Previous Completed Outflow Structure Information 1
Table 2. Proposed Outflow Structure Notch Information 2
Table 3. Proposed Outflow Structure Notch Stage Outflow 3
Table 4. Proposed Outflow Structure Information 3
Table 5. Proposed Full Outflow Structure Stage Outflow 4
Table 6. Composite Stage Outflow 4
Table 7. Proposed Spillway Chute Information 6
Table 8. Proposed Stilling Basin Information 6
Table 9. Downstream Channel, PMP Storm Summary 7
Table 10. Downstream Channel, 100-year Storm Summary 7

List of Appendices

Appendix A Labyrnith Wier Design References and Calculations
Appendix B Spillway Chute and Stilling Basin Design References and Calculations

A reservoir on East Locust Creek near Milan, Missouri (ELCR) is proposed to provide flood control, recreation and water supply for the surrounding community. The proposed reservoir has been in the planning stages since the 1980s. The design of the proposed reservoir will follow the Natural Resource Conservation Service (NRCS) guidelines for dam construction. This report addresses the hydraulics for the dam outfall, spillway chute and stilling basin of the proposed reservoir. The hydrology for ELCR is addressed in "East Locust Creek Reservoir Hydrology Report" Olsson Associates, June 2015.

1.0 DAM OUTFLOW STRUCTURE

The outflow structure for ELCR was designed to provide an economical, low maintenance and safe structure that meets freeboard requirements and allows the dam to fulfill the primary purposes of flood control, recreation and water supply for the surrounding community. The freeboard requirements for the dam are based on passing the Probable Maximum Precipitation (PMP) 5-point storm event with adequate freeboard to the top of the dam. The required calculated freeboard for the dam during the PMP event is 1.13 feet from the peak PMP elevation to the top of the dam. ELCR is proposed as an earthen embankment and erosion must be prevented along the flow path from the reservoir outflow structure to the toe of the dam to ensure the stability of the dam.

1.1 Previously Completed Design

A preliminary sizing of an outflow structure and spillway chute was completed by URS in 2013. The design consisted of a combined emergency and primary spillway with a labyrinth weir as the outfall structure, a concrete spillway chute and an energy dissipation basin. The summary of the outflow structure designed in 2013 can be seen in Table 1. The spillway design met all freeboard requirements and provided a feasible outflow structure for ELCR.

Table 1. Previous Completed Outflow Structure Information

Outflow Structure Summary	
Spillway Width	70 feet
Apex Width	4 feet
Number of Cycles	2
Magnification	1.3
Side Wall Angle	46.05º
Flow Line Elevation	924.8

1.2 Design of Outflow Structure

The design completed by URS was reviewed and it was determined that potential cost savings could be achieved. Several options were investigated to reduce cost and meet the design requirements and reservoir objectives. It was determined that a combined primary and emergency outflow structure labyrinth weir was the most economical option, however a revised configuration was designed to reduce costs.

1.2.1 Design References

The design of labyrinth weirs was completed using the equations developed by Henry Falvey and published in *Hydraulic Design of Labyrinth Weirs* (Falvey, Henry, T., *Hydraulic Design of Labyrinth Weirs, 2003)* additional research and testing into the flow characteristics of labyrinth weirs was completed and published by Brian Crookston (Crookston, Brian, M. *Hydraulic Design and Analysis of Labyrinth Weirs. 1: Discharge Relationships,* J. Irrig Drain Eng. 2013). The research completed by Brian Crookston concluded that coefficient adjustments for the equations developed in the *Hydraulic Design of Labyrinth Weirs* should be used to better analyze the proposed weir structure. In the analysis of the outflow structure the updated coefficients were used to analyze the proposed outflow structure.

1.2.2 Proposed Outflow Structure

The proposed labyrinth outflow structure is a two-stage outflow structure with a lower notch of the outflow structure at elevation 922.3 and the higher portion of the outflow structure set at elevation 924.8. The lower and higher portions of the outflow structure will provide a stage outflow curve that will allow for flood storage and will also maintain adequate freeboard to the top of the dam.

1.2.2.1 Low Flow Notch

The lower notch portion of the outflow structure was set to a length of 27.5 feet. The lower notch of the outflow structure will be constructed in the middle of the proposed outflow structure. The outflow structure was modeled using the equations for the calculation of flow over labyrinth weirs with the amended coefficients. The proposed outflow structure design parameters for the notch portion of the outflow structure are summarized in Table 2.

Table 2. Proposed Outflow Structure Notch Information

Outflow structure Summary	
Outflow structure Width	27.5 feet
Apex Width	4 feet
Number of Cycles	0.5
Magnification	2
Side Wall Angle	27.07º
Flow Line Elevation	922.3

The stage outflow table for the notch portion of the weir can be seen in Table 3. The flow in the notch portion of the spillway ranges from 924.8 to 922.3. The upper stage of the outflow structure begins at 924.8 and the effective length of the outflow structure is increased.

Table 3. Proposed Outflow Structure Notch Stage Outflow

Flow (cfs)	Elevation
753	924.80
642	924.55
536	924.30
436	924.05
342	923.80
256	923.55
179	923.30
112	923.05
59	922.80
19	922.55
0	922.30

1.2.2.2 Full Outflow structure

Once flow from the proposed reservoir reaches 924.8 the outflow will flow over the full width of the weir. The full width of the proposed outflow structure is 55 feet at elevation 924.8. The proposed outflow structure design parameters are summarized in Table 4.

Table 4. Proposed Outflow Structure Information

Outflow Structure Summary	
Outflow structure Width	55 feet
Apex Width	4 feet
Number of Cycles	1
Magnification	2
Side Wall Angle	27.07º
Flow Line Elevation	924.8

The stage outflow for upper full width portion of the can be seen in Table 5. The peak elevation for the notch portion of the outflow structure was calculated to 936.

Table 5. Proposed Full Outflow Structure Stage Outflow

Flow (cfs)	Elevation
10064	936.00
8717	934.60
7482	933.30
6135	931.90
4739	930.50
3399	929.20
1977	927.80
749	926.40
27	925.00
9	924.90
0	924.80

1.2.2.3 Composite Runoff Curve

The composite runoff curve for the labyrinth weir was computed by combining the flow from the notch outflow structure and the flow from the full width weir. The flow from the notch portion of the weir was only added into the composite curve from 922.3 to 924.8. Above elevation 924.8 the flow goes over the full outflow structure. It is assumed that when flow is above elevation 924.8 that the notch outflow structure is flowing full at 753 cfs. Table 6 gives the composite stage outflow curve for the combined outflow structure.

Table 6. Composite Stage Outflow

Flow (cfs)	Elevation
10817	936.00
9469	934.60
8235	933.30
6887	931.90
5491	930.50
4152	929.20
2730	927.80
1501	926.40
780	925.00
762	924.90
753	924.80

The proposed outflow structure will function as the primary and emergency outflow structure for ELCR. The openness of the labyrinth weir outflow structure will prevent clogging by brush and other debris. The outflow structure can also be easily inspected to assure proper function. The 55-foot-wide outflow structure with the labyrinth weir will reduce costs compared to the 70-foot-wide design and will still provide the required outflow from the reservoir.

1.2.3 Storm Routing

The composite elevation discharge curve was input into the SITES software program to determine the water surface elevation for the various storms. The 25-year 24-hour storm and PMP 5-point hydrograph were routed through the proposed outflow structure. The maximum elevation of the 25-year storm is 924.9. The majority of the 25-year outflow from the dam will pass through the lower notch outflow structure and the upper portion of the outflow structure will experience flows in storm events larger than the 25-year storm.

The peak elevation for the PMP 24 hour 5-point storm is 936.02 the top of dam is 938 which results in a freeboard of 1.98 feet.

The calculated freeboard required for the dam is 1.13 feet. The provided freeboard of 1.98 feet is above the required freeboard of 1.13 feet and provides extra protection from overtopping in the extreme storm events.

2.0 SPILLWAY CHUTE AND STILLING BASIN

Flow from the proposed labyrinth weir structure flows down the dam and into East Locust Creek. To protect the integrity of the dam and slow flows before they reach East Locust Creek a concrete spillway and stilling basin were designed for the dam.

2.1 Previously Completed Design

A preliminary sizing of an outflow structure and spillway chute was completed by URS in 2013. The design consisted of a combined emergency and primary spillway with a labyrinth weir as the outfall structure, a concrete spillway chute and an energy dissipation basin. The width for the spillway chute was set at 70 feet to match the width of the previously designed labyrinth weir.

2.2 Proposed Spillway Chute

The proposed spillway chute was modeled using the HEC-RAS software program. Since the spillway functions as the primary and emergency spillway the spillway was sized using the peak PMP outflow, 10,817 cfs, calculated in the SITES modeling. The freeboard requirements for the spillway walls were calculated using the Design of Small Dams, United States Bureau of Reclamation, 1987. The spillway width was set at 55 feet to match the width of the labyrinth spillway. The labyrinth weir was modeled as an inline structure in HEC-RAS. The weir coefficient of the inline structure was adjusted to obtain the peak elevation that was calculated in the routing of the PMP storm in SITES. The proposed concrete spillway chute was modeled in HEC-RAS with an interpolated cross section approximately every 10 feet. The freeboard was calculated using the formula from the *Design of Small Dams*. The flow in the spillway is supercritical and will be dissipated in a stilling basin before the flow enters the receiving stream. The summary of the spillway chute can be seen in Table 7.

Table 7. Proposed Spillway Chute Information

Spillway Chute Summary	
Chute Width	55 feet
Minimum Wall Height	10 feet
Maximum Velocity	52 feet/sec
Maximum Froude Number	4.66
Channel Slope	12.5%

The wall heights along the spillway chute were adjusted to match site conditions, however the minimum 10-foot wall height was maintained along the spillway chute.

2.3 Proposed Stilling Basin

The stilling basin was designed to dissipate energy from the spillway chute before the flow enters East Locust Creek. The stilling basin was designed using the guidance in the USBR Design of Small Dams. The Froude number is greater than 4.5 and the velocity in the channel upstream of the stilling basin is less than 60 feet/sec therefore a Type III basin was selected to dissipate the energy from the spillway chute. Table 8 provides a summary of the stilling basin.

Table 8. Proposed Stilling Basin Information

Stilling Basin Summary	
Basin Width	55 feet
Height of Hydraulic Jump	24.5 feet
Required Freeboard	7.7 feet
Wall Height	32.2 feet
Chute Block Height	4.1 feet
Baffle Block Height	5.7 feet
Length of Basin	56.3 feet
End Sill Height	5.1 feet

2.4 Proposed Channel Downstream of Stilling Basin

The channel downstream of the stilling basin will convey the water from the stilling basin to East Locust Creek. A trapezoidal channel is the most efficient design shape, and the channel will be lined with riprap to prevent erosion. The channel downstream will also provide the required tailwater for the stilling basin. The downstream channel was modeled in HEC-RAS in conjunction with the spillway chute and stilling basin. The channel at the outlet of the stilling basin will be 50-foot-wide at the base, and the channel will transition to a 20-foot-wide base to increase the tailwater in the stilling basin and limit the extents of excavation. The velocity in the channel at the outlet to East Locust Creek in the 100-year event is approximately 13 feet/sec. Riprap will be utilized for energy dissipation and slope protection at the transition from the proposed trapezoidal channel to the natural stream channel. The flow parameters in the channel for the PMP storm and the 100-year event are summarized in Table 9 and Table 10.

Table 9. Downstream Channel, PMP Storm Summary

Downstream Channel, PMP Storm, Summary	
Channel Width	20 feet
Peak Velocity	24 feet/sec
Peak Flow Depth	13.0 feet

Table 10. Downstream Channel, 100-year Storm Summary

Downstream Channel, 100-year Storm, Summary	
Channel Width	20 feet
Peak Velocity	13 feet/sec
Peak Flow Depth	3.1 feet

The rip-rap for the trapezoidal channel was sized for the 100-year event using the HEC No. 11. The calculated required D_{50} riprap size for the channel during the 100-year event is 1.44 ft. MoDOT Type 4 ditch lining with a D_{50} of 1.58 feet was selected as the ditch lining gradation for the channel.

APPENDIX A
LABYRNITH WIER DESIGN REFERENCES AND CALCULATIONS

If the function of the roughness is to increase the boundary layer thickness, then the roughness does not need to be placed on the weir crest. In fact, placing the roughness further upstream on the curved crest may be more effective, and a smaller roughness could be used.

As opposed to nappe vibration, which creates noise, the most important consideration with surging deals with the fluctuating pressures on the walls. Frequencies of oscillation are usually measured in a model study to ensure that the surging frequency does not coincide with the natural frequency of the wall.

Attachment A

Chapter 8
Design

Significant Parameters

Studies on labyrinth weirs have shown that the most significant parameters are the length to width ratio, L/W; the total head to crest height ratio, H_o/P; and the sidewall angle, α. The aspect ratio, W/P, which others found to be important, has been replaced by a disturbance to sidewall length ratio, L_d/B. Rounding the crest has only a minor effect on improving the discharge coefficient (< 3%). Finally, the number of weir cycles, n, is not a significant parameter on the discharge characteristics of labyrinth weirs. The approach flow conditions to the labyrinth weir are significant in determining the discharge coefficient for the spillway.

General Guidelines for Parameter Selection

Headwater Ratio

The headwater ratio is the total head on the weir divided by the weir height, H_o/P. Because the discharge coefficient decreases with increasing head, labyrinth weirs have the greatest application where the head is small. Lux (1989) recommends that the maximum headwater ratio be in the range of 0.45 to 0.50. Nevertheless, some labyrinth spillways have been designed with headwater ratios as large as 1. The maximum headwater ratio is more a question of the range over which the model discharge coefficients were determined rather than some absolute value. For example, the maximum headwater ratio for the Tullis et al (1996) tests is an H_o/P of 0.9. Because the equations to be used in the analysis are only valid up to an H_o/P of 0.9, this is the upper headwater limit. If higher values are necessary, then a physical model study of the structure is required.

Vertical Aspect Ratio/Sidewall Angle

The vertical aspect ratio is the width of a weir cycle divided by the weir height, W/P. Taylor (1968) recommends that to minimize the effect of nappe interference, the vertical aspect ratio should be larger than 2. For design purposes, a value between 2.0 and 2.5 is recommended by Lux (1989) for initial computations. As shown in Chapter 3, Nappe Interference, this ratio does not have a significant effect on nappe interference, as has been thought up until now. This criterion has been superseded by the disturbance length concept described below

Magnification Ratio

The magnification ratio is the length of the labyrinth crest divided by the cycle width, L/W. The limit for the curves of Tullis (1994) is an angle of 6°, which corresponds to a magnification ratio of about 9.5. As shown below, the effectiveness of a labyrinth weir decreases rapidly as the magnification ratio exceeds 10. With a magnification ratio of less than 2, consideration should be given to widening the intake or using an ogee crest that is curved in plan rather than using a labyrinth weir.

Sidewall Angle/Magnification

With a triangular labyrinth, the sidewall angle and the magnification are interrelated. The angle is given by

$$\alpha = \sin^{-1}\left(\frac{W}{2 \cdot B}\right) = \sin^{-1}\left(\frac{1}{m}\right) \tag{1}$$

in which m = the magnification ratio.

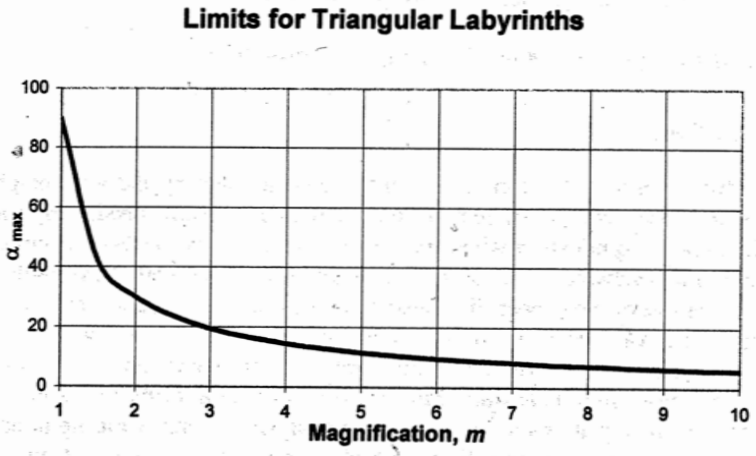


Figure 1. Maximum Angle for Triangular Labyrinth Weirs

Figure 1 gives the maximum angle for a triangular labyrinth weir. With a trapezoidal labyrinth, the angle of the sidewall will be less than that shown in Figure 1 for a given magnification. That is, the relationship between the magnification and the sidewall angle will lie below the curve with a trapezoidal labyrinth.

Efficacy

Actually, the magnification that is chosen applies only to small values of head. As the head increases, the discharge coefficient decreases. Thus, if a labyrinth is to pass the maximum discharge for a given reservoir elevation, then the product of the discharge coefficient and the magnification should be a maximum. Dividing this product by the discharge coefficient for a straight weir is called the efficacy. Efficacy is given by

$$\varepsilon = \frac{C_d(\alpha) \cdot M}{C_d(90^\circ)} \tag{2}$$

in which C_d (α) indicates that the discharge coefficient is a function of the sidewall angle.

Efficacy is essentially the same as the Q_L/Q_N parameter used by Taylor (1968). However, efficacy incorporates the magnification and the effect of the sidewall angle into one parameter. Thus, with this parameter, the benefits of changes in the labyrinth geometry can be estimated quickly during the design process.

The effects of head on the weir and the sidewall angle are clearly shown in Figure 2. The discharge coefficient for different angles is obtained from Figure 8 in Chapter 5, Design Curves.

The magnification parameter for a triangular labyrinth as a function of the sidewall angle is obtained from Figure 1 or Equation 1 above. For example, with an H_o/P of 0.7 and a sidewall angle of 18°, the discharge coefficient is 0.485, the magnification is

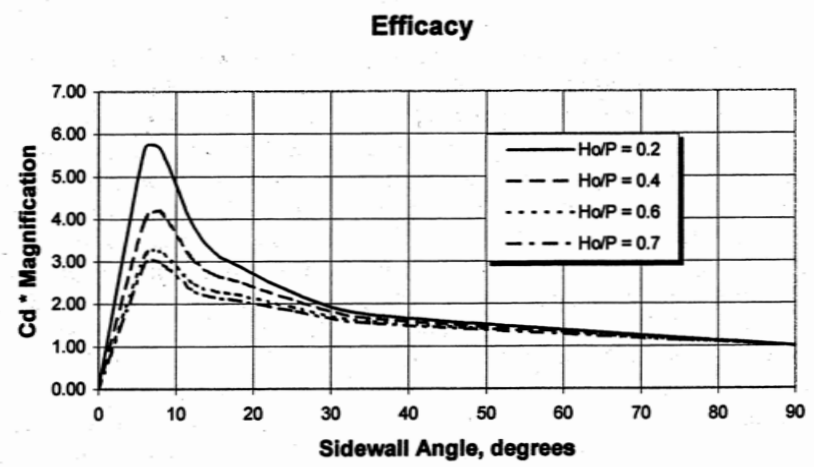


Figure 2. Efficacy for triangular weirs

3.24, and the discharge coefficient for the straight weir is 0.76. This gives an efficacy equal to 2.1. This means that the labyrinth can pass a little more than twice the flow for a given head than can a straight weir. However, if the sidewall angle is decreased to 8°, the efficacy increases to 3 because C_d (α) is 0.315, *m* is 7.18, and C_d (90°) is 0.76. Thus, the weir can pass three times the flow for a given head than can a straight weir.

The efficacy reaches a maximum value for all head ratios at a sidewall angle of about 8°. This angle corresponds to a magnification of 7.2. The efficacy decreases rapidly as the angle becomes smaller than 8°. In addition, Figure 2 shows that the efficacy decreases as the head over the weir increases.

The effects for a trapezoidal weir are similar to those for a triangular weir except that the efficacy does not approach zero as the sidewall angle approaches zero. With a trapezoidal or rectangular weir, the apex distance separates the two walls. For example, with a rectangular weir, a zero sidewall angle means that the two walls are parallel.

Taylor (1968) studied the decrease in the discharge for trapezoidal and rectangular weirs and presented his data in the form of Q_L/Q_N, as shown in Figure 3. This figure shows that the sidewall angle of 9.5° has a higher discharge than does the 7° angle. Unfortunately, the data are too incomplete to show the effect at larger angles. Note that Figure 2 is for a quarter-round crest, whereas the curves in Figure 3 are for a sharp crest. In addition, Figure 2 contains both the magnification and the angle effects in one curve. This is an area in which more research is needed.

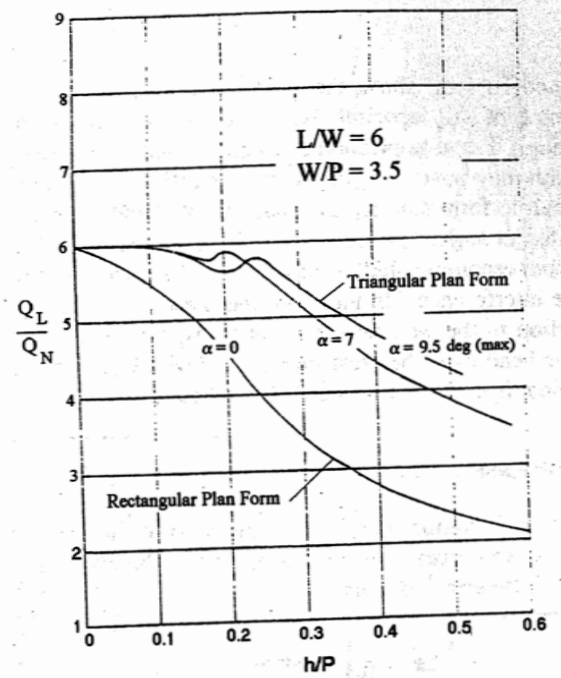


Figure 3. Effect of sidewall angle on discharge from Taylor, G., (1968). "The performance of labyrinth weirs." PhD thesis, University of Nottingham, Nottingham, England.

Apex Ratio

The apex ratio is the width of the apex divided by the cycle width, 2a/W. The most efficient labyrinth weir is the triangular plan form. Interference increases with an increase in the apex ratio. However, construction considerations often dictate the use of a finite apex width. Values of the apex ratio that are less than 0.08 will not have a significant effect on the performance of a labyrinth weir. This is because of two effects. One is interference at the upstream apex. With interference, the upstream section of the sidewall does not convey a significant amount of water. Therefore, replacing the sharp corner of the triangular labyrinth with a blunt apex has little effect on the overall performance of the labyrinth. Similarly, the downstream end of a triangular labyrinth is essentially a stagnation zone. This is made evident by the rise in the water surface profile at the downstream end of the channel between the sidewalls, as shown in Figure 1 in the Chapter 5, Design Curves. Because of the stagnant zone, the downstream end of the labyrinth can also be replaced with a blunt apex with little effect on the overall performance of the weir.

Crest Shape

As the discharge coefficients show, the crest shape does not have a significant effect on the performance of the labyrinth weir. The quarter-round and the half-round shapes are commonly found in prototype structures. An ogee shape that is not thicker than the wall width may have a slightly higher coefficient at small heads. This shape is not more difficult to form than are the quarter-round and the half-round shapes, and it may stay aerated at higher heads. The full ogee shape used by Megalháes and Lorena (1989) is not recommended. It has a lower discharge coefficient at high heads because of nappe interference. In addition, the mass on the top of the wall requires much more attention to the wall design. This configuration will be more susceptible to vibration as the head over the crest increases. The effect of the crest shape on the discharge coefficient is given in Chapter 4, Crest Shapes.

Interference Length Ratio

As shown in Chapter 3, Nappe Interference, the ratio of the disturbance length to the sidewall length is an important consideration to limit the effects of interference. The disturbance length is determined from

$$\frac{L_{de}}{h} = 6.1 \cdot e^{-0.052 \cdot \alpha} \tag{3}$$

in which α = the sidewall angle in degrees. Here, the equation of Indlekofer and Rouvé (1975) is used instead of the suggested equations based on model studies of labyrinth weirs. When research has been completed on the interference with labyrinth weirs, this equation will be replaced with a more accurate relationship.

The ratio of the disturbance length to the sidewall length, L_{de}/B, should be less than or equal to 0.3. This can be written as

$$\frac{L_{de}}{B} = \frac{h}{B} \cdot 6.1 \cdot e^{-0.052 \cdot \alpha} \leq 0.3 \tag{4}$$

Approach Flow Conditions

Houston (1983) made a very important study of the effect of placement of the labyrinth weir relative to the reservoir. As shown in Figure 4, the labyrinth can be placed within the chute in either the normal or the inverted position, at the entrance to the chute, or extending into the reservoir. With a magnification of 5 and the orientation of the labyrinth in the normal position, the discharge was 9% greater than it was in the inverted position. In the normal position, the friction on the chute walls is a minimum.

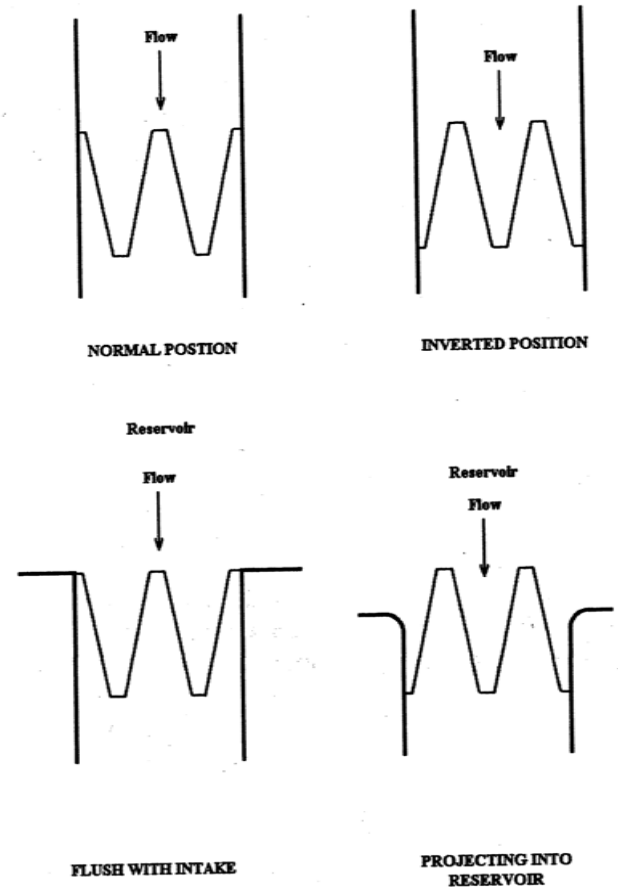


Figure 4. Labyrinth weir locations and orientations after Houston (1983)

As the labyrinth is moved into the reservoir, its capacity increases. The discharge with the labyrinth projecting into the reservoir is 20% greater than it is when in the normal position. However, a labyrinth projecting into the reservoir must use the less-efficient inverted position to tie the weir into the abutment. The curves used in the Excel spreadsheet, described below, are for a labyrinth weir placed in the normal position.

If a greater length of labyrinth is needed to pass a given discharge, the width of the approach section can be increased. For example, the width of the Avon spillway was made about 5.5 times wider than the downstream channel by creating a wide approach section. Similarly, the labyrinth width of the Kizilcapinar and Sarioglan spillways were made wider through the use of an expanded upstream approach channel. The alignment of the Avon and the Kizilcapinar spillways were curved, whereas that of the Sarioglan labyrinth was straight. Details of the alignments of these three spillways are given in Appendix A.

Downstream Channel

Considerations concerning the effects of the downstream channel geometry are given in Chapter 6, Downstream Chute.

Layout and Quantities

The dimensions of a labyrinth weir are shown in Figure 5. Stevens developed an Excel spreadsheet for URS[1] to be used in the design of labyrinth spillway installations. His spreadsheet was extensively modified to include the curves of Tullis (1994) and all the updated design limits. The spreadsheet is available in both English and metric units from falvey@members.asce.org.

[1] M. A. Stevens, PO Box 3263, Boulder, CO, 80307. Tel (303) 444-7120.

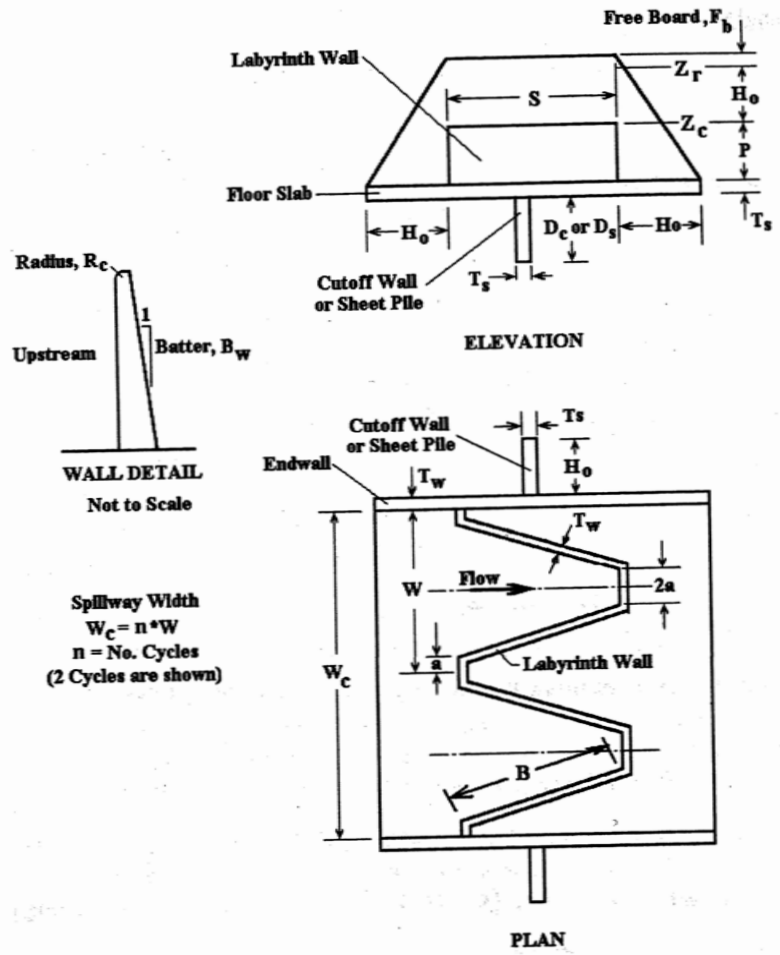


Figure 5. Definition Sketch for Labyrinth Spillway Geometry

Dimensions

The dimensions of the labyrinth weir are determined as follows:

Width of each cycle

$$W = \frac{W_c}{n} \tag{5}$$

Crest length of weir

$$L_w = \left(\frac{L}{W}\right) \cdot W = m \cdot W \tag{6}$$

Sidewall angle

$$\alpha = \tan^{-1}\left(\frac{W - 4 \cdot a}{2 \cdot S}\right) \tag{7}$$

Length of one leg of weir crest

$$B = \frac{L - 2 \cdot (2 \cdot a)}{2} \tag{8}$$

Depth of labyrinth weir

$$S = \sqrt{B^2 - \left(\frac{W - 2 \cdot a}{2}\right)^2} \tag{9}$$

Head on weir

$$H_o = Z_r - Z_c \tag{10}$$

Quantities

The volume computations to estimate the materials and costs are as follows:

Weir walls

$$V_w = n \cdot L \cdot P \cdot T_w \tag{11}$$

End walls

$$V_e = (P + H_o + F_b) \cdot (S + H_o) \cdot 2 \cdot T_w \tag{12}$$

Slab

$$V_s = (S + 2 \cdot H_o) \cdot W_s \cdot T_s \tag{13}$$

Concrete cutoff wall

(Without sheet piles)

$$V_c = [W_s \cdot D_c + 2 \cdot (D_c + T_s + P + H_0 + F_b)] \cdot T_s \tag{14}$$

(With sheet piles)

$$V_c = W_s \cdot 2 \cdot D_c \tag{15}$$

Sheet piles

$$A_s = (W_s \cdot D_s) + D_s \cdot (P + H_0 + F_b) \tag{16}$$

Reinforcing bars

$$M(lb) = \frac{\gamma_s}{3.5} \cdot (V_w + V_e + V_s + V_c) \tag{17}$$

in which γ_s = the unit weight of steel.

Discharge Coefficient

The discharge coefficients are obtained from Table 1 based on the design curves of Tullis (1994). In this table, the discharge coefficient is computed from

$$C_d = A_1 + A_2 \frac{H_o}{P} + A_3 \left(\frac{H_o}{P}\right)^2 + A_4 \left(\frac{H_o}{P}\right)^3 + A_5 \left(\frac{H_o}{P}\right)^4 \tag{18}$$

in which the discharge is given by

$$Q = C_d \cdot \frac{2}{3} \sqrt{2 \cdot g} \cdot L \cdot H_o^{3/2} \tag{19}$$

Interpolation for other angles should be done by first determining the coefficient for the adjacent angles and the given head ratio. Then, use linear interpolation between the two adjacent angles. Do not interpolate between the coefficients!

The discharge curves of Tullis (1994) are valid for an H_o/P of less than or equal to 0.9, for interference ratios less than those shown in Figure 7, and for sidewall angles greater than or equal to 6°.

Because the head ratio, H_o/P, should be less that 0.9, a maximum interference criterion of L_{de}/B equals 0.35 is recommended for use in the spreadsheet.

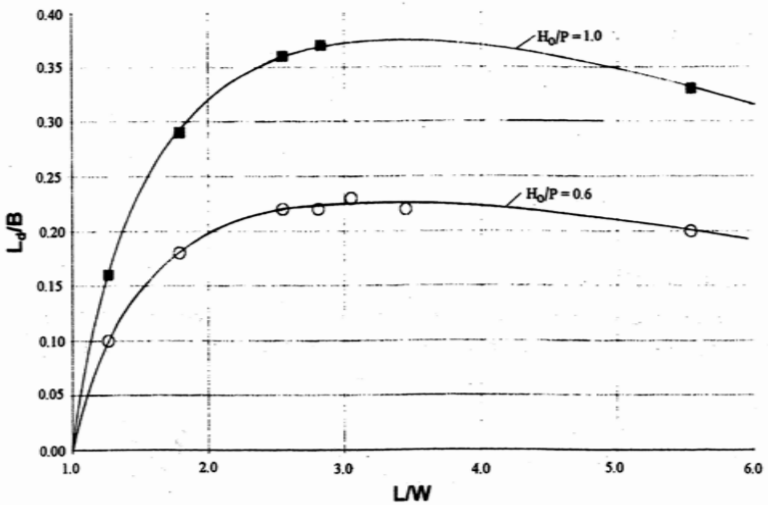


Figure 6. Maximum interference ratios for the design curves based on data from Tullis, J.P., Nosratollah, A., and Waldron, D., (1995). "Design of labyrinth spillways. " *American Society of Civil Engineering, Journal of Hydraulic Engineering,* 121(3), 247-255.

Design Procedure

Steps

The steps in the design procedure are based on the availability of a spreadsheet that facilitates the process.

- Determine the labyrinth's location and channel alignment based on site conditions.
- Define the maximum allowable operating head on the weir that will satisfy operational specifications.
- Define the maximum discharge to be passed at the maximum allowable operational head.
- Use the spreadsheet to determine the spillway configuration that will pass the discharge at the specified operational head. Varying the floor elevation, the magnification, and the number of cycles will determine the most economical configuration. Figure 5 in Chapter 3, Nappe Interference, shows that the smallest slab to support a labyrinth weir is the one that has the largest number of cycles. Therefore, the most economical design will be one with the smallest magnification ratio and the maximum number of cycles that does not violate the head and interference criteria. Violation of the interference criteria means that experimental conditions for which the discharge equations were developed are being exceeded. Thus, the discharge values may be in error. If the economics of the structure indicate that higher interference values are desirable, then a model study of the structure should be conducted to verify the performance at higher heads. As shown in Chapter 3, Nappe Interference, structures with interference values as high as 0.6 have performed satisfactorily.
- The designer must pay close attention to the estimated wall and slab thickness, as well as to the depth of the cut off wall. In addition, the unit prices should be as accurate as possible. These variables have a significant influence on the cost of the structure.
- Perform reservoir routing to verify that the selected design will meet the specified maximum head and discharge requirements.
- Analyze the approach flow conditions for high-velocity concentrations that may decrease the capacity of the spillway. For this analysis, a mathematical or a physical model study may be necessary.
- If either the reservoir routing or the approach flow conditions are not satisfactory, redesign the spillway by revising the approach flow width, changing the alignment, and varying the spillway input parameters using the spreadsheet.

Spreadsheet

For the Excel spreadsheet shown on the following pages, the required input is listed under the section "User Input." All other items are filled in automatically. The spreadsheet calculates the pertinent spillway dimensions, the maximum discharge, the estimated cost of the installation, a detailed discharge curve, and the labyrinth dimensions. The coordinates for one cycle are computed and plotted.

LABYRINTH WEIR DESIGN
No Approach Velocity

PROJECT:	Hyrum	**TIME:**	16:50:51
PROJECT NO.	1	**DATE:**	02-Sep-02
FLOOD CRITERIA:	PMF	**BY:**	HTF

USER INPUT

Max. Res	Zr	4678.0 ft	Thickness			
Crest el.	Zc	4672.0 ft	Wall	Tw	1	ft
Floor el.	Zf	4660.0 ft	Slab	Ts	1	ft
Spillway width	Ws	60.0 ft	Cutoff Depth			
Apex Width	2a	4 ft	Sheet Pile	Ds	0	ft
No. of cycles	n	2	Conc Wall	Dc	4	ft
Magnification	L/W	4.95				

CHECK ON RATIOS

L_d/B = 0.33 — Ld/B RATIO IS OK

H_o/P = 0.50 — Ho/P RATIO IS OK

L/W RATIO IS OK

Note: L_d/B must be <= 0.35

Ho/P must be <= 0.9

α must be >= 6 deg

LABYRINTH DIMENSIONS (Per Cycle)

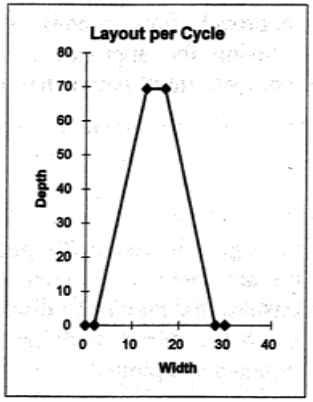
Wall Height	P	12	ft
Width	W	30.00	ft
Length	L	148.50	ft
Wall Length	B	70.25	ft
Depth	D	69.38	ft
Head max	H	6.00	ft
Wall Angle	α	9.01	deg
Length of Interference	L_b	22.99	

CREST LAYOUT
(One Cycle)

X	Y
0	0
2.00	0
13.00	69.38
17.00	69.38
28.00	0
30.00	0

COST CALCULATION

	Unit price $/unit	Units	Cost $
Weir wall, cy	350	132	46,200
Abutment walls, cy	350	106	37,133
Slab, cy	225	181	40,692
Concrete cutoff, cy	200	86	17,185
Sheet pile, sf	20	0	0
Reinforcement, lb	0.65	70,682	45,943



ESTIMATED COST
$187,154

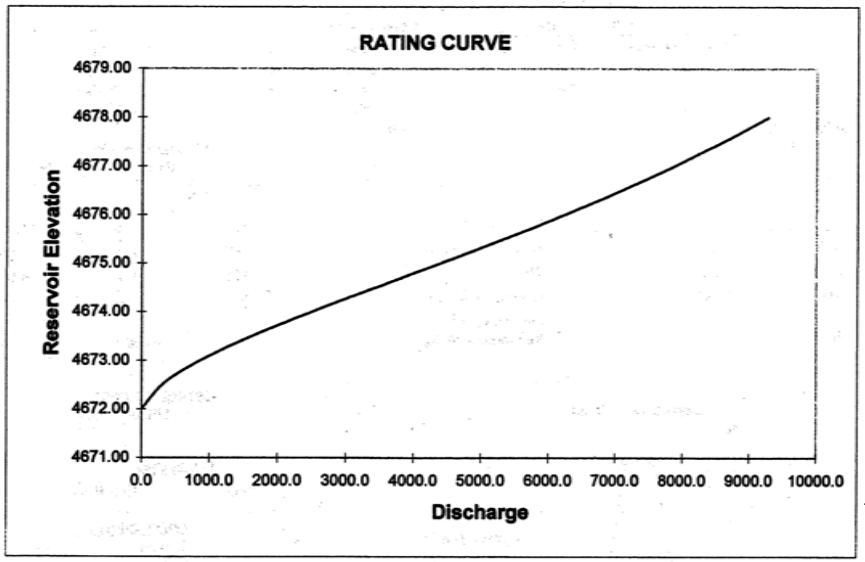
DISCHARGE
Qmax 9,285 cfs

COEFFICIENTS

Column	2.00
Cd lower	0.38
Cd Upper	0.44
Cd	0.40
Efficacy	2.59

RATING CURVE

HEAD	H_o/P	C_{lower}	C_{upper}	C_d	Q	RES
6.00	0.50	0.38	0.44	0.40	9285	4678.00
5.40	0.45	0.41	0.46	0.42	8455	4677.40
4.80	0.40	0.44	0.49	0.45	7559	4676.80
4.20	0.35	0.47	0.51	0.48	6580	4676.20
3.60	0.30	0.50	0.53	0.51	5518	4675.60
3.00	0.25	0.53	0.55	0.53	4394	4675.00
2.40	0.20	0.54	0.56	0.55	3247	4674.40
1.80	0.15	0.55	0.57	0.56	2140	4673.80
1.20	0.10	0.55	0.56	0.55	1155	4673.20
0.60	0.05	0.53	0.53	0.53	393	4672.60
0.00	0.00	0.49	0.49	0.49	0	4672.00



Discharge Coefficient Table Tullis et al. (1995)

Angle wall makes with centerline α

	6	8	12	15	18	25	35	90
A0	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
A1	-0.24	1.08	1.06	1.00	1.32	1.51	1.69	1.46
A2	-1.20	-5.27	-4.43	-3.57	-4.13	-3.83	-4.05	-2.56
A3	2.17	6.79	5.18	3.82	4.24	3.40	3.62	1.44
A4	-1.03	-2.83	-1.97	-1.38	-1.50	-1.05	-1.10	

LABYRINTH WEIR DESIGN

PROJECT:	Serne	TIME:	16:54:16
PROJECT NO.	1	DATE:	02-Sep-02
FLOOD CRITERIA:	PMF	BY:	*HTF*

USER INPUT

Max. Res	Zr	79.6 m	Thickness		
Crest el.	Zc	78.5 m	Wall	Tw	0.5 m
Floor el.	Zf	76.0 m	Slab	Ts	1 m
Spillway width	Ws	15.0 m	Cutoff Depth		
Apex Width	2a	3 m	Sheet Pile	Ds	0 m
No. of cycles	n	1	Conc Wall	Dc	2 m
Magnification	L/W	4			

CHECK ON RATIOS

L_d/B = 0.15 Ld/B RATIO IS OK

H_o/P = 0.44 Ho/P RATIO IS OK

L/W RATIO IS OK

Note: L_d/B must be <= 0.30

Ho/P must be <= 0.9

α must be >= 6 deg

LABYRINTH DIMENSIONS (Per Cycle)

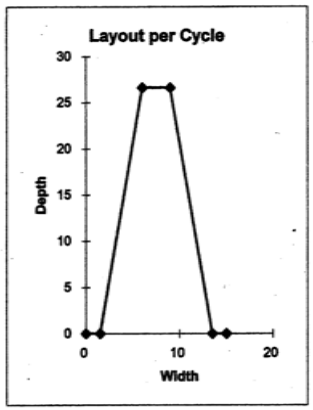
Wall Height	P	2.5	m
Width	W	15.00	m
Length	L	60.00	m
Wall Length	B	27.00	m
Depth	D	26.62	m
Head max	H	1.10	m
Wall Angle	α	9.59	deg
Length of Interference	L_d	4.09	m

CREST LAYOUT
(One Cycle)

X	Y
0	0
1.50	0
6.00	26.62
9.00	26.62
13.50	0
15.00	0

COST CALCULATION

	Unit price Euros/unit	Units	Cost Euros
Weir wall, m^3	150	75	11,250
Abutment walls, m^3	140	128	17,853
Slab, m^3	125	432	54,042
Concrete cutoff, m^3	300	508	152,400
Sheet pile, m^2	200	0	0
Reinforcement, kg	3.4	94,807	322,344



ESTIMATED COST
557,889 Euros

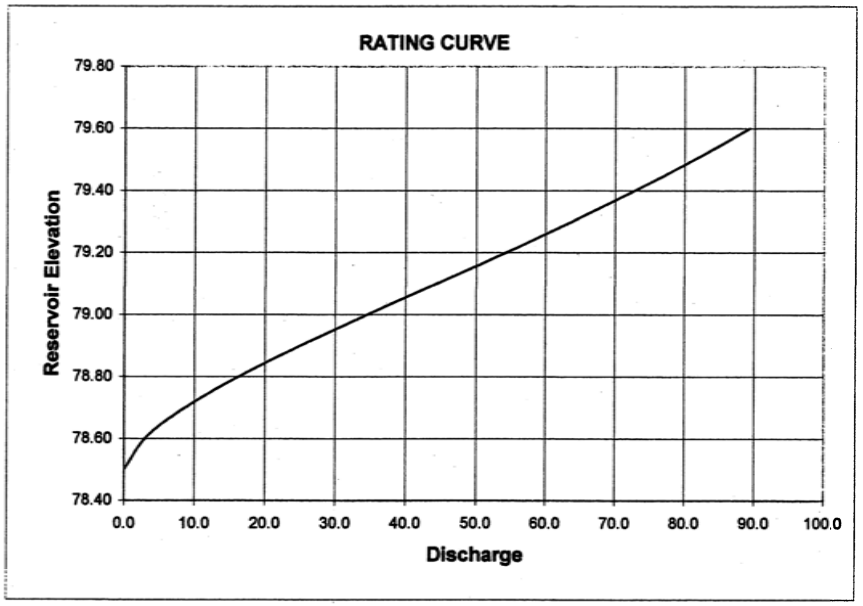
DISCHARGE
Qmax 89.3 m^3/s

COEFFICIENTS

Column	2.00
Cd lower	0.42
Cd Upper	0.47
Cd	0.44
Efficacy	2.59

RATING CURVE

HEAD	H/P	Clower	Cupper	Cd	Q	RES
1.10	0.44	0.42	0.47	0.44	89.3	79.60
0.99	0.40	0.44	0.49	0.46	80.5	79.49
0.88	0.35	0.47	0.51	0.49	71.1	79.38
0.77	0.31	0.50	0.53	0.51	61.0	79.27
0.66	0.26	0.52	0.55	0.53	50.4	79.16
0.55	0.22	0.54	0.56	0.55	39.5	79.05
0.44	0.18	0.55	0.57	0.56	28.8	78.94
0.33	0.13	0.56	0.56	0.56	18.8	78.83
0.22	0.09	0.55	0.55	0.55	10.1	78.72
0.11	0.04	0.53	0.53	0.53	3.4	78.61
0.00	0.00	0.49	0.49	0.49	0.0	78.50



Discharge Coefficient Table Tullis et al. (1995)

Angle wall makes with centerline α

	6	8	12	15	18	25	35	90
A0	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
A1	-0.24	1.08	1.06	1.00	1.32	1.51	1.69	1.46
A2	-1.20	-5.27	-4.43	-3.57	-4.13	-3.83	-4.05	-2.56
A3	2.17	6.79	5.18	3.82	4.24	3.40	3.62	1.44
A4	-1.03	-2.83	-1.97	-1.38	-1.50	-1.05	-1.10	

Attachment B

Hydraulic Design and Analysis of Labyrinth Weirs. I: Discharge Relationships

B. M. Crookston, A.M.ASCE[1]; and B. P. Tullis, M.ASCE[2]

Abstract: A method is presented for the hydraulic design and analysis of labyrinth weirs based upon the experimental results of physical modeling. Discharge coefficient data for labyrinth weirs with quarter-round and half-round crest shapes are presented for sidewall angles ranging from 6 to 35°. Cycle efficiency is also introduced as a design aid, which compares the hydraulic performance of different cycle geometries. Geometric parameters that affect flow performance are discussed. The predictive accuracy of the design method is evaluated through comparisons to previously published labyrinth weir head-discharge data. The companion paper examines nappe behaviors that affect flow performance and presents hydraulic design considerations specific to nappe characteristics. DOI: 10.1061/(ASCE)IR.1943-4774.0000558. © 2013 American Society of Civil Engineers.

CE Database subject headings: Weirs; Water discharge; Coefficients; Hydraulics; Design; Irrigation.

Author keywords: Labyrinth weir design; Discharge coefficients; Weir crest shape; Cycle efficiency; Local submergence.

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Introduction

A labyrinth weir is a linear weir that is folded in plan-view to increase the crest length for a given channel or spillway width (Fig. 1). There are an infinite number of possible labyrinth weir configurations and design variations; however, labyrinth cycles are typically placed in a linear fashion (i.e., upstream apexes align at a common channel cross section; Fig. 1), have a sidewall angle (α) less than 30°, and are oriented towards the approaching flow.

A labyrinth weir is able to pass large discharges at relatively low heads compared to traditional linear weir structures of equal width. As a result of their hydraulic performance and geometric versatility, labyrinth weirs have been placed in streams, canals, rivers, ponds, and reservoirs as headwater control structures, energy dissipaters, flow aerators, and spillways. Labyrinth weirs are well suited for spillway rehabilitation where aging infrastructure, dam safety concerns, freeboard limitations, and revised and larger probable maximum flows have required increased spillway capacity. Recently constructed examples are: Lake Brazos spillway in Texas (Vasquez et al. 2007) and Lake Townsend spillway in Greensboro, North Carolina (Tullis and Crookston 2008).

Flow Characteristics

The geometry of a labyrinth weir produces complex three-dimensional flow patterns. At very low heads, it behaves similar to a linear weir (α ¼ 90°, oriented normally to the approach flow direction) of equivalent length. However, as the head increases, labyrinth weir discharge efficiency, as quantified by the discharge coefficient value, begins to decline as nappe collision and local submergence regions develop (Crookston and Tullis 2012c).

Previous Studies

Labyrinth weir head-discharge relationships have been described by various empirical equations. These relationships vary based on different definitions of the discharge coefficient, the characteristic weir length, and the upstream driving head (e.g., the inclusion of the velocity head component V^2=2g, described in the following). In the present study, a standard form of the weir equation, Eq. (1), was selected with the centerline length of the crest (L_c) as the characteristic weir length:

$$Q \text{ ¼ } \frac{2}{3} C_{d\delta\alpha°\text{þ}} L_c \text{ þ } 2gH_T^{3=2} \qquad \delta 1\text{þ}$$

where Q = labyrinth weir discharge; $C_{d\delta\alpha°\text{þ}}$ = dimensionless discharge coefficient; L_c ¼ Nδ2l_c þ A þ Dþ where N = number of cycles, l_c = centerline length of the sidewall, A = inside apex length, and D = outside apex length; g = acceleration constant of gravity; and H_T = total upstream head (unsubmerged) measured relative to the crest elevation [H_T ¼ V_2=2g þ h (V is the average cross-sectional velocity at the gauging location, and h is the piezometric head upstream of the weir)].

Several earlier labyrinth weir studies resulted in published design methods; a selection is presented and discussed. Hay and Taylor (1970) presented parameter guidelines, based upon research by Taylor (1968), for sharp-crested triangular and trapezoidal labyrinth weirs. Discharge rating curves for h=P < 0.6 were presented in terms of a labyrinth-to-linear weir discharge ratio (based on a common channel width, W, and h), requiring discharge information for a linear weir (α ¼ 90°) of equivalent weir height (P), wall thickness (t_w), and crest shape. The Bureau of Reclamation (USBR) conducted model studies to aid in the design of Ute Dam (Houston 1982). Discrepancies between their experimental results and the recommendations by Hay and Taylor (1970) were attributed to different definitions of upstream head [h, Hay and Taylor (1970);

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J. Irrig. Drain Eng. 2013.139:363-370.

Table 1. Physical Model Test Program

Model	α^a (°)	P (mm)	$L_{c\text{-}cycle}$ (mm)	$L_{c\text{-}cycle}$=w (−)	w=P (−)	N (−)	Crest (−)
1[b]	6	304.8	4,654.6	7.607	2.008	2	HR
2–3	6	304.8	4,654.6	7.607	2.008	2	QR, HR
4–5	8	304.8	3,544.9	5.793	2.008	2	QR, HR
6–7	10	304.8	2,879.1	4.705	2.008	2	QR, HR
8–9	12	304.8	2,435.1	3.980	2.008	2	QR, HR
10–11	15	304.8	1,991.4	3.254	2.008	2	QR, HR
12	15	152.4	1,991.4	3.254	4.015	2	QR
13	15	152.4	995.7	3.254	2.008	4	QR
14	15	304.8	995.7	3.254	1.019	4	QR
15–16	20	304.8	1,548.1	2.530	2.008	2	QR, HR
17–18	35	304.8	983.5	1.607	2.008	2	QR, HR
19–20	90	304.8	1,223.8	1.000	4.015	—	QR, HR

[a]Linear configuration and normal orientation for all models unless noted.
[b]Inverse orientation.

in which at least 10% of the data were repeated to ensure accuracy and to determine measurement repeatability.

Experimental Results

Discharge Rating Curves

Eq. (1) was used to quantify the labyrinth weir head-discharge relationship with L_c representing the characteristic weir length. The term $C_{d\delta\alpha°\flat}$ can be influenced by weir geometry (e.g., P, t_w, A, w, α, and crest shape), weir abutments, flow conditions (H_T, approaching flow angle, local submergence, and nappe interference), and nappe aeration conditions (clinging, aerated, partially aerated, and drowned). The two-cycle sectional labyrinth weir models evaluated in this study did not account for the influence of abutments on discharge. Data for $C_{d\delta\alpha°\flat}$ are presented in terms of H_T=P for nonvented trapezoidal labyrinth weirs for 6° ≤ α ≤ 35° in Fig. 2 (quarter-round crest shape) and Fig. 3 (half-round crest shape). The data for α ¼ 90° (linear) weirs are also included for comparison.

The influence of labyrinth weir orientation in the channel [distal apexes connecting to channel sidewalls as upstream apexes (referred to as normal orientation) or as downstream apexes (inverse orientation)] was evaluated by testing the α ¼ 6° labyrinth weirs with both orientations. No measurable variations were observed between $C_{d\delta\alpha°\flat}$ data sets (data not presented). Consequently, the data in Figs. 2 and 3 are assumed to be applicable, independent of weir orientation. Crookston and Tullis (2012b) present additional design information and discussion regarding labyrinth weirs in reservoir applications and abutment effects on discharge.

For convenience, the labyrinth weir $C_{d\delta\alpha°\flat}$ data in Figs. 2 and 3 were curve-fit per Eq. (2), and the corresponding coefficients are presented in Tables 2 and 3. Eq. (3) was used for α ¼ 90° data and the corresponding coefficients are presented in the aforementioned tables. The curves have been validated for 0.05 ≤ H_T= P < 0.8–0.9; however, due to the well-behaved nature of the data and Eq. (2), the $C_{d\delta\alpha°\flat}$ curves have been extrapolated to H_T=P ¼ 1.0. Eqs. (2) and (3) were selected over polynomial relationships because of their improved data representation (R^2 ≥ 0.99) and extrapolation performance (they remain well-behaved up to H_T=P ≤ 2.0). Crookston et al. (2012) evaluated Eq. (2) for H_T=P < 2 via physical and numerical modeling and found that Eq. 2 may be used as a good first order approximation. When the Tullis et al. (1995) polynomial $C_{d\delta\alpha°\flat}$ relationships are extrapolated, they incorrectly compute $C_{d\delta\alpha°\flat}$ (even producing negative values) beyond the upper limit of their experimental data (experimental data limited to H_T=P < 0.9). For labyrinth weirs:

$$C_{d\delta\alpha°\flat} \text{ ¼ } a \left(\frac{H_T}{P}\right)^{b\left(\frac{H_T}{P}\right)^{c}} \text{ þ } d \qquad \delta 2\flat$$

For linear weirs:

$$C_{d\delta 90°\flat} \text{ ¼ } \frac{1}{a \text{ þ } b\left(\frac{H_T}{P}\right) \text{ þ } \left(\frac{c}{H_T=P}\right)} \text{ þ } d \qquad \delta 3\flat$$

A comparison between the half-round and quarter-round experimental data is presented in Fig. 4 as the ratio of the half-round over

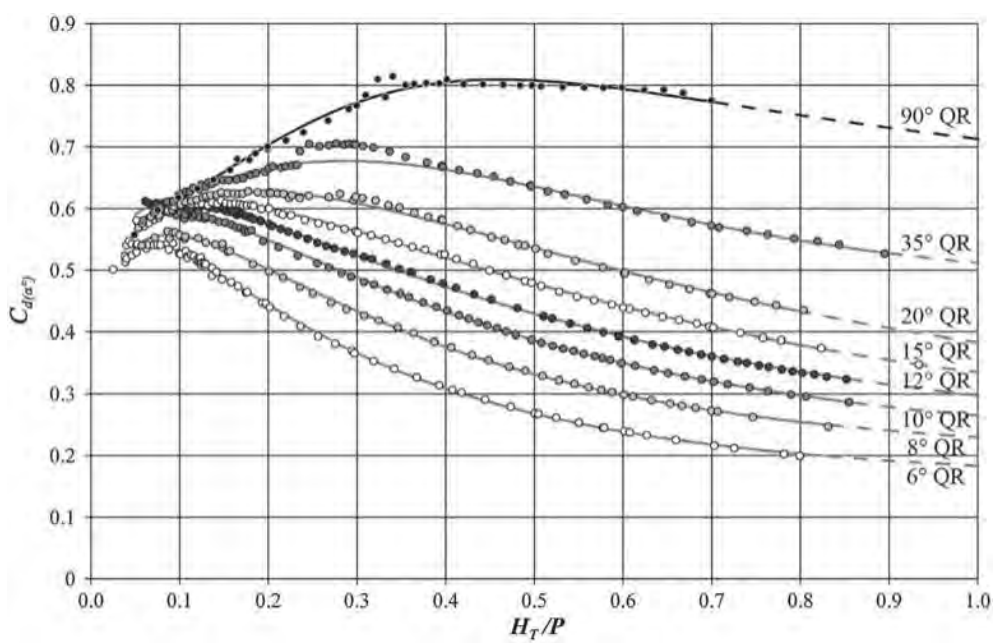

Fig. 2. Values of C_d versus H_T=P for quarter-round trapezoidal labyrinth weirs

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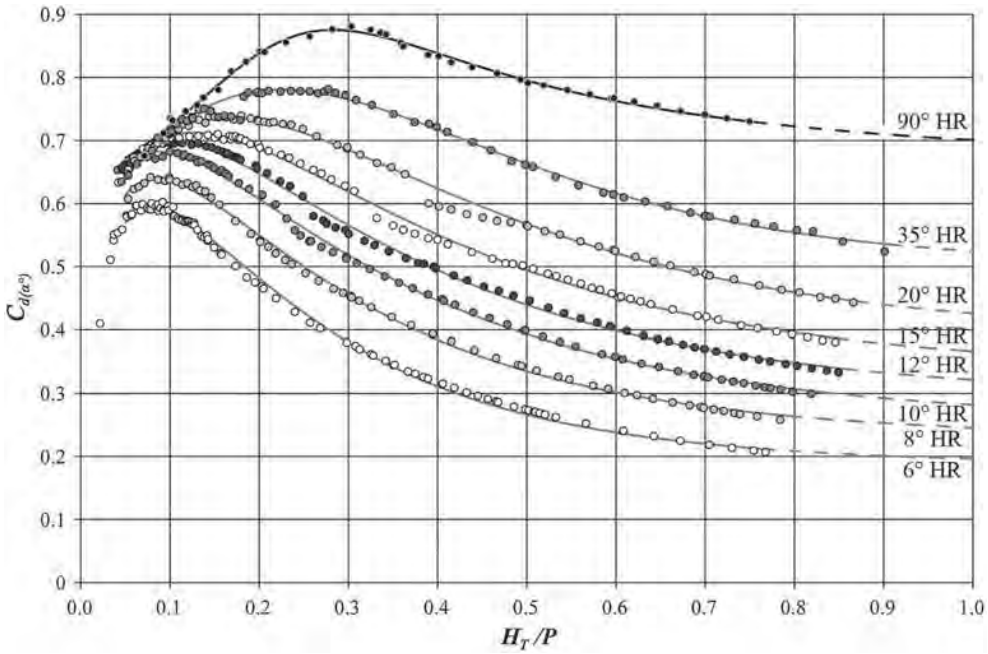


Fig. 3. Values of C_d versus H_T=P for half-round trapezoidal labyrinth weirs

Table 2. Curve-Fit Coefficients for Quarter-Round Labyrinth and Linear Weirs, Validated for $0.05 \le H_T=P < 0.9$

α	a	b	c	d
6°	0.02623	−2.681	0.3669	0.1572
8°	0.03612	−2.576	0.4104	0.1936
10°	0.06151	−2.113	0.4210	0.2030
12°	0.09303	−1.711	0.4278	0.2047
15°	0.10890	−1.723	0.5042	0.2257
20°	0.11130	−1.889	0.5982	0.2719
35°	0.03571	−3.760	0.7996	0.4759
90°	−2.3800	6.476	1.3710	0.5300

Table 3. Curve-Fit Coefficients for Half-Round Labyrinth and Linear Weirs, Validated for $0.05 \le H_T=P < 0.9$

α	a	b	c	d
6°	0.009447	−4.039	0.3955	0.1870
8°	0.017090	−3.497	0.4048	0.2286
10°	0.029900	−2.978	0.4107	0.2520
12°	0.030390	−3.102	0.4393	0.2912
15°	0.031600	−3.270	0.4849	0.3349
20°	0.033610	−3.500	0.5536	0.3923
35°	0.018550	−4.904	0.6697	0.5062
90°	−8.60900	22.650	1.8120	0.6375

the quarter-round $C_{d\delta\alpha°\flat}$ values ($C_{d\text{-}HR}=C_{d\text{-}QR}$) versus H_T=P. A crest that is rounded on the downstream face helps the flow stay attached (clinging flow) to the downstream weir wall at smaller H_T=P values, thus increasing flow efficiency and discharge capacity. As the discharge and the corresponding momentum of the flow passing over the weir increase, the nappe becomes aerated and the streamlines will eventually detach from the weir crest, creating a similar nappe profile to the quarter-round crest. Once nappe detachment occurs, the gains in the half-round crest flow efficiency are lost relative to the quarter-round crest. All of the $C_{d\text{-}HR}=C_{d\text{-}QR}$ curves are anticipated to eventually converge to 1.0 with increasing

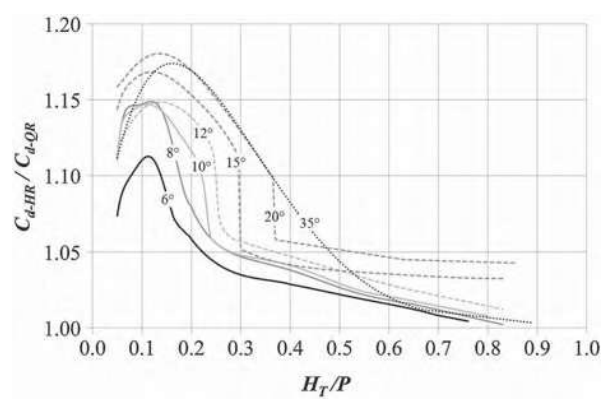


Fig. 4. Comparison of half-round and quarter-round crest shape on hydraulic performance of labyrinth weirs

H_T=P. Improving weir approach flow conditions and using a more efficient crest shape can obtain further gains in efficiency. Brazos Dam (Waco, TX), for example, features an ogee-type crest [modified half-round crest with an upstream radius of $1=3t_w$ and a downstream radius of $2=3t_w$ (Willmore 2004)].

Nappe Behavior and Artificial Aeration

Labyrinth weir flow can produce several nappe behavior phenomena that should not be overlooked: nappe aeration conditions, nappe instability (also termed flow surging), and nappe vibrations. These behaviors, conditions, and remedial actions are discussed in detail in the companion paper (Crookston and Tullis 2013). The artificial aeration, vent pipes, and nappe breakers are also discussed.

Labyrinth Design and Analyses

The recommended procedure for designing a labyrinth weir is presented in Table 4, which includes a design example for illustration

J. Irrig. Drain Eng. 2013.139:363-370.

Attachment C

USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

Conservation Engineering Division

Earth Dams and Reservoirs

TR–60

July 2005

Earth embankments and foundations

Earth embankments constructed of soil and rock are the principal means of impounding water. The earth embankment and its foundation must withstand the anticipated loads without movements leading to failure. Measures must be provided for adequate seepage control.

Height

The design height of an earth embankment must be sufficient to prevent overtopping during passage of either the freeboard hydrograph or stability design hydrograph plus the freeboard required for frost conditions or wave action, whichever is larger. The design height must also meet the requirements for minimum auxiliary spillway depth. The design height of the dam must be increased by the amount needed to compensate for settlement.

Top width

The minimum top width of embankment is shown in table 5-1.

The width may need to be greater than the above minimums to:

- meet state and local standards;
- accommodate embankment zoning;
- provide roadway access and traffic safety; and
- provide structural stability.

An increase in top width is a major design feature in preventing breaching after embankment slumping caused by earthquake ground motion.

When the embankment top is used as a public roadway, the minimum width shall be 16 feet for one-way and 26 feet for two-way traffic. Guardrails or other safety measures shall be used and must meet the requirements of the responsible road authority.

Embankment slope stability

Analyze the stability of embankment slopes using generally accepted methods based on sound engineering principles. Document all analyses including assumptions regarding shear strength parameters for each zone of the embankment and each soil type or horizon in the foundation. Documentation should include methods used for analyses and a summary of results. Design features necessary to provide required safety factors should be noted.

Table 5-1 Minimum top width of embankment

Total height of embankment, H, (ft)	Top Width (ft)		
	All dams	Single purpose floodwater retarding	Multipurpose or other purposes
14 or less	8	N/A	N/A
15–19	10	N/A	N/A
20–24	12	N/A	N/A
25–34	14	N/A	N/A
35–95	N/A	14	(H+35)/5
Over 95	N/A	16	26

Attachment D

LABYRINTH WEIR DESIGN - Low Flow Notch

No Approach Velocity

PROJECT:	East Locust Creek		**TIME:**	10:17:46
PROJECT NO.	A11-1513		**DATE:**	06-Aug-15
FLOOD CRITERIA:	PMF		**BY:**	BHL

USER INPUT

Units	-	English			-		
Max. Res	Zr	924.8	ft		**Thickness**		
Crest el.	Zc	922.3	ft	**Wall Crest**	Tw	1.3	ft
Floor el.	Zf	911.8	ft	**Wall Bottom**	Tb	2.5	ft
Spillway width	Ws	27.5	ft	**Slab**	Ts	4	ft
Apex Width	D	4	ft		**Cutoff Depth**		
No. of cycles	n	0.5	-	**Sheet Pile**	Ds	0	ft
Magnification	L/W	2	-	**Conc Wall**	Dc	4	ft

CHECK ON RATIOS

Lde/B =	0.07	**Ld/B RATIO IS OK**
H_o/P =	0.24	**Ho/P RATIO IS OK**
a =	27.07	**Angle IS OK**

Note: L_{de}/B must be <= 0.35

Ho/P must be <= 0.9

a must be >= 6 deg

LABYRINTH DIMENSIONS (Per Cycle)

Wall Height	P	10.5	ft
Width	W	55.00	ft
Effective Length	L_e	110.00	ft
Inside Apex	A	2.41	ft
Wall Length	L_1	53.39	ft
Depth	B	48.84	ft
Head max	H	2.50	ft
Wall Angle	a	27.07	deg
Interference Length	L_{de}	3.74	ft

CREST LAYOUT

(One Cycle)

X	Y
0.00	0.00
0.00	1.30
1.20	1.30
25.50	48.84
29.50	48.84
53.80	1.30
55.00	1.30
55.00	0.00
53.00	0.00
28.70	47.54
26.30	47.54
2.00	0.00
0.00	0.00

DISCHARGE

Qmax	2,235	**cfs**

COST ESTIMATE

	Unit price $/unit	Units	Cost $
Weir wall, cy	350	41	14,224
Abutment walls, cy	350	101	35,404
Slab, cy	225	207	46,601
Concrete cutoff, cy	200	47	9,333
Sheet pile, sf	20	0	0
Reinforcement, lb	0.65	55,381	35,998

ESTIMATED COST

$141,560

Slab & Weir Wa $ 60,825

RATING CURVE

Metric
English

HEAD	H_o/P	C_{lower}	C_{upper}	C_d	Q	RES		
ft	-	-	-	-	cfs	ft		
2.50	0.24	0.6230	0.67	0.65	753	924.80		924.8
2.25	0.21	0.63	0.67	0.65	642	924.55		924.55
2.00	0.19	0.63	0.66	0.64	536	924.30		924.3
1.75	0.17	0.63	0.65	0.64	436	924.05		924.05
1.50	0.14	0.62	0.64	0.63	342	923.80		923.8
1.25	0.11904762	0.61	0.63	0.62	256	923.55		923.55
1.00	0.10	0.60	0.61	0.61	179	923.30		923.3
0.75	0.07	0.58	0.59	0.59	112	923.05		923.05
0.50	0.05	0.55	0.57	0.56	59	922.80		922.8
0.25	0.024	0.51	0.55	0.52737	19	922.55		922.55
0.00	0.00	0.00	0.00	0.00	0	922.30		922.3

Discharge Coefficient Table Tullis et al. (1995)

Angle wall makes with centerline a

	6	8	10	12	15	20	35	90
	---	---	---	---	---	---	---	---
a	0.02623	0.03612	0.06151	0.09303	0.1089	0.1113	0.03571	-2.38
b	-2.681	-2.576	-2.113	-1.711	-1.723	-1.889	-3.76	6.476
c	0.3669	0.4104	0.421	0.4278	0.5042	0.5982	0.7996	1.371
d	0.1572	0.1936	0.203	0.2047	0.2257	0.2719	0.4759	0.53

COEFFICIENTS

Column	6.00
Cd lower	0.98
Cd Upper	2.98
Cd	1.92
Efficacy	5.40

50.0
4
1
2

LABYRINTH WEIR DESIGN - Main Spillway

No Approach Velocity

PROJECT:		East Locust Creek				TIME:	10:18:52
PROJECT NO.		A11-1513				DATE:	06-Aug-15
FLOOD CRITERIA:		PMF				BY:	BHL

USER INPUT

Units	-	English			-		
Max. Res	Zr	936.0	ft		Thickness		
Crest el.	Zc	924.8	ft	Wall Crest	Tw	1.3	ft
Floor el.	Zf	912.8	ft	Wall Bottom	Tb	2.5	ft
Spillway width	Ws	55.0	ft	Slab	Ts	4	ft
Apex Width	D	4	ft		Cutoff Depth		
No. of cycles	n	1	-	Sheet Pile	Ds	0	ft
Magnification	L/W	2	-	Conc Wall	Dc	4	ft

CHECK ON RATIOS

Lde/B =	0.31	Ld/B RATIO IS OK
H_o/P =	0.93	WARNING! H/P > 0.9!
a =	27.07	Angle IS OK

Note: L_{de}/B must be <= 0.35

Ho/P must be <= 0.9

a must be >= 6 deg

LABYRINTH DIMENSIONS (Per Cycle)

Wall Height	P	12	ft
Width	W	55.00	ft
Effective Length	L_e	110.00	ft
Inside Apex	A	2.41	ft
Wall Length	L_1	53.39	ft
Depth	B	48.84	ft
Head max	H	11.20	ft
Wall Angle	a	27.07	deg
Interference Length	L_{de}	16.77	ft

CREST LAYOUT

(One Cycle)

X	Y
0.00	0.00
0.00	1.30
1.20	1.30
25.50	48.84
29.50	48.84
53.80	1.30
55.00	1.30
55.00	0.00
53.00	0.00
28.70	47.54
26.30	47.54
2.00	0.00
0.00	0.00

DISCHARGE

Qmax	9,993	cfs

COST ESTIMATE

	Unit price $/unit	Units	Cost $
Weir wall, cy	350	93	32,511
Abutment walls, cy	350	204	71,570
Slab, cy	225	414	93,203
Concrete cutoff, cy	200	97	19,378
Sheet pile, sf	20	0	0
Reinforcement, lb	0.65	113,190	73,573

ESTIMATED COST

$290,235

Slab & Weir Wa $ 125,714

RATING CURVE

Metric
English

HEAD	H_o/P	C_{lower}	C_{upper}	C_d	Q	RES	Rating Curve with I	
ft	-	-	-	-	cfs	ft		
11.20	0.93	0.3980	0.52	0.46	10064	936.00	10816.6	936
9.80	0.82	0.43	0.54	0.48	8717	934.60	9469.2	934.6
8.50	0.71	0.46	0.57	0.51	7482	933.30	8234.83	933.3
7.10	0.59	0.50	0.61	0.55	6135	931.90	6887.43	931.9
5.70	0.48	0.55	0.64	0.59	4739	930.50	5491.15	930.5
4.40	0.36666667	0.59	0.67	0.63	3399	929.20	4151.88	929.2
3.00	0.25	0.62	0.68	0.65	1977	927.80	2729.7	927.8
1.60	0.13	0.62	0.64	0.63	749	926.40	1501.09	926.4
0.20	0.02	0.49	0.54	0.51	27	925.00	779.542	925
0.10	0.008	0.46	0.53	0.49152	9	924.90	761.689	924.9
0.00	0.00	0.00	0.00	0.00	0	924.80	752.542	924.8

Discharge Coefficient Table Tullis et al. (1995)

Angle wall makes with centerline a

	6	8	10	12	15	20	35	90
	---	---	---	---	---	---	---	---
a	0.02623	0.03612	0.06151	0.09303	0.1089	0.1113	0.03571	-2.38
b	-2.681	-2.576	-2.113	-1.711	-1.723	-1.889	-3.76	6.476
c	0.3669	0.4104	0.421	0.4278	0.5042	0.5982	0.7996	1.371
d	0.1572	0.1936	0.203	0.2047	0.2257	0.2719	0.4759	0.53

COEFFICIENTS

Column	6.00
Cd lower	0.39
Cd Upper	0.52
Cd	0.45
Efficacy	1.14

50.0
4
1
2

APPENDIX B
SPILLWAY CHUTE AND STILLING BASIN DESIGN REFERENCES AND CALCULATIONS

Attachment A - Design of Small Dams

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

DESIGN OF SMALL DAMS

A WATER RESOURCES TECHNICAL PUBLICATION

Table 9-3.—Side channel spillway computations. Using eq(15) for design example in section 9.17(b): given Q = 2,000 ft³/s, bottom width = 10 feet, side slopes = ½:1, and bottom slope = 1 foot in 100 feet.

(1) Station	(2) Δx	(3) Elevation bottom	(4) Trial Δy	(5) Water surface elevation	(6) d	(7) A	(8) Q	(9) v	(10) Q_1+Q_2	(11) $\frac{Q_1}{g(Q_1+Q_2)}$	(12) v_1+v_2	(13) v_2-v_1	(14) Q_2-Q_1	(15) $\frac{Q_2-Q_1}{Q_1}$	(16) $\frac{v_2(Q_2-Q_1)}{Q_1}$	(17) (13)+(16)	(18) Δy = (11) ×(12)×(17)	(19) Remarks
1+00	–	100.0	–	116.34	16.34	297	2,000	6.73	–	–	–	–	–	–	–	–	–	–
0+75	25	100.25	1.00	117.34	17.09	317	1,500	4.73	3,500	0.01332	11.46	2.00	500	0.333	2.24	4.24	0.64	Too low
			.62	116.96	16.71	307	–	4.89	–	–	11.62	1.84	–	–	–	4.08	.63	OK
0+50	25	100.50	.50	117.46	16.96	313	1,000	3.19	2,500	.01244	8.08	1.70	500	.50	2.44	4.14	.42	Too low
			.42	117.38	16.88	311	–	3.22	–	–	8.11	1.67	–	–	–	4.11	.41	OK
0+25	25	100.75	.30	117.68	16.93	313	500	1.60	1,500	.01036	4.82	1.62	500	1.00	3.22	4.84	.24	Too low
			.24	117.62	16.87	311	–	1.61	–	–	4.83	1.61	–	–	–	4.83	.24	OK
0+00	15	100.90	.10	117.72	16.82	310	200	.64	700	.00888	2.25	.97	300	1.50	2.41	3.38	.07	Too low
			.07	117.69	16.79	309	–	.65	–	–	2.26	.96	–	–	–	3.37	.07	OK

reservoir water level. To obtain the assumed crest coefficient value of 3.6, excessive submergence of the overflow must be avoided. If it is assumed that a maximum of two-thirds submergence at the upstream end of the channel can be tolerated, the maximum water surface level in the channel will be $\frac{2}{3}H_o$ above the crest, or elevation 1002.0. Then at station 0+10, the channel datum water surface level elevation 117.7 will become elevation 1002.0, placing the channel floor level for station 0+00 at approximately elevation 985.3, and for station 1+00 at approximately elevation 984.3.

The design of the side channel control structure would be completed by designing the uncontrolled ogee crest by the methods shown in section 9.13, to obtain the crest coefficient value of 3.6 that was assumed.

Variations in the design can be made by assuming different bottom widths, different channel slopes, and varying control sections. A proper and economical design can usually be achieved after comparing several alternatives.

D. HYDRAULICS OF FREE-FLOW DISCHARGE CHANNELS

9.18. ***General.***—Discharge generally passes through the critical stage in the spillway control structure and enters the discharge channel as supercritical or shooting flow. To avoid a hydraulic jump below the control, the flow must remain at the supercritical stage throughout the length of the channel. The flow in the channel may be uniform or it may be accelerated or decelerated, depending on the slopes and dimensions of the channel and on the total drop. Where it is desired to minimize the grade to reduce excavation at the upstream end of a channel, the flow might be uniform or decelerating, followed by accelerating flow in the steep drop leading to the downstream river level. Flow at any point along the channel will depend upon the specific energy, $d+h_v$, available at that point. This energy will equal the total drop from the reservoir water level to the floor of the channel at the point under consideration, less the head losses accumulated to that point. The velocities and depths of flow along the channel can be fixed by selecting the grade and the cross-sectional dimensions of the channel.

The velocities and depths of free surface flow in a channel, whether it be an open channel, a conduit, or a tunnel, conform to the principle of the conservation of energy as expressed by Bernoulli's theorem, which states "the absolute energy of flow at any cross section is equal to the absolute energy at a downstream section plus intervening losses of energy." As applied to figure 9-35 this relationship can be expressed as follows:

$$\Delta Z + d_1 + h_{v_2} = d_2 + h_{v_2} + \Delta h_L \qquad (17)$$

When the channel grades are not too steep, for practical purposes the normal depth, d_n, can be considered equal to the vertical depth d. The term Δh_L includes all losses that occur in the reach of channel, such as friction, turbulence, impact, and transition losses. Because changes in most channels are made gradually, all losses except those from friction

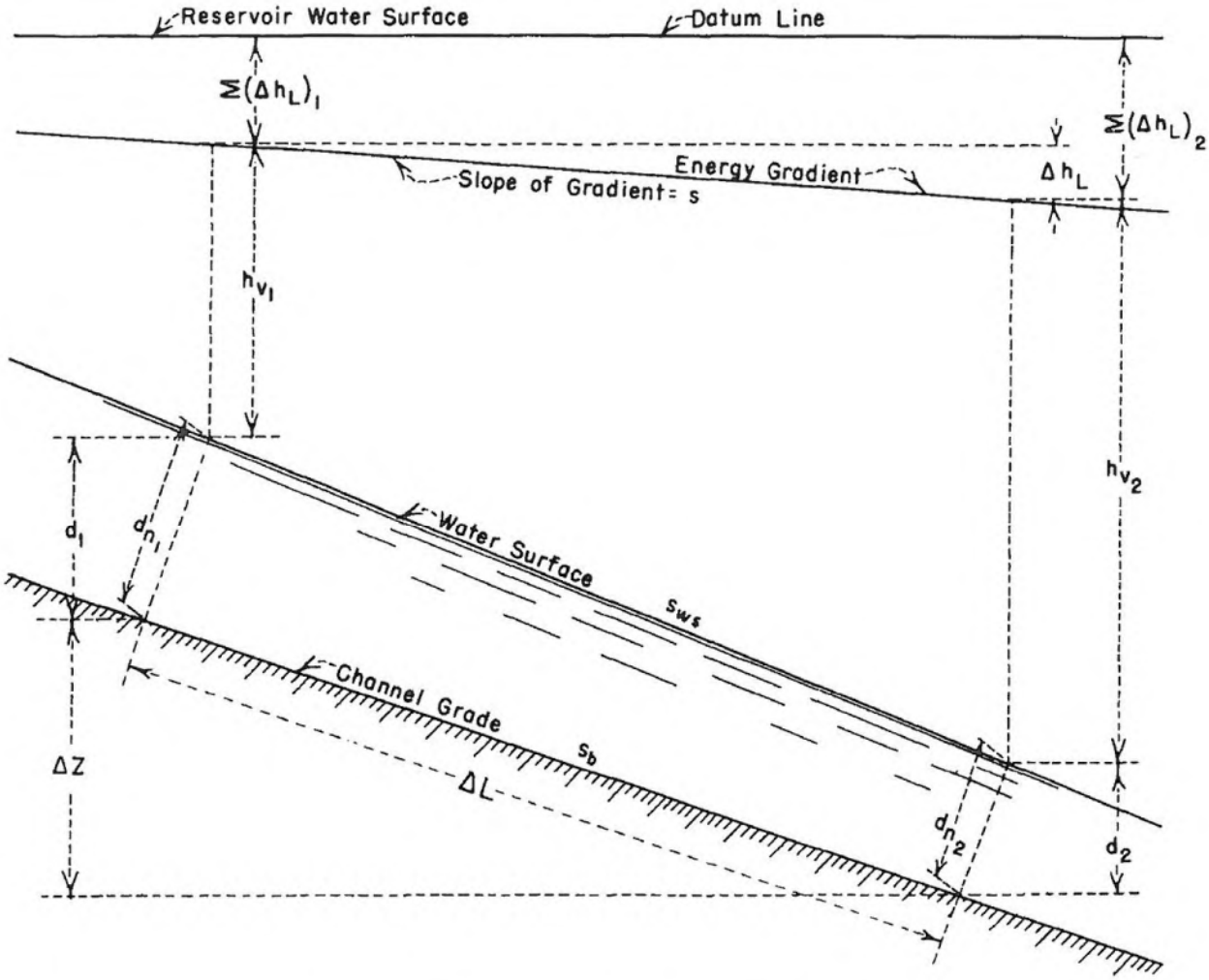


Figure 9-35.—Flow in open channels. 288-D-2421.

can ordinarily be neglected. The friction loss can then be expressed as:

$$\Delta h_L = s\Delta L \tag{18}$$

where s is the average friction slope expressed by either the Chezy or the Manning formula. For the reach ΔL, the head loss can be expressed as:

$$\Delta h_L = \left(\frac{s_1 + s_2}{2}\right) \Delta L$$

From the Manning formula (eq. (30), app. B), $s = (vn/1.486r^{2/3})^2$.

The roughness coefficient, n, will depend on the nature of the channel surface. For conservative design the frictional loss should be maximized when evaluating depths of flow and minimized when evaluating the energy content of the flow. For determining depths of flow in a concrete-lined channel, an n of about 0.014 should be assumed. For determining specific energies of flow needed to design the dissipating device, an n of about 0.008 should be assumed.

Where only rough approximations of depths and velocities of flow in a discharge channel are desired, the total head loss $\Sigma\Delta h_L$ to any point along the channel might be expressed in terms of the velocity head. Thus, at any section the relationship can be stated: reservoir water surface elevation minus floor grade elevation $= d + h_v + Kh_v$. For spillways with small drops, K can be assumed as approximately 0.2 for determining depths of flow and 0.1 or less for evaluating the energy of flow. Rough approximations of losses can also be obtained from figure B-5.

9.19. *Open Channels.*—(a) *Profile.*—The profile of an open channel is usually selected to conform to topographic and geologic site conditions. It is generally defined as straight reaches connected

by vertical curves. Sharp convex and concave vertical curves would develop unsatisfactory flows in the channel and should be avoided. Convex curves should be flat enough to maintain positive pressures and thus preclude the tendency for the flow to separate from the floor. Concave curves should have a sufficiently long radius of curvature to minimize the dynamic forces on the floor brought about by the centrifugal force from a change in the direction of flow.

To avoid the tendency for the water to spring away from the floor and, thereby, reduce the surface contact pressure, the floor shape for convex curvature should be made slightly flatter than the trajectory of a free-discharging jet issuing under a head equal to the specific energy of flow as it enters the curve. The curvature should approximate a shape defined by the equation:

$$-y = x \tan\theta + \frac{x^2}{K[4(d + h_v)\cos^2\theta]} \qquad (19)$$

where θ is the slope angle of the floor upstream from the curve. Except for the factor K, the equation is that of a free-discharging trajectory issuing from an inclined orifice. To ensure positive pressure along the entire contact surface of the curve, K should be equal to or greater than 1.5.

For the concave curvature, the pressure exerted upon the floor surface by the centrifugal force of the flow varies directly with the energy of the flow and inversely with the radius of curvature. An approximate relationship of these criteria can be expressed in the equations:

$$R = \frac{2qv}{p} \text{ and } R = \frac{2dv^2}{p} \qquad (20)$$

where:

R = the minimum radius of curvature, in feet,
q = the discharge, in cubic feet per second per foot of width,
v = the velocity, in feet per second,
d = the depth of flow, in feet, and
p = the normal dynamic pressure exerted on the floor, in pounds per square foot.

An assumed value of $p = 1{,}000$ will normally produce an acceptable radius; however, in no case should the radius be less than $10d$. For the reverse curve at the lower end of the ogee crest, radii of not less than $5d$ have been found acceptable.

(b) *Convergence and Divergence.*—The best hydraulic performance in a discharge channel is obtained when the confining sidewalls are parallel and the distribution of flow across the channel is maintained uniform. However, economy may dictate a channel section narrower or wider than either the crest or the terminal structure, thereby requiring converging or diverging transitions to fit the various components together. Sidewall convergence must be made gradual to avoid cross waves, wave runup on the walls, and uneven distribution of flow across the channel. Similarly, the rate of divergence of the sidewalls must be limited or else the flow will not spread to occupy the entire width of the channel uniformly. This will result in undesirable flow conditions at the terminal structure.

The inertial and gravitational forces of streamlined kinetic flow in a channel can be expressed by the Froude number parameter, $v/(gd)^{1/2}$. Variations from streamlined flow caused by outside interferences that cause an expansion or a contraction of the flow can also be related to this parameter. Experiments have shown that an angular variation of the flow boundaries not exceeding that produced by the equation,

$$\tan\alpha = \frac{1}{3F} \qquad (21)$$

will provide an acceptable transition for either a contracting or an expanding channel. In this equation, $F = v/(gd)^{1/2}$, and α is the angular variation of the sidewall with respect to the channel centerline; v and d are the velocity and depth at the start of the transition. Figure 9-36 is a nomograph from which the tangent of the flare angle or the flare angle in degrees may be obtained for known values of depth and velocity of flow.

(c) *Channel Freeboard.*—In a channel conducting flow at the supercritical stage, the surface roughness, wave action, air bulking, splash, and spray are related to the velocity and energy content of the flow. Expressed in terms of v and d, the energy per foot of width $qh_v = v^3d/2g$. Therefore the relationship of velocity and depth to the flow energy also can be expressed in terms of v and $d^{1/3}$. An empirical expression based on this relationship that gives a reasonable indication of desirable freeboard values is:

$$\text{Freeboard (in feet)} = 2.0 + 0.025v\sqrt[3]{d} \qquad (22)$$

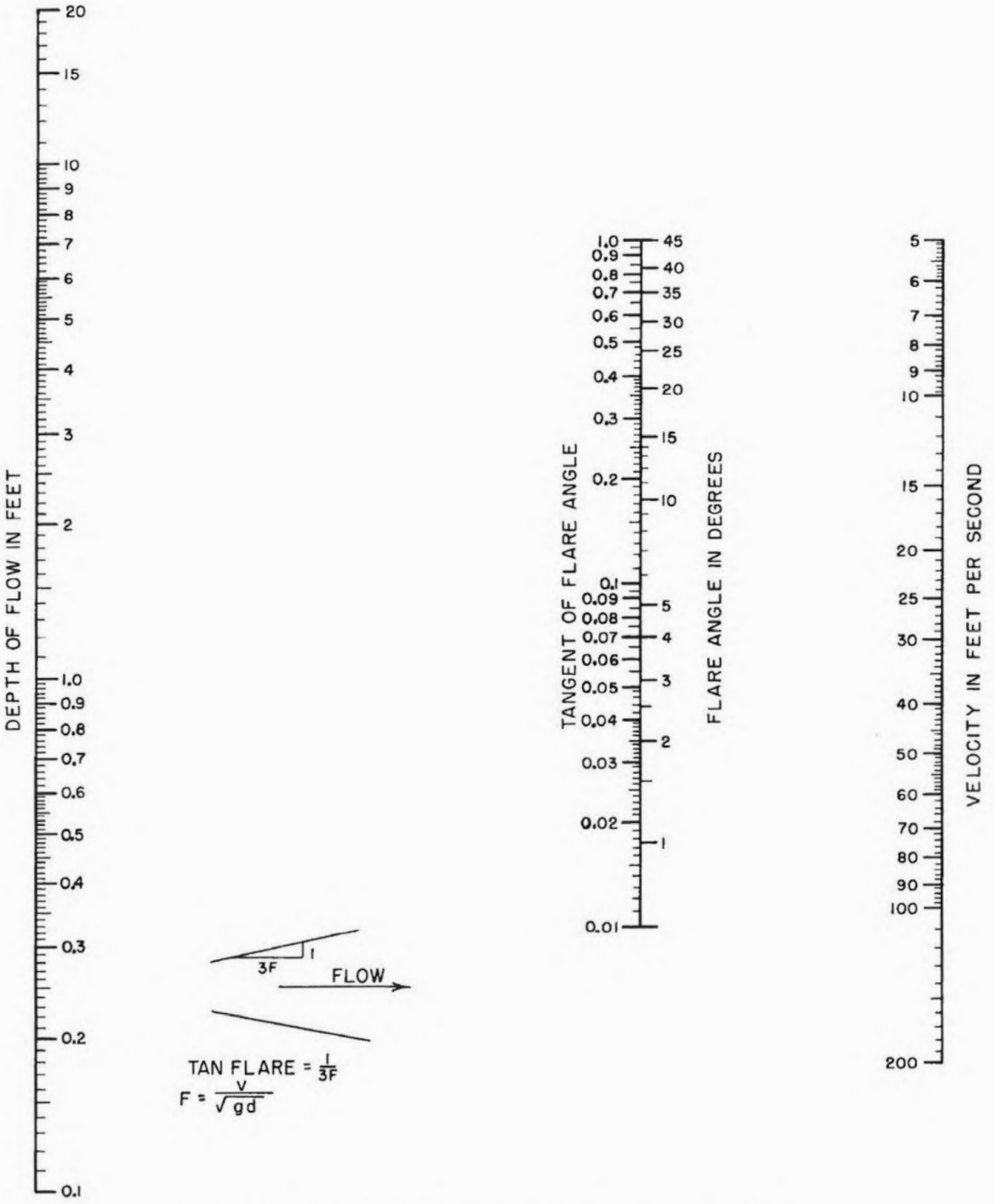


Figure 9-36.—Flare angle for divergent or convergent channels. 288–D–2422.

E. HYDRAULICS OF TERMINAL STRUCTURES

9.20. ***Deflector Buckets.***—Where the spillway discharge may be safely delivered directly to the river without providing a dissipating or stilling device, the jet is often projected beyond the structure by a deflector bucket or lip. Flow from these deflectors leaves the structure as a free-discharging upturned jet and falls into the stream channel some distance from the end of the spillway. The path the jet assumes depends on the energy of flow available at the lip and the angle at which the jet leaves the bucket.

With the origin of the coordinates taken at the end of the lip, the path of the trajectory is given by the equation:

$$y = x \tan \theta - \frac{x^2}{K[4(d + h_v) \cos^2 \theta]} \qquad (23)$$

where:

θ = angle of the edge of the lip with the horizontal, and

K = a factor, equal to 1, for the theoretical jet.

To compensate for loss of energy and the velocity reduction caused by air resistance, internal turbulences, and disintegration of the jet, $K = 0.9$ should be assumed.

The horizontal range of the jet at the level of the lip is obtained by making $y = 0$ in equation (23). Then, $x=4K(d+h_v)\tan\ \theta \cos^2\ \theta = 2K(d+h_v)\sin\ 2\theta$. The maximum value of x will be $2K(d + h_v)$ when $\theta = 45°$. However, the angle of the lip is influenced by the bucket radius and the height of the lip above the bucket invert; ordinarily the exit angle should not be more than 30°.

The bucket radius should be made long enough to maintain concentric flow as the water moves around the curve. The rate of curvature must be limited, similar to that of a vertical curve in a discharge channel (sec. 9.19), so that the floor pressures will not alter the streamline distribution of the flow. The minimum radius of curvature, R, can be determined from equation (20), except that values of $p \leq 1{,}000$ lb/ft^2 will produce values of the radius that have proved satisfactory in practice. However, the radius should not be less than $5d$, five times the depth of water. Structurally, the cantilever bucket must be strong enough to withstand this normal dynamic force in addition to the other applied forces.

9.21. ***Hydraulic-Jump Basins.***—(a) *General.*—Where the energy of flow in a spillway must be dissipated before the discharge is returned to the downstream river channel, the hydraulic-jump stilling basin is an effective device for reducing the exit velocity to a tranquil state. The jump that will occur in such a stilling basin has distinctive characteristics and assumes a definite form, depending on the relation between the energy of flow that must be dissipated and the depth of the flow.

A comprehensive series of tests have been performed by the Bureau of Reclamation [15] to determine the properties of the hydraulic jump. The jump form and the flow characteristics can be related to the kinetic flow factor, v^2/gd, of the discharge entering the basin; to the critical depth of flow, d_c ; or to the Froude number parameter, $v/(gd)^{1/2}$. Forms of the hydraulic-jump phenomena for various ranges of the Froude number are illustrated on figure 9-37.

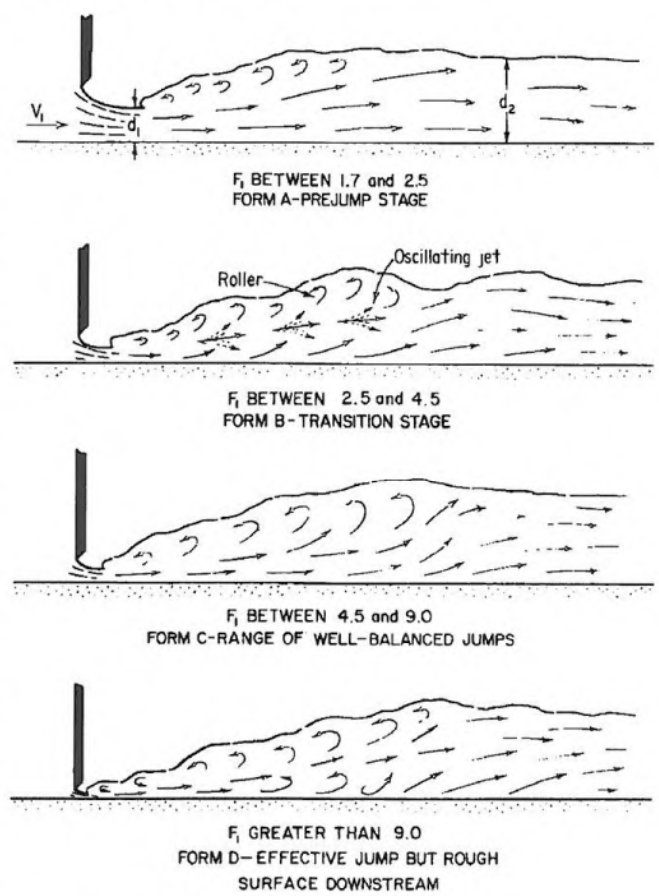


Figure 9-37.—Characteristic forms of hydraulic jump related to the Froude number. 288-D-2423.

When the Froude number of the incoming flow is 1.0, the flow is at critical depth and a hydraulic jump cannot form. For Froude numbers from 1.0 to about 1.7, the incoming flow is only slightly below critical depth, and the change from this low stage to the high stage flow is gradual and manifests itself only by a slightly ruffled water surface. As the Froude number approaches 1.7, a series of small rollers begins to develop on the surface. These become more intense with increasingly higher values of the number. Other than the surface roller phenomena, relatively smooth flows prevail throughout the Froude number range up to about 2.5. Stilling action for the range of Froude numbers from 1.7 to 2.5 is shown as form A on figure 9-37. Forms B, C, and D on figure 9-37 show characteristic forms at hydraulic jumps related to higher Froude numbers.

For Froude numbers between 2.5 and 4.5, an oscillating form of jump occurs. The entering jet intermittently flows near the bottom and then along the surface of the downstream channel. This oscillating flow causes objectionable surface waves that carry far beyond the end of the basin. The action represented through this range of flows is designated as form B on figure 9-37.

For Froude numbers between 4.5 and 9, a stable and well-balanced jump occurs. Turbulence is confined to the main body of the jump, and the water surface downstream is comparatively smooth. As the Froude number increases above 9, the turbulence within the jump and the surface roller becomes increasingly active, resulting in a rough water surface with strong surface waves downstream from the jump. Stilling action for Froude numbers between 4.5 and 9 is designed as form C on figure 9-37, and that above 9 is designated as form D.

Figure 9-38 plots relationships of conjugate depths and velocities for the hydraulic jump in a rectangular channel. The ranges for the various forms of jump described above are also indicated on the figure.

(b) *Basin Design in Relation to Froude Numbers.*—Stilling basin designs suitable to provide stilling action for the various forms of jump are described in the following paragraphs.

(1) *Basins for Froude Numbers Less Than 1.7.*—For a Froude number of 1.7, the conjugate depth, d_2, is about twice the incoming depth, or about 40 percent greater than the critical depth. The exit velocity, v_2, is about one-half the incoming velocity, or 30 percent less than the critical velocity. No special stilling basin is needed to still flows where the Froude number of the incoming flow is less than 1.7, except that the channel lengths beyond the point where the depth starts to change should be not less than about $4d_2$. No baffles or other dissipating devices are needed. These basins, designated type I, are not shown here (see [15]).

(2) *Basins for Froude Numbers Between 1.7 and 2.5.*—Flow phenomena for these basins will be in the form designated as the prejump stage, as shown on figure 9-37. Because such flows are not attended by active turbulence, baffles or sills are not required. The basin should be long enough to contain the flow prism while it is undergoing retardation. Conjugate depths and basin lengths shown on figure B-15 will provide acceptable basins. These basins, designated type I, are not shown here (see [15]).

(3) *Basins for Froude Numbers Between 2.5 and 4.5.*—Flows for these basins are considered to be in the transition flow stage because a true hydraulic jump does not fully develop. Stilling basins that accommodate these flows are the least effective in providing satisfactory dissipation because the attendant wave action ordinarily cannot be controlled by the usual basin devices. Waves generated by the flow phenomena will persist beyond the end of the basin and must often be dampened by means apart from the basin.

Where a stilling device must be provided to dissipate flows for this range of Froude number, the basin shown on figure 9-39(A), which is designated a type IV basin, has proved relatively effective for dissipating the bulk of the energy of flow. However, the wave action propagated by the oscillating flow cannot be entirely dampened. Auxiliary wave dampeners or wave suppressors must sometimes be used to provide smooth surface flow downstream.

Because of the tendency of the jump to sweep out and as an aid in suppressing wave action, the water depths in the basin should be about 10 percent greater than the computed conjugate depth.

Often, the need to design this type of basin can be avoided by selecting stilling basin dimensions that will provide flow conditions that fall outside the range of transition flow. For example, with an 800-ft^3/s capacity spillway where the specific energy at the upstream end of the basin is about 15 feet and the velocity into the basin is about 30 ft/s, the Froude number will be 3.2 for a basin width of 10 feet. The Froude number can be raised to 4.6 by widening the basin to 20 feet. The selection of basin

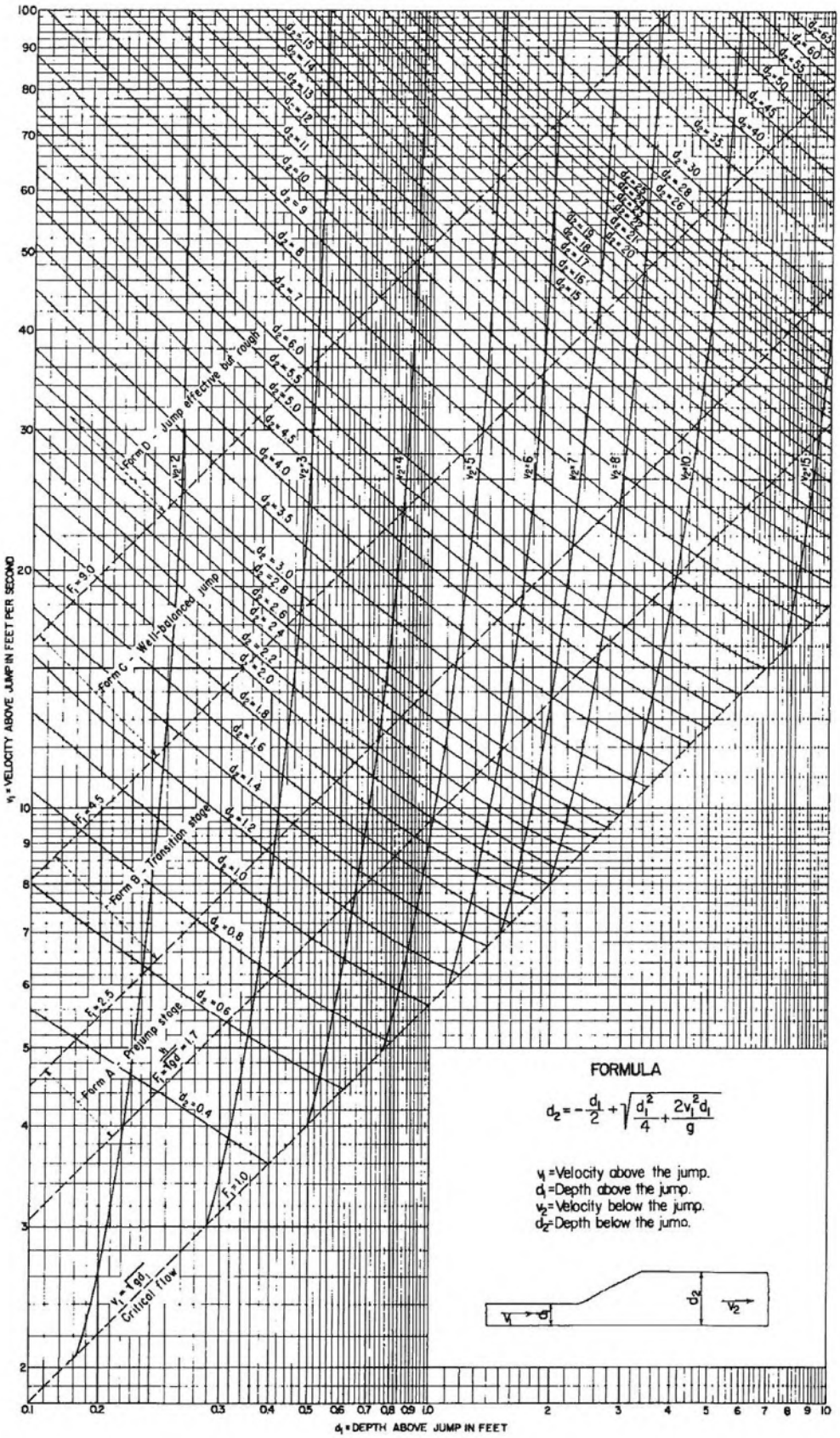


Figure 9-38.—Relations between variables in hydraulic jump for rectangular channel. 288-D-2424.

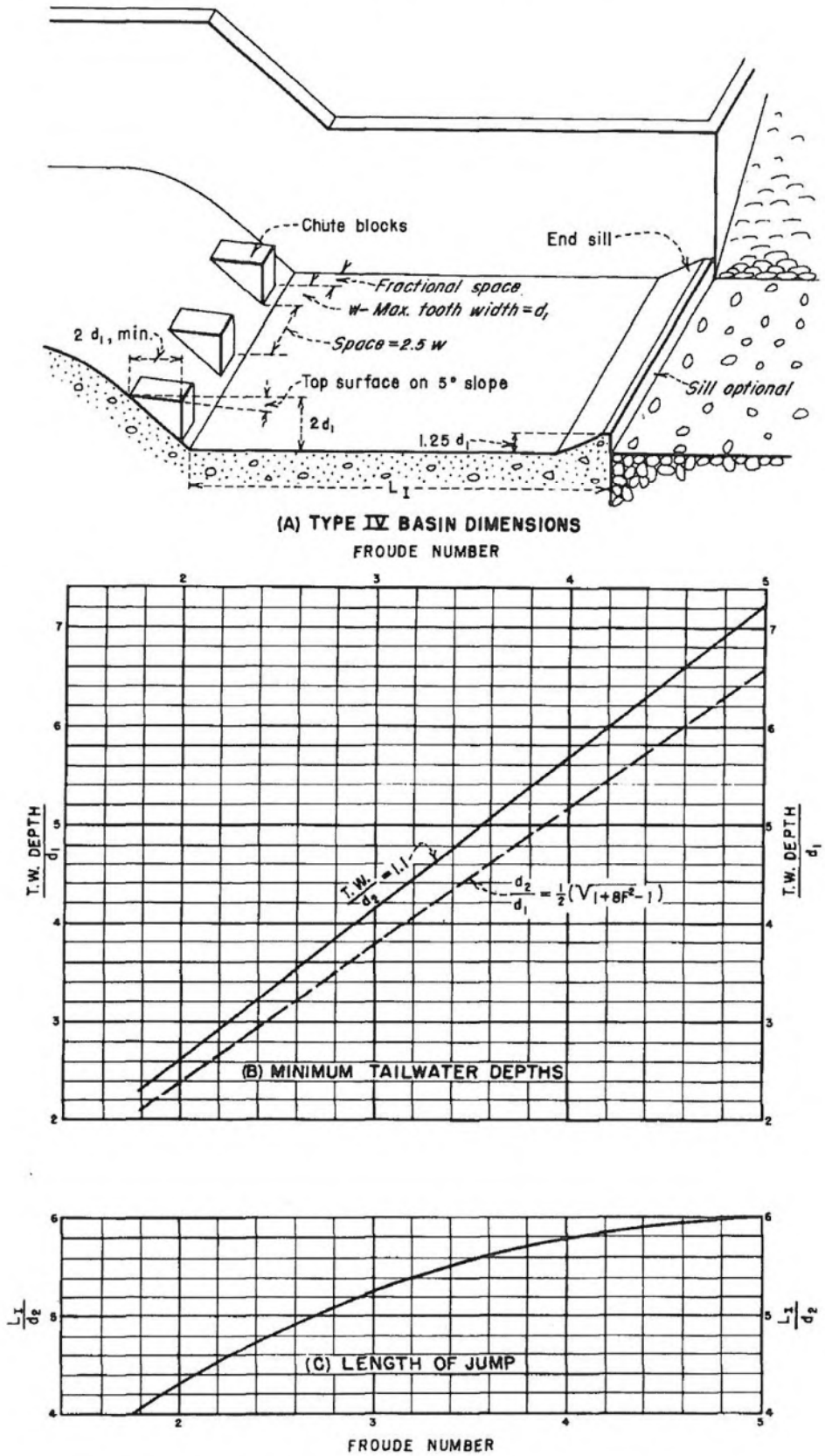


Figure 9-39.—Stilling basin characteristics for Froude numbers between 2.5 and 4.5. 288-D-2425.

width then becomes a matter of economics as well as hydraulic performance.

(4) *Alternative Low Froude Number Stilling Basins.*—Type IV basins are fairly effective at low Froude number flows for small canals and for structures with small unit discharges. However, recent model tests have developed designs quite different from the type IV basin design, even though the type IV basin design was included in the initial tests.

Palmetto Bend Dam stilling basin [22] is an example of a low Froude number structure, modeled in the Bureau of Reclamation Hydraulics Laboratory, whose recommended design is quite different from type IV design. The type IV design has large deflector blocks, similar to but larger than chute blocks, and an optional solid end sill; the Palmetto Bend design has no chute blocks, but has large baffle piers and a dentated end sill.

The foregoing generalized designs have not been suitable for some Bureau applications, and the increased use of low Froude number stilling basins has created a need for additional data on this type of design. A study was initiated to develop generalized criteria for the design of low Froude number hydraulic-jump stilling basins. The criteria and guidelines from previous studies were combined with the results of this study to formulate the design guidelines recommended for low Froude number stilling basins [23]. However, it should be noted that a hydraulic-jump stilling basin is not an efficient energy dissipator at low Froude numbers; that is, the efficiency of a hydraulic-jump basin is less than 50 percent in this Froude number range. Alternative energy dissipators, such as the baffled apron chute or spillway, should be considered for these conditions.

The recommended design has chute blocks, baffle piers, and a dentated end sill. All design data are presented on figure 9-40. The length is rather short, approximately three times d_2 (the conjugate depth after the jump). The size and spacing of the chute blocks and baffle piers are a function of d_1 (incoming depth) and the Froude number. The dentated end sill is proportioned according to d_2 and the Froude number. The end sill is placed at or near the downstream end of the stilling basin. Erosion tests were not included in the development of this basin. Observations of flow patterns near the invert downstream from the basin indicated that no erosion problem should exist. However, if hydraulic model tests are performed to confirm a design based on these criteria, erosion tests should be included. Tests should be made over a full range of discharges to determine whether abrasive materials will move upstream into the basin and to determine the erosion potential downstream from the basin. If the inflow velocity is greater than 50 ft/s, hydraulic model studies should be performed.

(5) *Basins for Froude Numbers Higher Than 4.5.*—For these basins, a true hydraulic jump will form. The elements of the jump will vary according to the Foude number, as shown on figure B-15. The installation of accessory devices such as blocks, baffles, and sills along the floor of the basin produce a stabilizing effect on the jump, which permits shortening the basin and provides a safety factor against sweepout caused by inadequate tailwater depth.

The basin shown on figure 9-41, which is designated a type III basin, can be adopted where incoming velocities do not exceed 60 ft/s. The type III basin uses chute blocks, impact baffle blocks, and an end sill to shorten the jump length and to dissipate the high-velocity flow within the shortened basin length. This basin relies on dissipation of energy by the impact blocks and on the turbulence of the jump phenomena for its effectiveness. Because of the large impact forces to which the baffles are subjected by the impingement of high incoming velocities and because of the possibility of cavitation along the surfaces of the blocks and floor, the use of this basin must be limited to heads where the velocity does not exceed 60 ft/s.

Cognizance must be taken of the added loads placed on the structure floor by the dynamic force brought against the upstream face of the baffle blocks. This dynamic force will approximate that of a jet impinging upon a plane normal to the direction of flow. The force, in pounds, may be expressed by the formula:

$$\text{Force} = 2wA(d_1+h_{v_1}) \qquad (24)$$

where:

w = unit weight of water, in pounds per cubic foot,
A = area of the upstream face of the block, in square feet, and
$(d_1+h_{v_1})$ = the specific energy of the flow entering the basin, in feet.

Negative pressure on the back face of the blocks

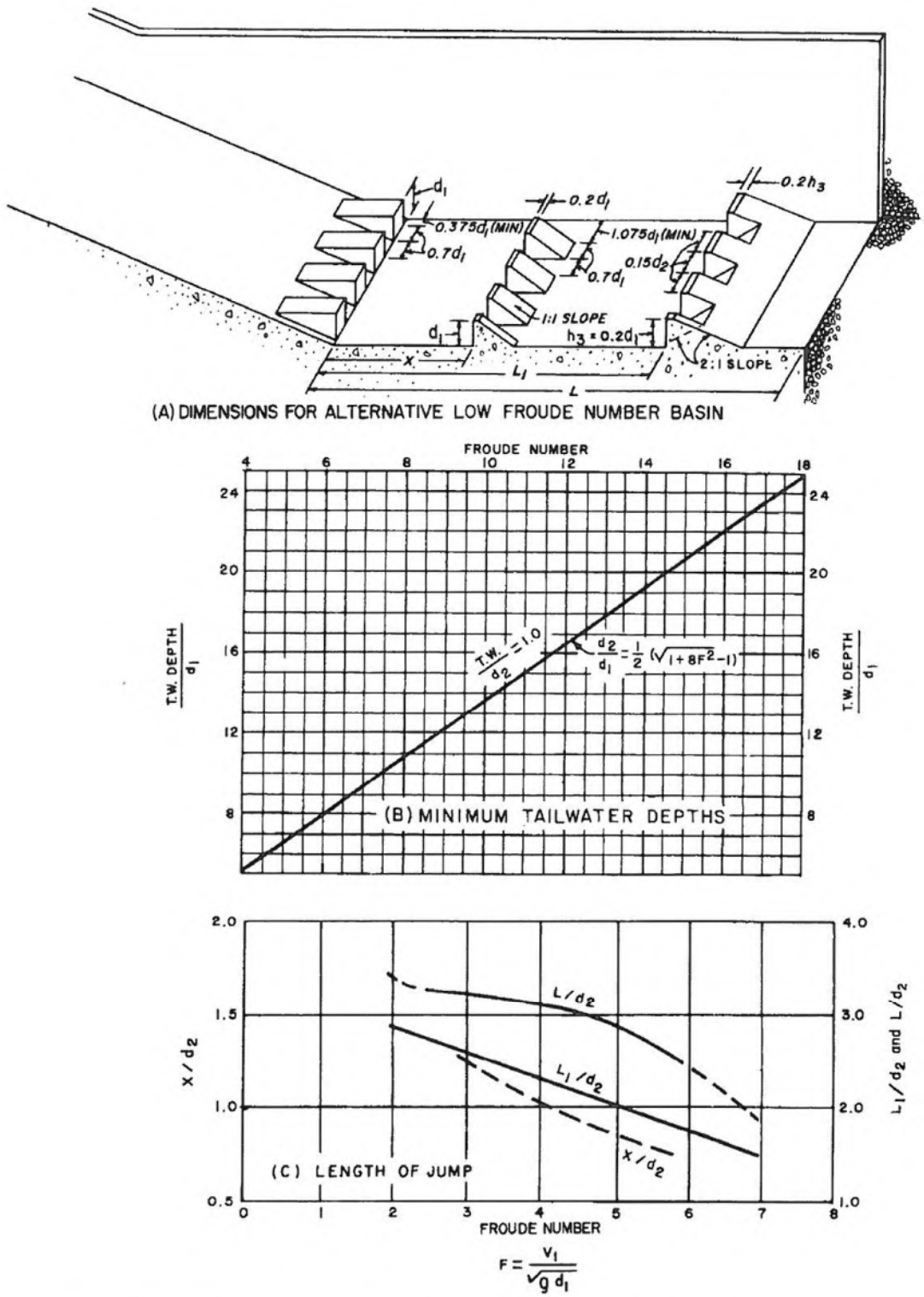


Figure 9-40.—Characteristics for alternative low Froude number stilling basins. 103–D–1876.

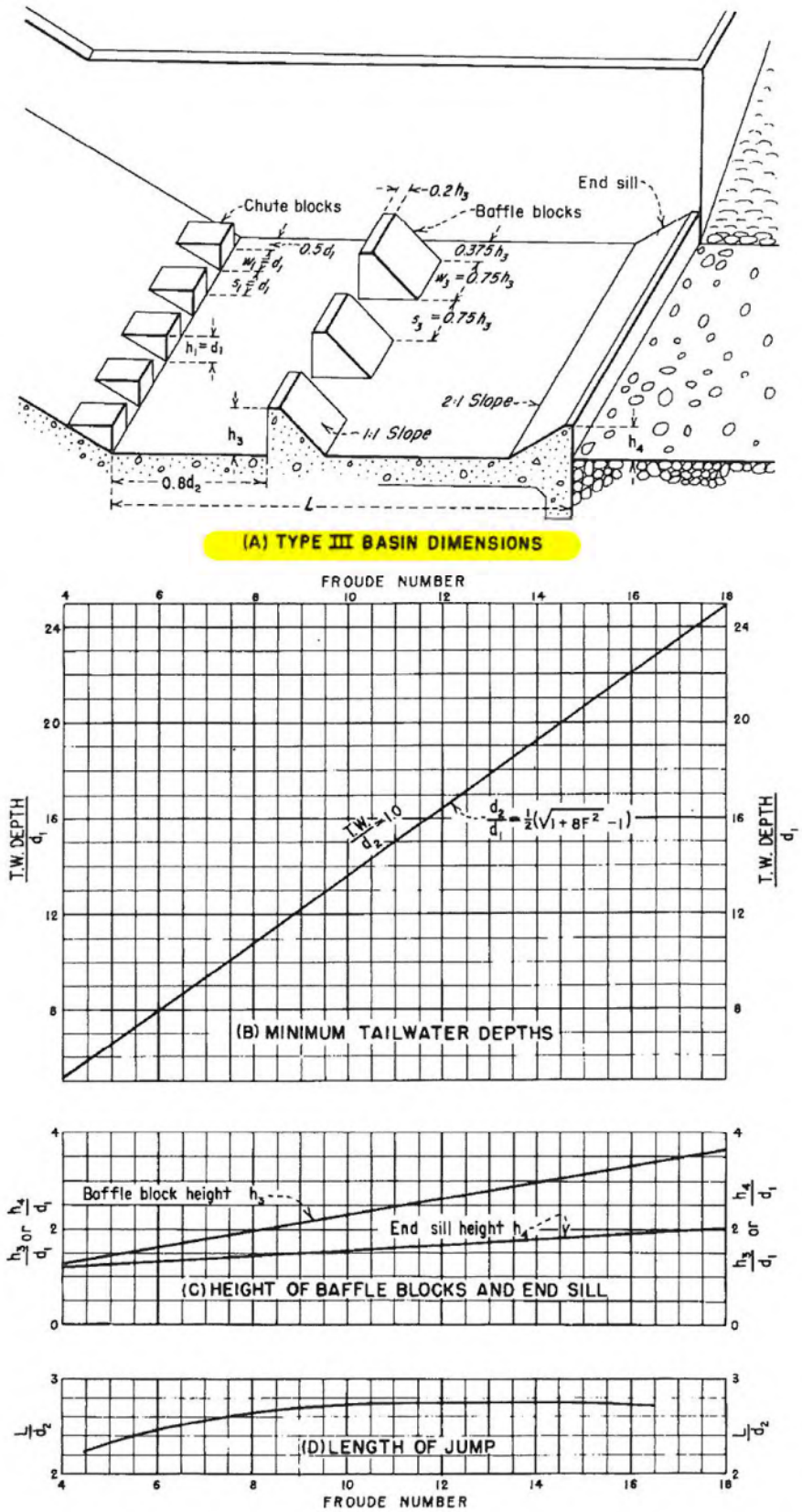


Figure 9-41.—Stilling basin characteristics for Froude numbers above 4.5 where incoming velocity, $V_1 \leq 60$ ft/s. 288–D–2426.

will further increase the total load. However, because the baffle blocks are placed a distance equal to $0.8d_2$ beyond the start of the jump, there will be some cushioning effect by the time the incoming jet reaches the blocks, and the force will be less than that indicated by the above equation. If the full force computed by equation (24) is used, the negative pressure force may be neglected.

Where incoming velocities exceed 60 ft/s, or where impact baffle blocks are not used, the type II basin (fig. 9-42) may be adopted. Because the dissipation is accomplished primarily by hydraulic-jump action, the basin length will be greater than that indicated for the type III basin. However, the chute blocks and dentated end sill will still effectively reduce the length. Because of the reduced margin of safety against sweepout, the water depth in the basin should be about 5 percent greater than the computed conjugate depth.

(c) *Rectangular Versus Trapezoidal Stilling Basin.*—The use of a trapezoidal stilling basin instead of a rectangular basin may often be proposed where economy favors sloped side lining over vertical wall construction. Model tests have shown, however, that the hydraulic-jump action in a trapezoidal basin is much less complete and less stable than it is in the rectangular basin. In a trapezoidal basin, the water in the triangular areas along the sides of the basin adjacent to the jump does not oppose the incoming high-velocity jet. The jump, which tends to occur vertically, cannot spread sufficiently to occupy the side areas. Consequently, the jump will form only in the central portion of the basin, while areas along the outside will be occupied by upstream-moving flows that ravel off the jump or come from the lower end of the basin. The eddy or horizontal roller action resulting from this phenomenon tends to interfere and interrupt the jump action to the extent that there is incomplete dissipation of the energy and severe scouring can occur beyond the basin. For good hydraulic performance, the sidewalls of a stilling basin should be vertical or as close to vertical as practicable.

(d) *Basin Depths Versus Hydraulic Heads.*—The nomograph on figure 9-43 can help determine approximate basin depths for various basin widths and for various differences between reservoir and tailwater levels. Plots are shown for the condition of no loss of head to the upstream end of the stilling basin, and for 10, 20, and 30 percent loss as scales A, B, C, and D, respectively. The required conjugate depths, d_2, will depend on the specific energy available at the entrance of the basin, as determined by the procedure discussed in section 9.18. Where the specific energy is known, the head loss in the channel upstream can be related to the velocity head, the percentage loss can be determined, and the approximate conjugate depth can be read for the nomograph. Where head losses have not been computed, a quick approximation of the head losses can be obtained from figure B-5. Where only a rough determination of basin depths is needed, the choice of the loss to be applied for various spillway designs may be generalized as follows:

(1) For a design of an overflow spillway where the basin is directly downstream from the crest, or where the chute is not longer than the hydraulic head, consider no loss of head.
(2) For a design of a channel spillway where the channel length is between one and five times the hydraulic head, consider 10 percent loss of head.
(3) For a design of a spillway where the channel length exceeds five times the hydraulic head, consider 20 percent loss of head.

The nomograph on figure 9-43 gives values of the conjugate depth of the hydraulic jump. Tailwater depths for the various types of basin described should be increased as noted earlier in this section.

(e) *Tailwater Considerations.*—Determination of the tailwater rating curve, which gives the stage-discharge relationship of the natural stream below the dam, is discussed in appendix B, part B. Tailwater rating curves for the regime of river below a dam are fixed by the natural conditions along the stream and ordinarily cannot be altered by the spillway design or by the release characteristics. As discussed in section 9.7(d), the retrogression or aggradation of the river below the dam, which will affect the ultimate stage-discharge conditions, must be recognized in selecting the tailwater rating curve to be used for stilling basin design. Usually, river flows that approach the maximum design discharges do not occur, and an estimate of the tailwater rating curve must either be extrapolated from known conditions or computed on a basis of assumed or empirical criteria. Thus, the tailwater rating curve is, at best, only approximate, and safety factors must be included in the design to compensate for variations in tailwater.

For a jump-type stilling basin, downstream water

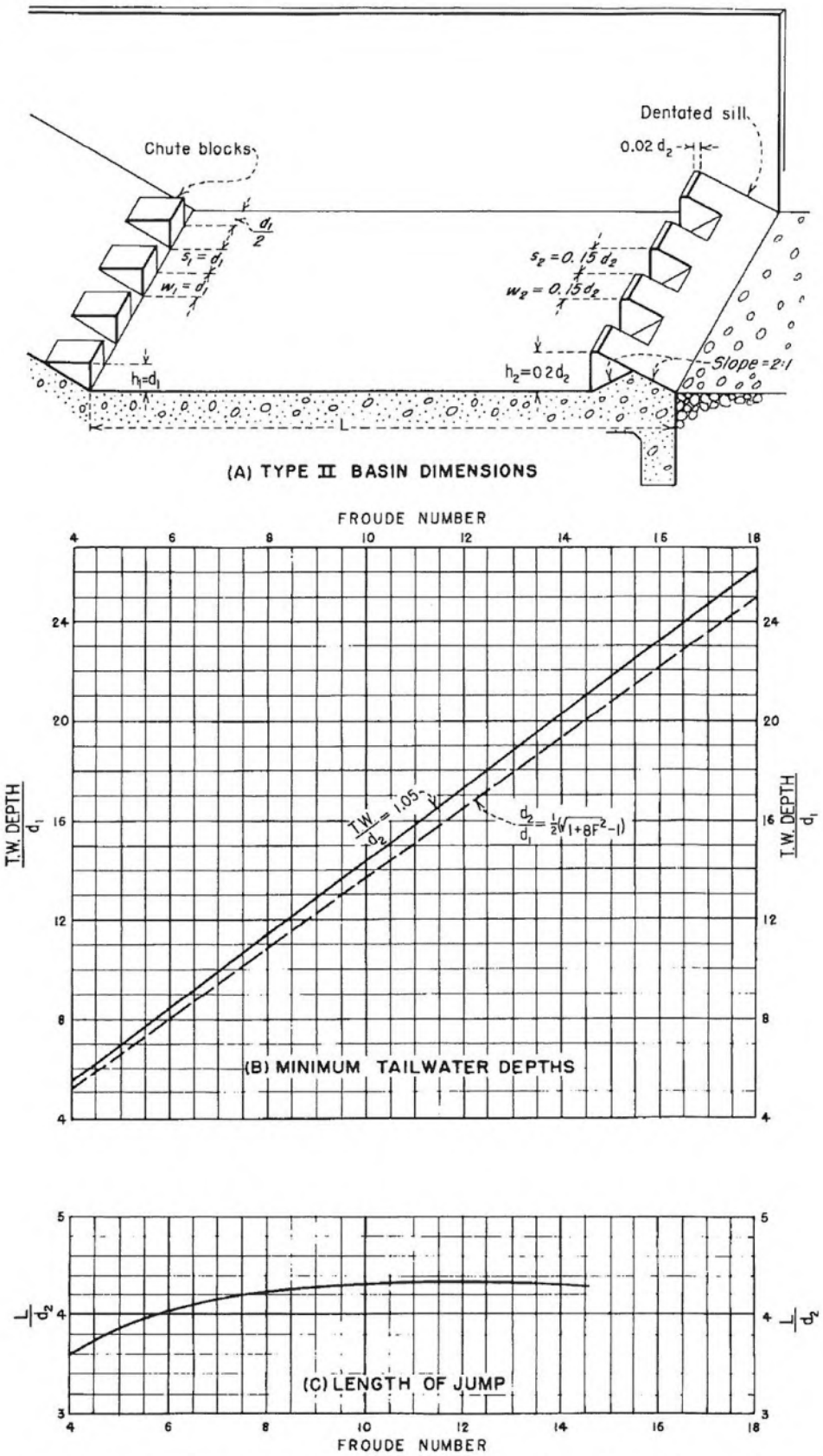


Figure 9-42.—Stilling basin characteristics for Froude numbers above 4.5. 288-D-2427.

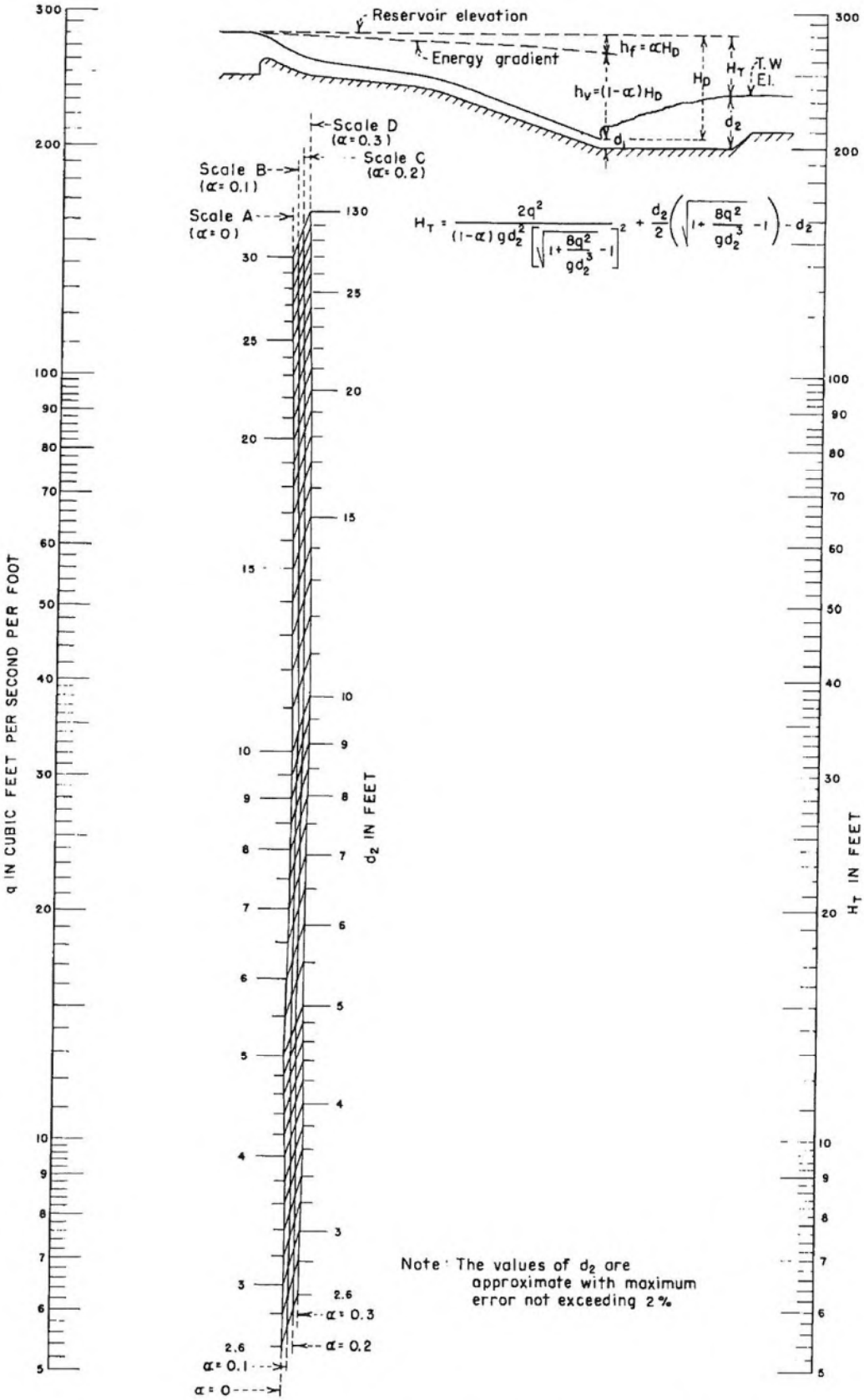


Figure 9-43.—Stilling basin depths versus hydraulic heads for various channel losses. 288-D-2428.

levels for various discharges must conform to the tailwater rating curve. The basin floor level must therefore be selected to provide jump depths that most nearly agree with the tailwater depths. For a given basin design, the tailwater depth for each discharge seldom corresponds to the conjugate depth needed to form a perfect jump. Thus, the relative shapes and relationships of the tailwater curve to the depth curve will determine the required minimum depth to the basin floor. This is shown on figure 9-44(A) where the tailwater rating curve is shown as curve 1, and a conjugate depth versus discharge curve for a basin of certain width is represented by curve 3. Because the basin must be deep enough to provide for full conjugate depth (or some greater depth to provide a safety factor) at the maximum spillway design discharge, the curves will intersect at point D. For lesser discharges the tailwater depth will be greater than the required conjugate depth, thus providing an excess of tailwater, which is conducive to the formation of a "drowned jump." (With the drowned jump condition, instead of achieving good jump-type dissipation by the intermingling of the upstream and downstream flows, the incoming jet plunges to the bottom and carries along the entire length of the basin floor at high velocity.) If the basin floor is higher than indicated by the position of curve 3 on figure 9-44, the depth curve and tailwater rating curve will intersect to the left of point D. This indicates an excess of tailwater for smaller discharges and a deficiency of tailwater for higher discharges.

As an alternative to the selected basin represented by curve 3, a wider basin might be considered for which conjugate depth curve 2 will apply. This design will provide a shallower basin, in which the ideal jump depths will more nearly match the tailwater depths for all discharges. The choice of basin widths, of course, involves consideration of economics, as well as of hydraulic performance.

Where a tailwater rating curve shaped similar to that represented by curve 4 on figure 9-44(B) is encountered, the level of the stilling basin floor must be determined for some discharge other than the maximum design capacity. If the tailwater curve intersects the required water surface elevation at the maximum design capacity, as in figure 9-44(A), there would be insufficient tailwater depth for most smaller discharges. In this case the basin floor elevation is selected so that there will be sufficient tailwater depth for all discharges. For a basin of

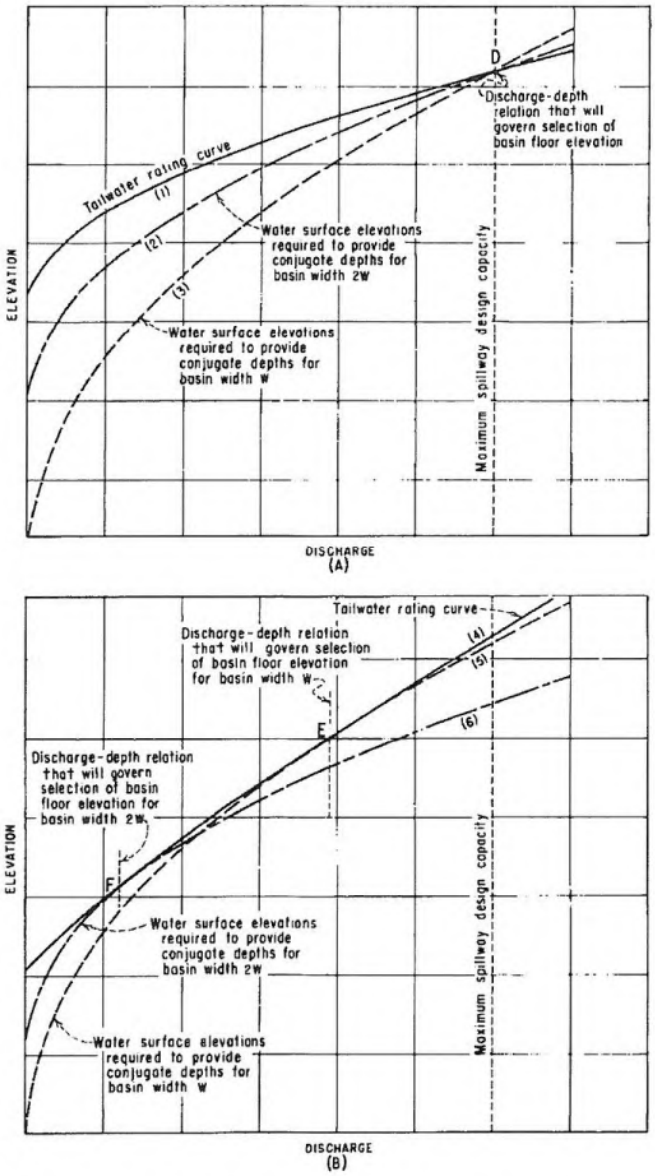


Figure 9-44.—Relationships of conjugate depth curves to tailwater rating curves. 288-D-2429.

width W, the floor level should be selected so that the two curves would coincide at the discharge represented by point E on the figure 9-44(B). For all other discharges the tailwater depth will be greater than that needed to form a satisfactory jump. Similarly, if a basin width of $2W$ were considered, the basin floor level would be selected so that curve 6 would intersect the tailwater curve at point F. Here also, the selection of basin widths should be based on economics as well as on hydraulic performance.

Where exact conjugate depth conditions for forming the jump cannot be attained, the relative desirability of having insufficient tailwater as com-

pared with having excessive tailwater should be considered. With insufficient tailwater the back pressure will be deficient and sweepout of the basin will occur. With an excess of tailwater the jump will be formed, and energy dissipation within the basin will be complete until the drowned-jump phenomenon becomes critical. Chute blocks, baffles, and end sills will also assist in energy dissipation, even with a drowned jump.

(f) *Stilling Basin Freeboard.*—Freeboard is ordinarily provided so that the stilling basin walls will not be overtopped by surges, splash and spray, and wave action set up by the turbulence of the jump. The surface roughness of the flow is related to the energy dissipated in the jump and to the depth of flow in the basin. The following empirical expression provides values that have proved satisfactory for most basins:

$$\text{Freeboard in feet} = 0.1(v_1 + d_2) \qquad (25)$$

9.22. *Submerged Bucket Dissipators.*—When the tailwater depth is too great for the formation of a hydraulic jump, the high energy can be dissipated by the use of a submerged bucket deflector. The hydraulic behavior in this type of dissipator is manifested primarily by the formation of two rollers: one occurs on the surface, moves counterclockwise, and is contained within the region above the curved bucket; the other is a ground roller, moves clockwise, and is situated downstream from the bucket. The movements of these rollers, along with the intermingling of the incoming flows, effectively dissipate the high energy of the water and prevent excessive scouring downstream from the bucket.

Two types of roller buckets have been developed and model tested [15]. Their shape and dimensions are shown on figure 9-45. The general nature of the dissipating action for each type is represented on figure 9-46. The hydraulic actions of the two buckets have the same characteristics, but distinctive features of their flows differ to the extent that each has certain limitations. The high-velocity flow leaving the deflector lip of the solid bucket is directed upward (fig. 9-46(A)). This creates a high boil on the water surface and a violent ground roller moving clockwise downstream from the bucket. This ground roller continuously pulls loose material back towards the lip of the bucket and keeps some of the intermingling material in a constant state of agitation. The typical scour pattern that results from this action is shown on figure 9-47. The high-velocity jet leaves the lip of a slotted bucket at a flatter angle, and only a part of the high-velocity flow finds its way to the surface (fig. 9-46(B)). Thus, a less violent surface boil occurs, and there is a better dissipation of flow in the region above the ground roller. This results in less concentration of high-energy flow throughout the bucket and a smoother downstream flow.

Use of a solid bucket dissipator may be objectionable because of the abrasion on the concrete surfaces caused by material that is swept back along the lip of the deflector by the ground roller. In addition, the more turbulent surface roughness induced by the severe surface boil carries farther down the river, causing objectionable eddy currents that contribute to riverbank sloughing. Although the slotted bucket provides better energy dissipation with less severe surface and streambed disturbances, it is more sensitive to sweepout at lower tailwaters and is conducive to a diving and scouring action at excessive tailwaters. This is not the case with the solid bucket. Thus, the tailwater range that provides good performance with the slotted bucket is much narrower than that of the solid bucket. A

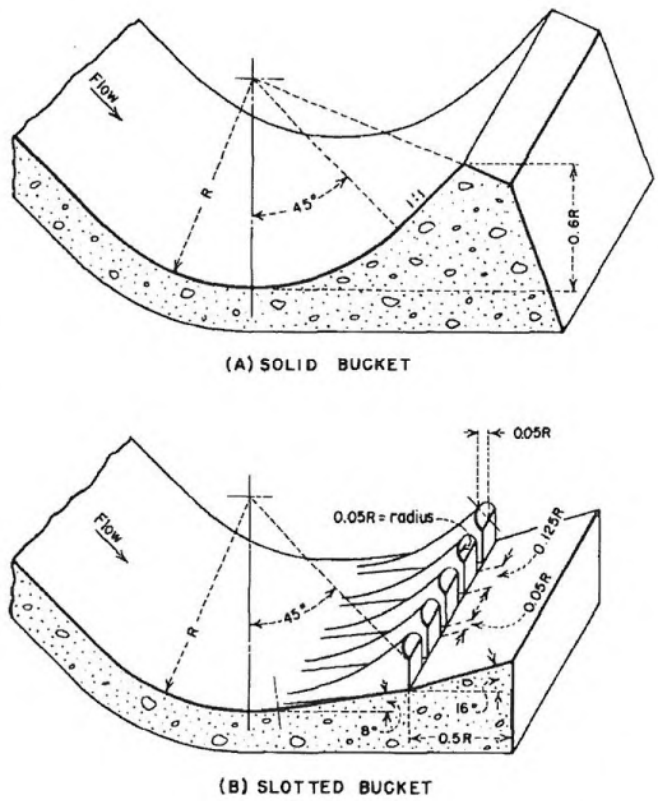
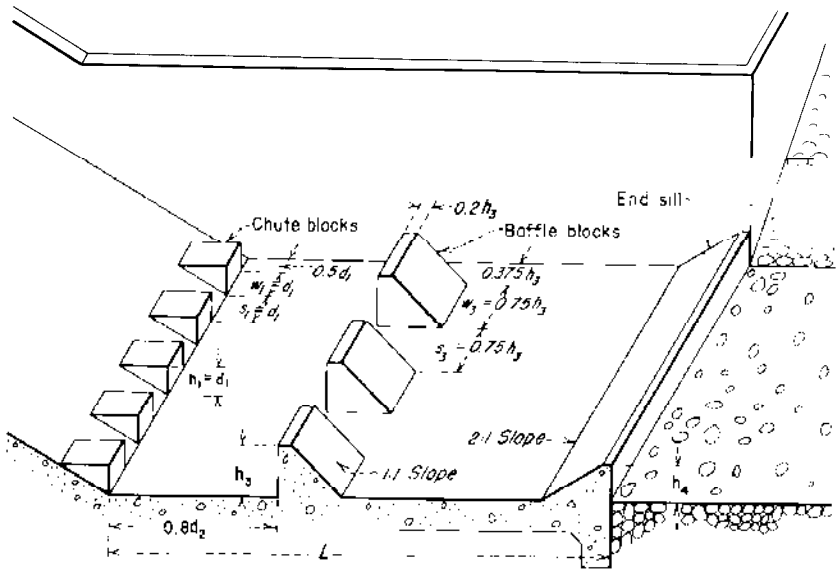


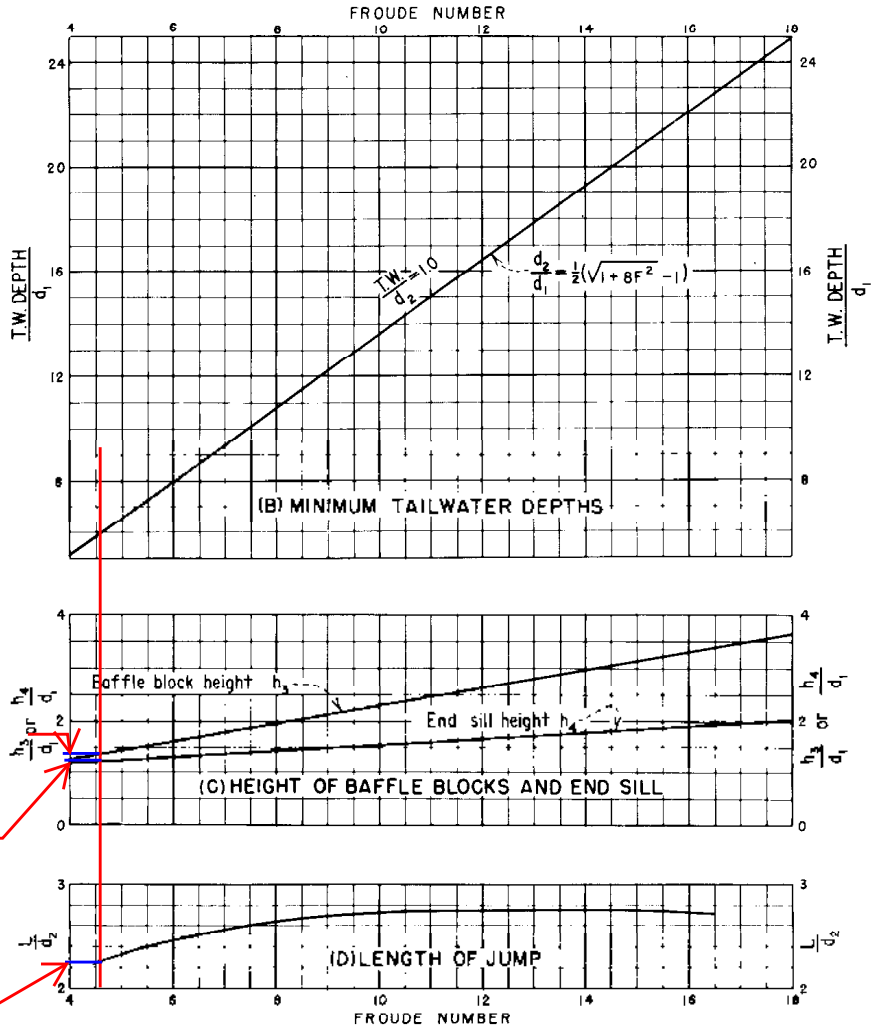
Figure 9-45.—Submerged buckets. 288-D-2430.

d2 = 24.51
d1= 4.08
v1=52.6
Fr=4.6



(A) TYPE III BASIN DIMENSIONS

h3 = 5.7
h4 = 5.1
L = 56.3



1.4

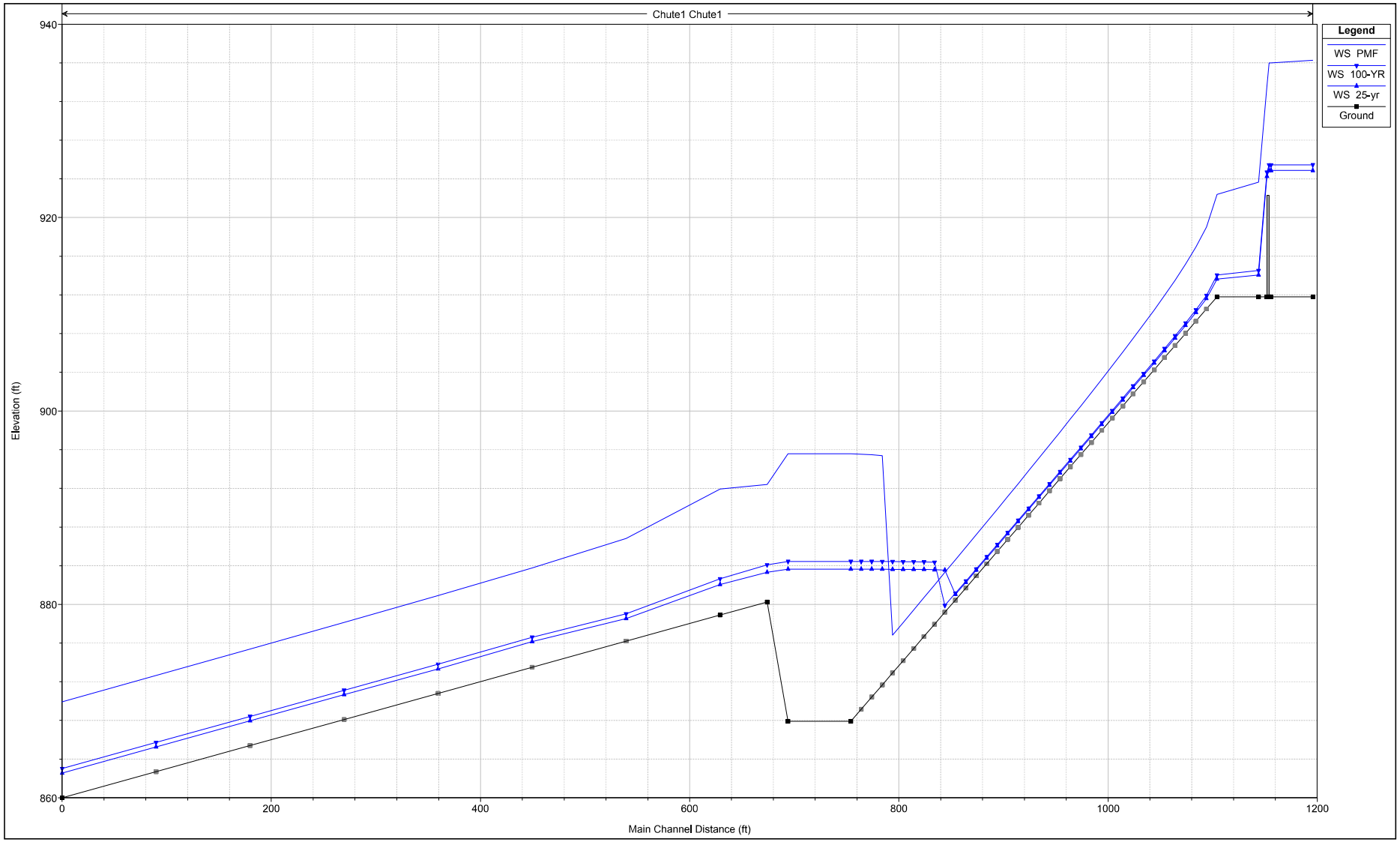
1.25

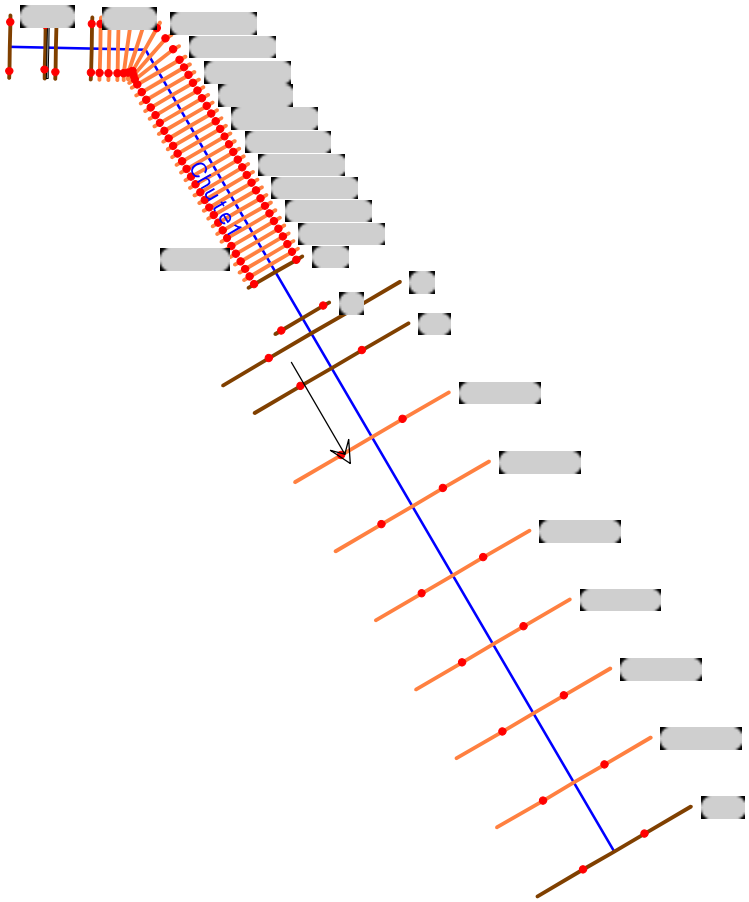
2.3

Figure 9-41.—Stilling basin characteristics for Froude numbers above 4.5 where incoming velocity, $V_1 \leq 60$ ft/s. 288–D–2426.

Freeboard = 0.1(52.6 + 24.51) = 7.7 ft

Attachment C - HEC-RAS Output





None of the XS's are Geo-Referenced (Geo-Ref user entered XS Geo-Ref interpolated XS Non Geo-Ref user entered XS Non Geo-Ref interpolated XS)

HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	542.5	PMF	10817.00	911.80	936.26	922.42	937.27	0.000217	8.04	1345.65	55.02	0.29
Chute1	542.5	25-yr	783.00	911.80	924.87	913.64	924.89	0.000007	1.09	719.17	55.01	0.05
Chute1	542.5	100-YR	1065.00	911.80	925.45	914.06	925.48	0.000011	1.42	750.96	55.01	0.07
Chute1	502.65	PMF	10817.00	911.80	935.99	923.12	937.23	0.000287	8.94	1209.74	50.02	0.32
Chute1	502.65	25-yr	783.00	911.80	924.87	913.76	924.89	0.000008	1.20	653.57	50.01	0.06
Chute1	502.65	100-YR	1065.00	911.80	925.44	914.21	925.48	0.000014	1.56	682.31	50.01	0.07
Chute1	496.65		Inl Struct									
Chute1	490.65	PMF	10817.00	911.80	923.66	922.40	927.93	0.001670	16.58	652.46	55.01	0.85
Chute1	490.65	25-yr	783.00	911.80	914.07		914.68	0.001489	6.27	124.96	55.00	0.73
Chute1	490.65	100-YR	1065.00	911.80	914.53	914.06	915.31	0.001516	7.08	150.40	55.00	0.75
Chute1	450.8	PMF	10817.00	911.80	922.40	922.40	927.74	0.002328	18.56	582.93	55.01	1.00
Chute1	450.8	25-yr	783.00	911.80	913.64	913.64	914.57	0.002951	7.74	101.19	55.00	1.01
Chute1	450.8	100-YR	1065.00	911.80	914.06	914.06	915.20	0.002806	8.57	124.26	55.00	1.00
Chute1	440.777*	PMF	10817.00	910.55	919.01	921.17	927.40	0.004562	23.24	465.53	55.01	1.41
Chute1	440.777*	25-yr	783.00	910.55	911.63	912.39	914.34	0.016954	13.21	59.26	55.00	2.24
Chute1	440.777*	100-YR	1065.00	910.55	911.94	912.81	914.96	0.013671	13.95	76.35	55.00	2.09
Chute1	430.754*	PMF	10817.00	909.29	916.97	919.91	927.16	0.006136	25.62	422.16	55.01	1.63
Chute1	430.754*	25-yr	783.00	909.29	910.20	911.13	914.01	0.029629	15.66	50.00	55.00	2.89
Chute1	430.754*	100-YR	1065.00	909.29	910.47	911.55	914.67	0.023423	16.44	64.78	55.00	2.67
Chute1	420.731*	PMF	10817.00	908.04	915.19	918.66	926.94	0.007615	27.50	393.29	55.01	1.81
Chute1	420.731*	25-yr	783.00	908.04	908.86	909.88	913.57	0.042024	17.41	44.97	55.00	3.39
Chute1	420.731*	100-YR	1065.00	908.04	909.10	910.30	914.29	0.033143	18.28	58.27	55.00	3.13
Chute1	410.708*	PMF	10817.00	906.78	913.53	917.40	926.71	0.009084	29.13	371.29	55.01	1.98
Chute1	410.708*	25-yr	783.00	906.78	907.54	908.62	913.01	0.053876	18.78	41.70	55.00	3.80
Chute1	410.708*	100-YR	1065.00	906.78	907.76	909.04	913.82	0.042790	19.75	53.91	55.00	3.52
Chute1	400.685*	PMF	10817.00	905.53	911.96	916.15	926.48	0.010539	30.57	353.79	55.01	2.12
Chute1	400.685*	25-yr	783.00	905.53	906.25	907.37	912.36	0.064624	19.84	39.46	55.00	4.13
Chute1	400.685*	100-YR	1065.00	905.53	906.45	907.79	913.27	0.051975	20.96	50.82	55.00	3.84

HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	390.662*	PMF	10817.00	904.27	910.43	914.89	926.24	0.012014	31.90	339.09	55.01	2.26
Chute1	390.662*	25-yr	783.00	904.27	904.96	906.11	911.61	0.074377	20.70	37.82	55.00	4.40
Chute1	390.662*	100-YR	1065.00	904.27	905.15	906.53	912.65	0.060693	21.97	48.48	55.00	4.12
Chute1	380.64*	PMF	10817.00	903.02	908.96	913.64	925.99	0.013483	33.11	326.67	55.00	2.39
Chute1	380.64*	25-yr	783.00	903.02	903.69	904.86	910.78	0.082726	21.38	36.62	55.00	4.62
Chute1	380.64*	100-YR	1065.00	903.02	903.87	905.28	911.94	0.068604	22.80	46.71	55.00	4.36
Chute1	370.617*	PMF	10817.00	901.77	907.51	912.39	925.72	0.014961	34.24	315.87	55.00	2.52
Chute1	370.617*	25-yr	783.00	901.77	902.42	903.61	909.88	0.089887	21.93	35.71	55.00	4.80
Chute1	370.617*	100-YR	1065.00	901.77	902.59	904.03	911.17	0.075796	23.50	45.32	55.00	4.56
Chute1	360.594*	PMF	10817.00	900.51	906.08	911.13	925.44	0.016456	35.31	306.34	55.00	2.64
Chute1	360.594*	25-yr	783.00	900.51	901.15	902.35	908.92	0.096168	22.38	34.99	55.00	4.94
Chute1	360.594*	100-YR	1065.00	900.51	901.31	902.77	910.33	0.082364	24.10	44.19	55.00	4.74
Chute1	350.571*	PMF	10817.00	899.26	904.68	909.88	925.16	0.017963	36.32	297.84	55.00	2.75
Chute1	350.571*	25-yr	783.00	899.26	899.89	901.10	907.91	0.101156	22.72	34.46	55.00	5.06
Chute1	350.571*	100-YR	1065.00	899.26	900.05	901.52	909.44	0.088070	24.60	43.30	55.00	4.89
Chute1	340.548*	PMF	10817.00	898.00	903.28	908.62	924.86	0.019490	37.28	290.13	55.00	2.86
Chute1	340.548*	25-yr	783.00	898.00	898.62	899.84	906.86	0.105805	23.03	33.99	55.00	5.16
Chute1	340.548*	100-YR	1065.00	898.00	898.77	900.26	908.50	0.093340	25.03	42.54	55.00	5.02
Chute1	330.525*	PMF	10817.00	896.75	901.90	907.37	924.55	0.021016	38.19	283.22	55.00	2.97
Chute1	330.525*	25-yr	783.00	896.75	897.36	898.59	905.76	0.109252	23.26	33.66	55.00	5.24
Chute1	330.525*	100-YR	1065.00	896.75	897.51	899.01	907.53	0.097882	25.40	41.93	55.00	5.13
Chute1	320.502*	PMF	10817.00	895.49	900.52	906.11	924.23	0.022561	39.07	276.86	55.00	3.07
Chute1	320.502*	25-yr	783.00	895.49	896.10	897.33	904.64	0.112282	23.45	33.38	55.00	5.31
Chute1	320.502*	100-YR	1065.00	895.49	896.24	897.75	906.50	0.101833	25.71	41.43	55.00	5.22
Chute1	310.48*	PMF	10817.00	894.24	899.17	904.86	923.89	0.024097	39.90	271.09	55.00	3.17
Chute1	310.48*	25-yr	783.00	894.24	894.84	896.08	903.49	0.114638	23.60	33.18	55.00	5.36
Chute1	310.48*	100-YR	1065.00	894.24	894.99	896.50	905.44	0.105102	25.95	41.04	55.00	5.29
Chute1	300.457*	PMF	10817.00	892.99	897.82	903.61	923.54	0.025641	40.70	265.77	55.00	3.26
Chute1	300.457*	25-yr	783.00	892.99	893.59	894.83	902.33	0.116741	23.73	33.00	55.00	5.40

HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	300.457*	100-YR	1065.00	892.99	893.73	895.25	904.36	0.107980	26.17	40.70	55.00	5.36
Chute1	290.434*	PMF	10817.00	891.73	896.47	902.35	923.19	0.027207	41.48	260.79	55.00	3.36
Chute1	290.434*	25-yr	783.00	891.73	892.33	893.57	901.16	0.118588	23.84	32.84	55.00	5.44
Chute1	290.434*	100-YR	1065.00	891.73	892.46	893.99	903.25	0.110596	26.36	40.41	55.00	5.42
Chute1	280.411*	PMF	10817.00	890.48	895.14	901.10	922.81	0.028753	42.21	256.24	55.00	3.45
Chute1	280.411*	25-yr	783.00	890.48	891.08	892.32	899.95	0.119680	23.91	32.75	55.00	5.46
Chute1	280.411*	100-YR	1065.00	890.48	891.21	892.74	902.12	0.112723	26.51	40.18	55.00	5.47
Chute1	270.388*	PMF	10817.00	889.22	893.80	899.84	922.42	0.030313	42.93	251.96	55.00	3.53
Chute1	270.388*	25-yr	783.00	889.22	889.81	891.06	898.74	0.120787	23.98	32.66	55.00	5.48
Chute1	270.388*	100-YR	1065.00	889.22	889.95	891.48	900.97	0.114690	26.65	39.96	55.00	5.51
Chute1	260.365*	PMF	10817.00	887.97	892.48	898.59	922.02	0.031864	43.62	248.01	55.00	3.62
Chute1	260.365*	25-yr	783.00	887.97	888.56	889.81	897.52	0.121573	24.02	32.59	55.00	5.50
Chute1	260.365*	100-YR	1065.00	887.97	888.69	890.23	899.81	0.116301	26.76	39.80	55.00	5.54
Chute1	250.342*	PMF	10817.00	886.71	891.15	897.33	921.61	0.033428	44.29	244.25	55.00	3.70
Chute1	250.342*	25-yr	783.00	886.71	887.30	888.55	896.30	0.122408	24.07	32.53	55.00	5.52
Chute1	250.342*	100-YR	1065.00	886.71	887.43	888.97	898.64	0.117811	26.87	39.64	55.00	5.58
Chute1	240.32*	PMF	10817.00	885.46	889.84	896.08	921.18	0.034966	44.92	240.78	55.00	3.78
Chute1	240.32*	25-yr	783.00	885.46	886.05	887.30	895.07	0.122828	24.10	32.49	55.00	5.53
Chute1	240.32*	100-YR	1065.00	885.46	886.18	887.72	897.44	0.118775	26.93	39.54	55.00	5.60
Chute1	230.297*	PMF	10817.00	884.21	888.53	894.83	920.73	0.036502	45.54	237.53	55.00	3.86
Chute1	230.297*	25-yr	783.00	884.21	884.80	886.05	893.83	0.123182	24.12	32.46	55.00	5.53
Chute1	230.297*	100-YR	1065.00	884.21	884.93	886.47	896.24	0.119657	26.99	39.45	55.00	5.62
Chute1	220.274*	PMF	10817.00	882.95	887.21	893.57	920.27	0.038046	46.14	234.43	55.00	3.94
Chute1	220.274*	25-yr	783.00	882.95	883.54	884.79	892.59	0.123648	24.15	32.42	55.00	5.54
Chute1	220.274*	100-YR	1065.00	882.95	883.67	885.21	895.03	0.120572	27.06	39.36	55.00	5.64
Chute1	210.251*	PMF	10817.00	881.70	885.91	892.32	919.79	0.039551	46.71	231.56	55.00	4.01
Chute1	210.251*	25-yr	783.00	881.70	882.29	883.54	891.35	0.123776	24.16	32.41	55.00	5.55
Chute1	210.251*	100-YR	1065.00	881.70	882.41	883.96	893.81	0.121121	27.09	39.31	55.00	5.65

HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1 (Continued)

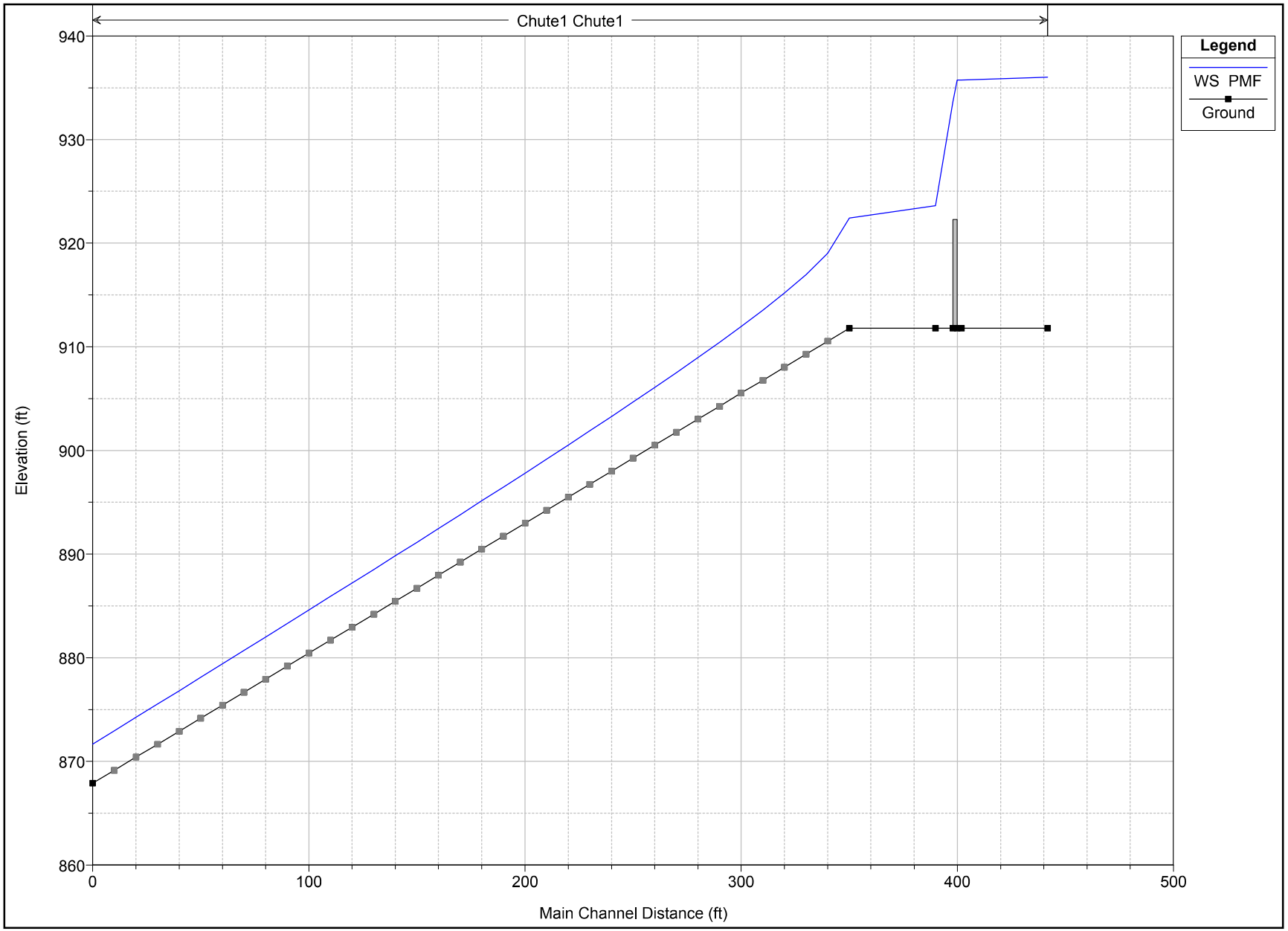
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	200.228*	PMF	10817.00	880.44	884.60	891.06	919.31	0.041078	47.28	228.79	55.00	4.09
Chute1	200.228*	25-yr	783.00	880.44	881.03	882.28	890.11	0.124159	24.18	32.38	55.00	5.55
Chute1	200.228*	100-YR	1065.00	880.44	881.15	882.70	892.59	0.121842	27.14	39.24	55.00	5.66
Chute1	190.205*	PMF	10817.00	879.19	883.30	889.81	918.81	0.042589	47.82	226.19	55.00	4.16
Chute1	190.205*	25-yr	783.00	879.19	883.54	881.03	883.71	0.000187	3.27	239.23	55.00	0.28
Chute1	190.205*	100-YR	1065.00	879.19	879.90	881.45	891.36	0.122259	27.17	39.20	55.00	5.67
Chute1	180.182*	PMF	10817.00	877.93	882.00	888.55	918.31	0.044114	48.36	223.69	55.00	4.23
Chute1	180.182*	25-yr	783.00	877.93	883.59		883.68	0.000082	2.52	311.07	55.00	0.19
Chute1	180.182*	100-YR	1065.00	877.93	884.36	880.19	884.50	0.000102	3.01	353.70	55.01	0.21
Chute1	170.16*	PMF	10817.00	876.68	880.70	887.30	917.78	0.045603	48.87	221.36	55.00	4.29
Chute1	170.16*	25-yr	783.00	876.68	883.61		883.67	0.000044	2.05	381.05	55.01	0.14
Chute1	170.16*	100-YR	1065.00	876.68	884.39		884.49	0.000059	2.51	424.07	55.01	0.16
Chute1	160.137*	PMF	10817.00	875.43	879.41	886.05	917.24	0.047067	49.36	219.15	55.00	4.36
Chute1	160.137*	25-yr	783.00	875.43	883.62		883.67	0.000026	1.74	450.51	55.01	0.11
Chute1	160.137*	100-YR	1065.00	875.43	884.41		884.48	0.000037	2.16	493.79	55.01	0.13
Chute1	150.114*	PMF	10817.00	874.17	878.12	884.79	916.69	0.048546	49.84	217.03	55.00	4.42
Chute1	150.114*	25-yr	783.00	874.17	883.63		883.66	0.000017	1.51	520.26	55.01	0.09
Chute1	150.114*	100-YR	1065.00	874.17	884.42		884.47	0.000025	1.89	563.73	55.01	0.10
Chute1	140.091*	PMF	10817.00	872.92	876.83	883.54	916.13	0.049990	50.31	215.02	55.00	4.48
Chute1	140.091*	25-yr	783.00	872.92	883.63		883.66	0.000012	1.33	589.31	55.01	0.07
Chute1	140.091*	100-YR	1065.00	872.92	884.43		884.47	0.000018	1.68	632.92	55.01	0.09
Chute1	130.068*	PMF	10817.00	871.66	895.39	882.28	896.45	0.000235	8.29	1305.26	55.02	0.30
Chute1	130.068*	25-yr	783.00	871.66	883.64		883.66	0.000009	1.19	658.83	55.01	0.06
Chute1	130.068*	100-YR	1065.00	871.66	884.43		884.47	0.000013	1.52	702.54	55.01	0.07
Chute1	120.045*	PMF	10817.00	870.41	895.46		896.42	0.000197	7.84	1386.53	70.02	0.28
Chute1	120.045*	25-yr	783.00	870.41	883.64		883.66	0.000006	1.08	727.74	55.01	0.05
Chute1	120.045*	100-YR	1065.00	870.41	884.44		884.47	0.000010	1.38	771.53	55.01	0.06
Chute1	110.022*	PMF	10817.00	869.15	895.53		896.39	0.000165	7.42	1479.69	70.02	0.25
Chute1	110.022*	25-yr	783.00	869.15	883.64		883.66	0.000005	0.98	797.16	55.01	0.05

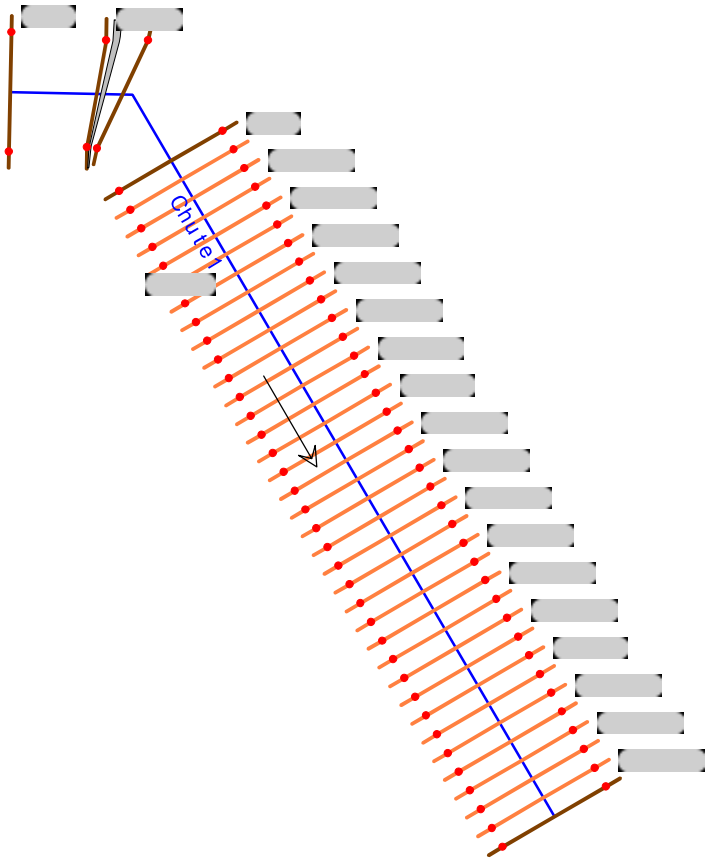
HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	110.022*	100-YR	1065.00	869.15	884.44		884.46	0.000008	1.27	841.02	55.01	0.06
Chute1	100	PMF	10817.00	867.90	895.58		896.36	0.000155	7.10	1522.65	55.02	0.24
Chute1	100	25-yr	783.00	867.90	883.64		883.66	0.000004	0.90	865.99	55.01	0.04
Chute1	100	100-YR	1065.00	867.90	884.44		884.46	0.000006	1.17	909.90	55.01	0.05
Chute1	40	PMF	10817.00	867.90	895.57		896.35	0.000156	7.11	1522.09	55.02	0.24
Chute1	40	25-yr	783.00	867.90	883.64		883.66	0.000004	0.90	865.97	55.01	0.04
Chute1	40	100-YR	1065.00	867.90	884.44		884.46	0.000006	1.17	909.88	55.01	0.05
Chute1	20	PMF	10817.00	880.25	892.41	889.80	896.06	0.003870	11.02	977.90	116.33	0.65
Chute1	20	25-yr	783.00	880.25	883.32		883.63	0.002928	4.42	177.34	65.37	0.47
Chute1	20	100-YR	1065.00	880.25	884.10		884.43	0.002494	4.64	229.29	69.23	0.45
Chute1	-25	PMF	10817.00	878.90	891.92	891.92	895.79	0.008582	15.81	702.90	120.96	0.95
Chute1	-25	25-yr	783.00	878.90	882.04	882.04	883.28	0.014024	8.94	87.58	35.72	1.01
Chute1	-25	100-YR	1065.00	878.90	882.66	882.66	884.10	0.013399	9.64	110.51	38.80	1.01
Chute1	-114.85*	PMF	10817.00	876.20	886.82	889.22	894.25	0.022335	21.88	494.35	73.10	1.48
Chute1	-114.85*	25-yr	783.00	876.20	878.54	879.34	881.14	0.040846	12.95	60.45	31.69	1.65
Chute1	-114.85*	100-YR	1065.00	876.20	879.02	879.97	882.05	0.038744	13.99	76.14	34.08	1.65
Chute1	-204.71*	PMF	10817.00	873.50	883.77	886.52	892.02	0.025704	23.05	469.33	71.37	1.58
Chute1	-204.71*	25-yr	783.00	873.50	876.16	876.64	878.06	0.025765	11.05	70.86	33.30	1.33
Chute1	-204.71*	100-YR	1065.00	873.50	876.61	877.28	878.97	0.027050	12.34	86.31	35.54	1.40
Chute1	-294.57*	PMF	10817.00	870.80	880.91	883.82	889.59	0.027540	23.64	457.53	70.54	1.64
Chute1	-294.57*	25-yr	783.00	870.80	873.32	873.94	875.49	0.031218	11.81	66.31	32.61	1.46
Chute1	-294.57*	100-YR	1065.00	870.80	873.81	874.56	876.38	0.030381	12.85	82.87	35.05	1.47
Chute1	-384.42*	PMF	10817.00	868.10	878.12	881.12	887.04	0.028591	23.97	451.24	70.09	1.66
Chute1	-384.42*	25-yr	783.00	868.10	870.66	871.24	872.74	0.029350	11.56	67.74	32.82	1.42
Chute1	-384.42*	100-YR	1065.00	868.10	871.13	871.86	873.66	0.029848	12.77	83.39	35.13	1.46
Chute1	-474.28*	PMF	10817.00	865.40	875.37	878.42	884.43	0.029164	24.15	447.94	69.85	1.68
Chute1	-474.28*	25-yr	783.00	865.40	867.95	868.54	870.06	0.030111	11.66	67.14	32.73	1.43
Chute1	-474.28*	100-YR	1065.00	865.40	868.42	869.16	870.97	0.030155	12.82	83.09	35.08	1.47

HEC-RAS Plan: Plan 01 River: Chute1 Reach: Chute1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	-564.14*	PMF	10817.00	862.70	872.64	875.72	881.78	0.029529	24.26	445.89	69.71	1.69
Chute1	-564.14*	25-yr	783.00	862.70	865.25	865.84	867.36	0.030062	11.65	67.18	32.74	1.43
Chute1	-564.14*	100-YR	1065.00	862.70	865.72	866.46	868.26	0.030004	12.79	83.24	35.10	1.46
Chute1	-654	PMF	10817.00	860.00	869.92	873.02	879.11	0.029743	24.32	444.70	69.62	1.70
Chute1	-654	25-yr	783.00	860.00	862.55	863.14	864.66	0.030062	11.65	67.18	32.74	1.43
Chute1	-654	100-YR	1065.00	860.00	863.02	863.76	865.56	0.030004	12.79	83.24	35.10	1.46


Chute1 Chute1
Legend
WS PMF
Ground
Elevation (ft)
940
930
920
910
900
890
880
870
860
0
100
200
300
400
500
Main Channel Distance (ft)



None of the XS nced

HEC-RAS Plan: chute2 River: Chute1 Reach: Chute1 Profile: PMF

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	542.5	PMF	10817.00	911.80	936.03	922.42	937.05	0.000222	8.12	1332.73	55.02	0.29
Chute1	502.65	PMF	10817.00	911.80	935.75	923.12	937.02	0.000295	9.03	1197.67	50.02	0.33
Chute1	496.65		Inl Struct									
Chute1	490.65	PMF	10817.00	911.80	923.62	922.42	927.92	0.001688	16.64	650.06	55.01	0.85
Chute1	450.8	PMF	10817.00	911.80	922.42	922.42	927.74	0.002315	18.52	584.03	55.01	1.00
Chute1	440.777*	PMF	10817.00	910.55	919.01	921.17	927.40	0.004561	23.24	465.53	55.01	1.41
Chute1	430.754*	PMF	10817.00	909.29	916.97	919.91	927.16	0.006135	25.62	422.16	55.01	1.63
Chute1	420.731*	PMF	10817.00	908.04	915.19	918.66	926.94	0.007615	27.50	393.29	55.01	1.81
Chute1	410.708*	PMF	10817.00	906.78	913.53	917.40	926.71	0.009084	29.13	371.29	55.01	1.98
Chute1	400.685*	PMF	10817.00	905.53	911.96	916.15	926.48	0.010538	30.57	353.79	55.01	2.12
Chute1	390.662*	PMF	10817.00	904.27	910.43	914.89	926.24	0.012013	31.90	339.09	55.00	2.26
Chute1	380.64*	PMF	10817.00	903.02	908.96	913.64	925.99	0.013483	33.11	326.67	55.00	2.39
Chute1	370.617*	PMF	10817.00	901.77	907.51	912.39	925.72	0.014964	34.25	315.87	55.00	2.52
Chute1	360.594*	PMF	10817.00	900.51	906.08	911.13	925.44	0.016457	35.31	306.33	55.00	2.64
Chute1	350.571*	PMF	10817.00	899.26	904.68	909.88	925.16	0.017961	36.32	297.84	55.00	2.75
Chute1	340.548*	PMF	10817.00	898.00	903.28	908.62	924.86	0.019490	37.28	290.13	55.00	2.86
Chute1	330.525*	PMF	10817.00	896.75	901.90	907.37	924.55	0.021016	38.19	283.22	55.00	2.97
Chute1	320.502*	PMF	10817.00	895.49	900.52	906.11	924.23	0.022558	39.07	276.86	55.00	3.07
Chute1	310.48*	PMF	10817.00	894.24	899.17	904.86	923.89	0.024096	39.90	271.09	55.00	3.17
Chute1	300.457*	PMF	10817.00	892.99	897.82	903.61	923.54	0.025642	40.70	265.77	55.00	3.26
Chute1	290.434*	PMF	10817.00	891.73	896.47	902.35	923.18	0.027205	41.48	260.80	55.00	3.36
Chute1	280.411*	PMF	10817.00	890.48	895.14	901.10	922.81	0.028752	42.21	256.24	55.00	3.45
Chute1	270.388*	PMF	10817.00	889.22	893.80	899.84	922.42	0.030312	42.93	251.96	55.00	3.53
Chute1	260.365*	PMF	10817.00	887.97	892.48	898.59	922.02	0.031864	43.62	248.01	55.00	3.62
Chute1	250.342*	PMF	10817.00	886.71	891.15	897.33	921.61	0.033429	44.29	244.25	55.00	3.70
Chute1	240.32*	PMF	10817.00	885.46	889.84	896.08	921.18	0.034966	44.92	240.79	55.00	3.78
Chute1	230.297*	PMF	10817.00	884.21	888.53	894.83	920.73	0.036501	45.54	237.53	55.00	3.86
Chute1	220.274*	PMF	10817.00	882.95	887.21	893.57	920.27	0.038045	46.14	234.43	55.00	3.94
Chute1	210.251*	PMF	10817.00	881.70	885.91	892.32	919.79	0.039546	46.71	231.56	55.00	4.01
Chute1	200.228*	PMF	10817.00	880.44	884.60	891.06	919.31	0.041079	47.28	228.79	55.00	4.09
Chute1	190.205*	PMF	10817.00	879.19	883.30	889.81	918.81	0.042586	47.82	226.20	55.00	4.16
Chute1	180.182*	PMF	10817.00	877.93	882.00	888.55	918.31	0.044118	48.36	223.69	55.00	4.23
Chute1	170.16*	PMF	10817.00	876.68	880.70	887.30	917.78	0.045603	48.86	221.37	55.00	4.29
Chute1	160.137*	PMF	10817.00	875.43	879.41	886.05	917.24	0.047073	49.36	219.16	55.00	4.36
Chute1	150.114*	PMF	10817.00	874.17	878.12	884.79	916.69	0.048547	49.84	217.03	55.00	4.42
Chute1	140.091*	PMF	10817.00	872.92	876.83	883.54	916.13	0.049985	50.31	215.03	55.00	4.48
Chute1	130.068*	PMF	10817.00	871.66	875.53	882.28	915.55	0.051439	50.76	213.09	55.00	4.54
Chute1	120.045*	PMF	10817.00	870.41	874.25	881.03	914.96	0.052857	51.20	211.27	55.00	4.60

HEC-RAS Plan: chute2 River: Chute1 Reach: Chute1 Profile: PMF (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Chute1	110.022*	PMF	10817.00	869.15	872.96	879.77	914.35	0.054278	51.63	209.51	55.00	4.66
Chute1	100	PMF	10817.00	867.90	871.68	878.52	913.73	0.055672	52.04	207.85	55.00	4.72

Attachment D - Chute Freeboard Calculation

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Freeboard	Required Wall Height	Flow depth
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)				
Chute1	542.5	PF 1	10817	911.8	936.56	922.42	937.54	0.00021	7.94	1362.08	55.02	0.28			
Chute1	502.65	PF 1	10817	911.8	936.3	923.12	937.51	0.000278	8.83	1225.06	50.02	0.31			
Chute1	496.65		Labrynith Weir Spillway												
Chute1	490.65	PF 1	10817	911.8	923.62	922.42	927.92	0.001688	16.64	650.06	55.01	0.85	2.95	14.77	11.82
Chute1	450.8	PF 1	10817	911.8	922.42	922.42	927.74	0.002315	18.52	584.02	55.01	1	3.02	13.64	10.62
Chute1	440.777*	PF 1	10817	910.55	919.01	921.17	927.4	0.004562	23.24	465.53	55.01	1.41	3.18	11.64	8.46
Chute1	430.754*	PF 1	10817	909.29	916.97	919.91	927.16	0.006136	25.62	422.16	55.01	1.63	3.26	10.94	7.68
Chute1	420.731*	PF 1	10817	908.04	915.19	918.66	926.94	0.007615	27.5	393.29	55.01	1.81	3.32	10.47	7.15
Chute1	410.708*	PF 1	10817	906.78	913.53	917.4	926.71	0.009084	29.13	371.29	55.01	1.98	3.38	10.13	6.75
Chute1	400.685*	PF 1	10817	905.53	911.96	916.15	926.48	0.010539	30.57	353.79	55.01	2.12	3.42	9.85	6.43
Chute1	390.662*	PF 1	10817	904.27	910.43	914.89	926.24	0.012014	31.9	339.09	55.01	2.26	3.46	9.62	6.16
Chute1	380.64*	PF 1	10817	903.02	908.96	913.64	925.99	0.013483	33.11	326.67	55	2.39	3.50	9.44	5.94
Chute1	370.617*	PF 1	10817	901.77	907.51	912.39	925.72	0.014961	34.24	315.87	55	2.52	3.53	9.27	5.74
Chute1	360.594*	PF 1	10817	900.51	906.08	911.13	925.44	0.016456	35.31	306.34	55	2.64	3.56	9.13	5.57
Chute1	350.571*	PF 1	10817	899.26	904.68	909.88	925.16	0.017963	36.32	297.84	55	2.75	3.59	9.01	5.42
Chute1	340.548*	PF 1	10817	898	903.28	908.62	924.86	0.01949	37.28	290.13	55	2.86	3.62	8.90	5.28
Chute1	330.525*	PF 1	10817	896.75	901.9	907.37	924.55	0.021016	38.19	283.22	55	2.97	3.65	8.80	5.15
Chute1	320.502*	PF 1	10817	895.49	900.52	906.11	924.23	0.022561	39.07	276.86	55	3.07	3.67	8.70	5.03
Chute1	310.48*	PF 1	10817	894.24	899.17	904.86	923.89	0.024097	39.9	271.09	55	3.17	3.70	8.63	4.93
Chute1	300.457*	PF 1	10817	892.99	897.82	903.61	923.54	0.025641	40.7	265.77	55	3.26	3.72	8.55	4.83
Chute1	290.434*	PF 1	10817	891.73	896.47	902.35	923.19	0.027207	41.48	260.79	55	3.36	3.74	8.48	4.74
Chute1	280.411*	PF 1	10817	890.48	895.14	901.1	922.81	0.028753	42.21	256.24	55	3.45	3.76	8.42	4.66
Chute1	270.388*	PF 1	10817	889.22	893.8	899.84	922.42	0.030313	42.93	251.96	55	3.53	3.78	8.36	4.58
Chute1	260.365*	PF 1	10817	887.97	892.48	898.59	922.02	0.031864	43.62	248.01	55	3.62	3.80	8.31	4.51
Chute1	250.342*	PF 1	10817	886.71	891.15	897.33	921.61	0.033428	44.29	244.25	55	3.7	3.82	8.26	4.44
Chute1	240.32*	PF 1	10817	885.46	889.84	896.08	921.18	0.034966	44.92	240.78	55	3.78	3.84	8.22	4.38
Chute1	230.297*	PF 1	10817	884.21	888.53	894.83	920.73	0.036502	45.54	237.53	55	3.86	3.85	8.17	4.32
Chute1	220.274*	PF 1	10817	882.95	887.21	893.57	920.27	0.038046	46.14	234.43	55	3.94	3.87	8.13	4.26
Chute1	210.251*	PF 1	10817	881.7	885.91	892.32	919.79	0.039551	46.71	231.56	55	4.01	3.89	8.10	4.21
Chute1	200.228*	PF 1	10817	880.44	884.6	891.06	919.31	0.041078	47.28	228.79	55	4.09	3.90	8.06	4.16
Chute1	190.205*	PF 1	10817	879.19	883.3	889.81	918.81	0.042589	47.82	226.19	55	4.16	3.91	8.02	4.11
Chute1	180.182*	PF 1	10817	877.93	882	888.55	918.31	0.044114	48.36	223.69	55	4.23	3.93	8.00	4.07
Chute1	170.16*	PF 1	10817	876.68	880.7	887.3	917.78	0.045603	48.87	221.36	55	4.29	3.94	7.96	4.02
Chute1	160.137*	PF 1	10817	875.43	879.41	886.05	917.24	0.047067	49.36	219.15	55	4.36	3.96	7.94	3.98
Chute1	150.114*	PF 1	10817	874.17	878.12	884.79	916.69	0.048546	49.84	217.03	55	4.42	3.97	7.92	3.95
Chute1	140.091*	PF 1	10817	872.92	876.83	883.54	916.13	0.04999	50.31	215.02	55	4.48	3.98	7.89	3.91
Chute1	130.068*	PF 1	10817	871.66	875.53	882.28	915.55	0.05144	50.76	213.09	55	4.54	3.99	7.86	3.87
Chute1	120.045*	PF 1	10817	870.41	874.25	881.03	914.96	0.052864	51.2	211.27	55	4.6	4.00	7.84	3.84
Chute1	110.022*	PF 1	10817	869.15	872.96	879.77	914.35	0.054282	51.63	209.51	55	4.66	4.02	7.83	3.81
Chute1	100	PF 1	10817	867.9	871.68	878.52	913.73	0.05567	52.04	207.85	55	4.72	4.03	7.81	3.78

Attachment E - Riprap Sizing

RIP RAP REVETMENT SIZING

Project Name: East Locust Creek
Project # A11-1513
Date Created: 8/19/2015
Path= F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Spillway\[RipRap Revetm

Stream Name:
Chain Name
Calculated:
Checked:

Hydraulic Engineering Circular No. 11 - Design of Riprap Revetment 1989

VARIABLES		DESCRIPTION
$V_a =$	13	Average Velocity in Main Channel (ft/sec)
$d_{avg} =$	3.10	Average Depth in Main Channel (ft)
$\theta =$	21.80	Bank Angle with Horizontal (deg) (See Bank Angle Sheet)
$\varphi =$	42.0	Material Angle Repose (deg) (See Angle of Repose Sheet)

Section 4.1.1.1 Equation (6)

$$K_1 = \left[1 - \left(\frac{(\sin\theta)^2}{(\sin\varphi)^2}\right)\right]^{0.5}$$

K_1 = 0.8318

$$D_{50} = \frac{0.001 \times V_a^3}{d_{avg}^{0.5} \times K_1^{1.5}}$$

D_{50} = 1.64

Coorection Factor

VARIABLES		DESCRIPTION
SF =	1.10	Stabity Facter (See Stablity Factor Sheet)
$S_s =$	2.65	Specific Gravity of Rip Rap

$$C = \frac{1.61 \times SF^{1.5}}{(S_s - 1)^{1.5}}$$

C = 0.88

CD_{50} = 1.44

EM_1110-2-1601 Hyraulic Design of Flood Control Channels 1994

East Locust Creek Reservoir Water Budget Summary

Appendix C.

East Locust Creek Reservoir Hydrology Report

EAST LOCUST CREEK RESERVOIR
HYDROLOGY REPORT

PREPARED FOR

NORTH CENTRAL MISSOURI
REGIONAL WATER COMMISSION
MILAN, MISSOURI

STATE OF MISSOURI
BRIAN H.
LADD
NUMBER
PE-2014012020
5-24-17
PROFESSIONAL ENGINEER

JUNE 2015
UPDATED MARCH 2016

OA PROJECT NO. A11-1513

OLSSON
ASSOCIATES

Table of Contents

Watershed Description 2
Curve Number 3
Climate Area Zone 4
Time of Concentration 4
Rainfall Data 4
Design Storm Simulation 4
Probable Maximum Precipitation 5
Calibration Approach 6
Gage Data 7
Regional Regression Equations 9
HEC-HMS Model Development 9

A reservoir on East Locust Creek near Milan, Missouri is proposed to provide flood control, recreation and water supply for the surrounding community. The proposed reservoir has been in the planning stages since the 1980s. The design of the proposed reservoir will follow the Natural Resource Conservation Service (NRCS) guidelines for dam construction. This report addresses the hydrology for the contributing drainage area of the proposed reservoir. The report also summarizes the calculation of the storms for sizing the primary and auxiliary spillway and the freeboard required above these spillways.

Watershed Description

The proposed reservoir on East Locust Creek is situated in north-central Missouri. The watershed for the proposed reservoir drains portions of Putnam and Sullivan Counties, Figure 1. The contributing drainage area of the proposed reservoir on East Locust Creek is approximately 32.6 square miles. The watershed for the proposed reservoir was determined by URS in 2013 using Surdex Corporation LiDAR (June 2009). The watershed area was reviewed, validated, and used for this analysis. The watershed is largely rural and contains mostly agricultural lands. Figures 2 and 3 show the extents of the watershed. The table below shows the land uses, as classified by The National Land Cover Database published by the U.S. Geological Survey, 2011. The normal pool of the proposed reservoir is included as open water.

Table 1 - Land Use above Proposed Reservoir

Land Use in East Locust Creek Watershed Upstream of Proposed Reservoir	
Hay/Pasture	56%
Deciduous Forest	20%
Open Water	12%
Developed, Open Space	4%
Cultivated Crops	2%
Other Land Uses	6%

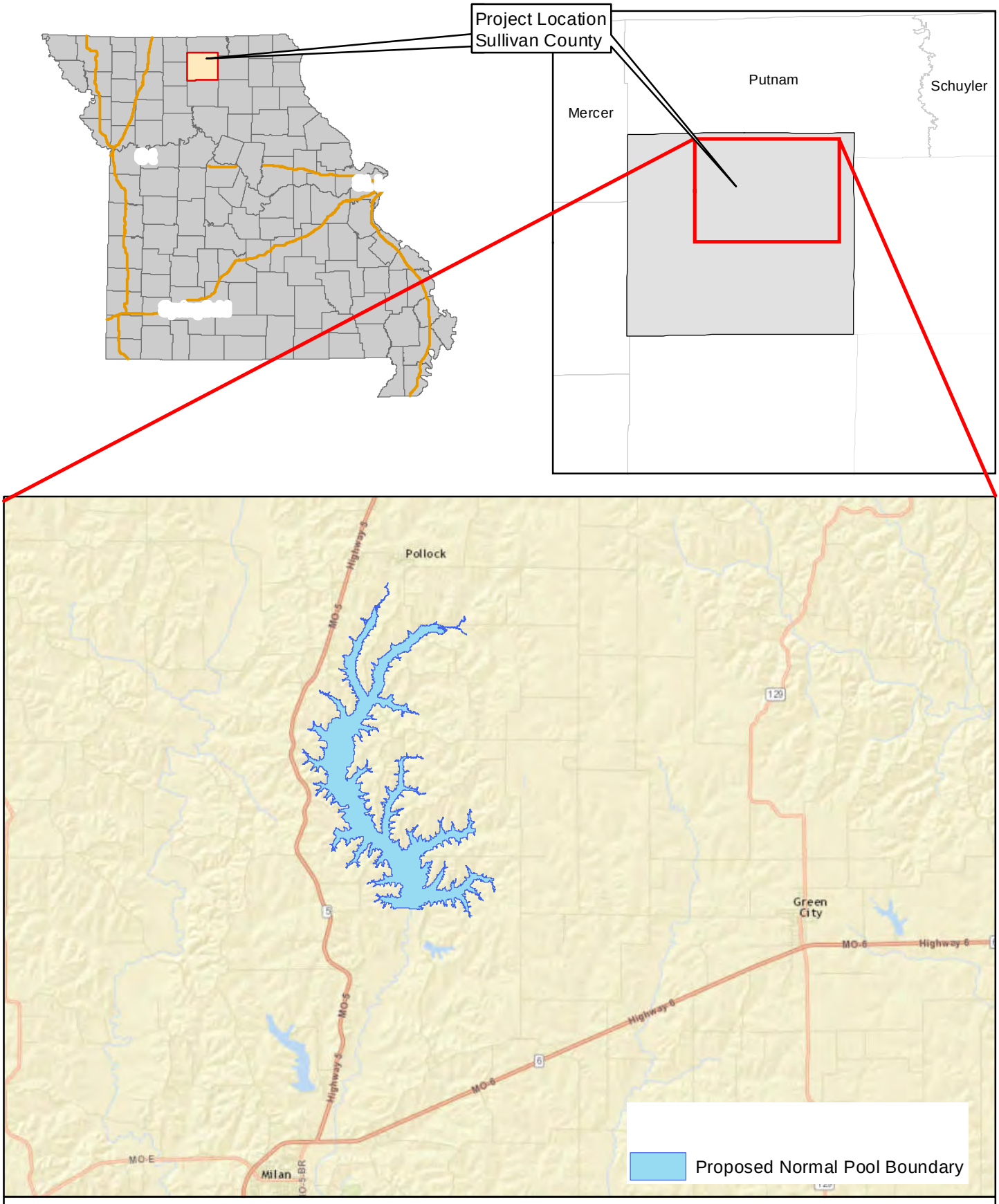


FIGURE 1
Site Location Map

N

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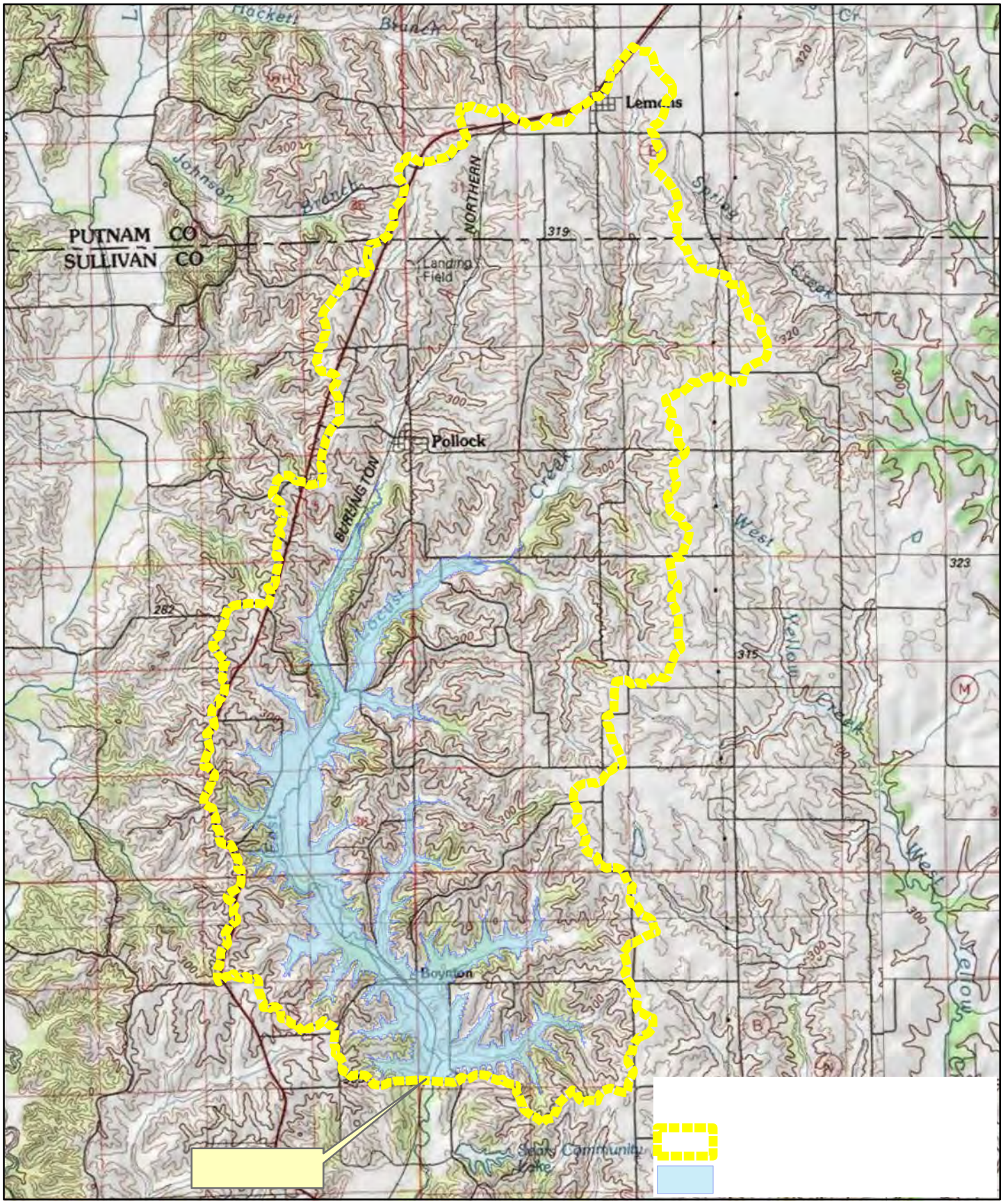

FIGURE 2
Watershed Map

N

Miles
0 0.5 1

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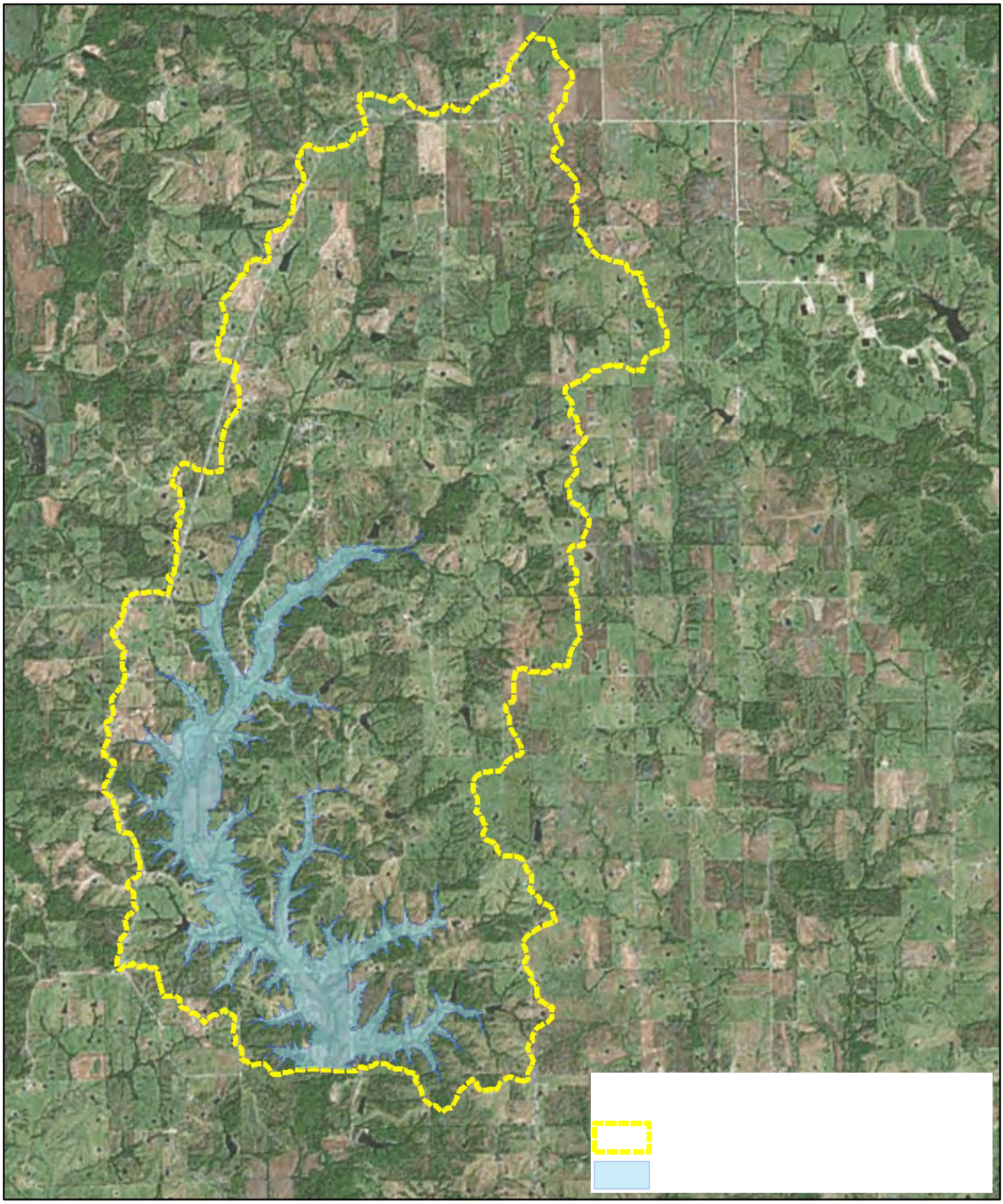

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Miles

0 0.5 1

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FIGURE 3
Aerial Map

The watershed and proposed dam were modeled using the United States Department of Agriculture (USDA) SITES program, version 3.5. Per the guidance in the Natural Resources Conservation Service Technical Release 60, “Earth Dams and Reservoirs” issued July, 2005 (TR-60), and the National Engineering Handbook (NEH), Part 630 - Hydrology, USDA NRCS, version 2010, the watershed was analyzed as one watershed and was not broken into smaller watersheds.

Curve Number

To calculate the curve number for the watershed, the hydraulic soil group from the Natural Resources Conservation Service SSURGO Soil Data (accessed 2015) and land use data were compiled. The soil and land use information can be seen in Figures 4 and 5. The curve number tables, located in TR-55, were used to obtain a curve number for each land use and soil group. Table 2 below provides the curve number for the corresponding land use and hydraulic soil group.

Table 2 – Curve Number Table

Land Use Description	**Soil Group and Curve Number**			
	A	B	C	D
Open Water	98	98	98	98
Hay/Pasture	49	69	79	84
Barren Land & Cultivated Crops	77	86	91	94
Roads	98	98	98	98
Farmsteads	59	74	82	86
Mixed Forest	43	65	76	82
Deciduous Forest & Evergreen Forest & Woody Wetlands	36	60	73	79
Shrub/Scrub	35	56	70	77
Developed, Open Space	39	61	74	80
Developed, Low Intensity	68	79	86	89
Emergent Herbaceous Wetlands	48	67	77	83

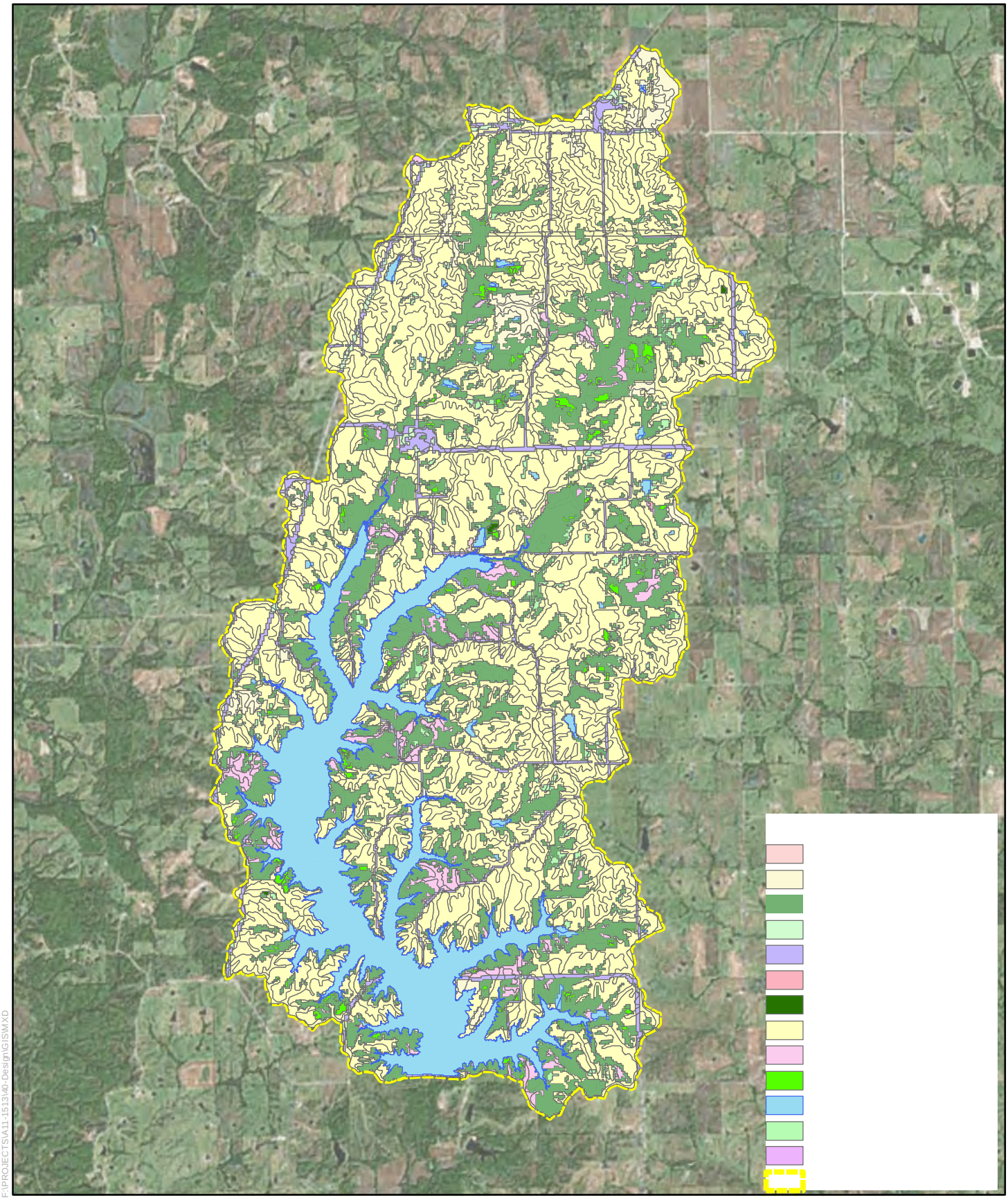

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FIGURE 5
Landuse Map

Feet
0 5,000 10,000

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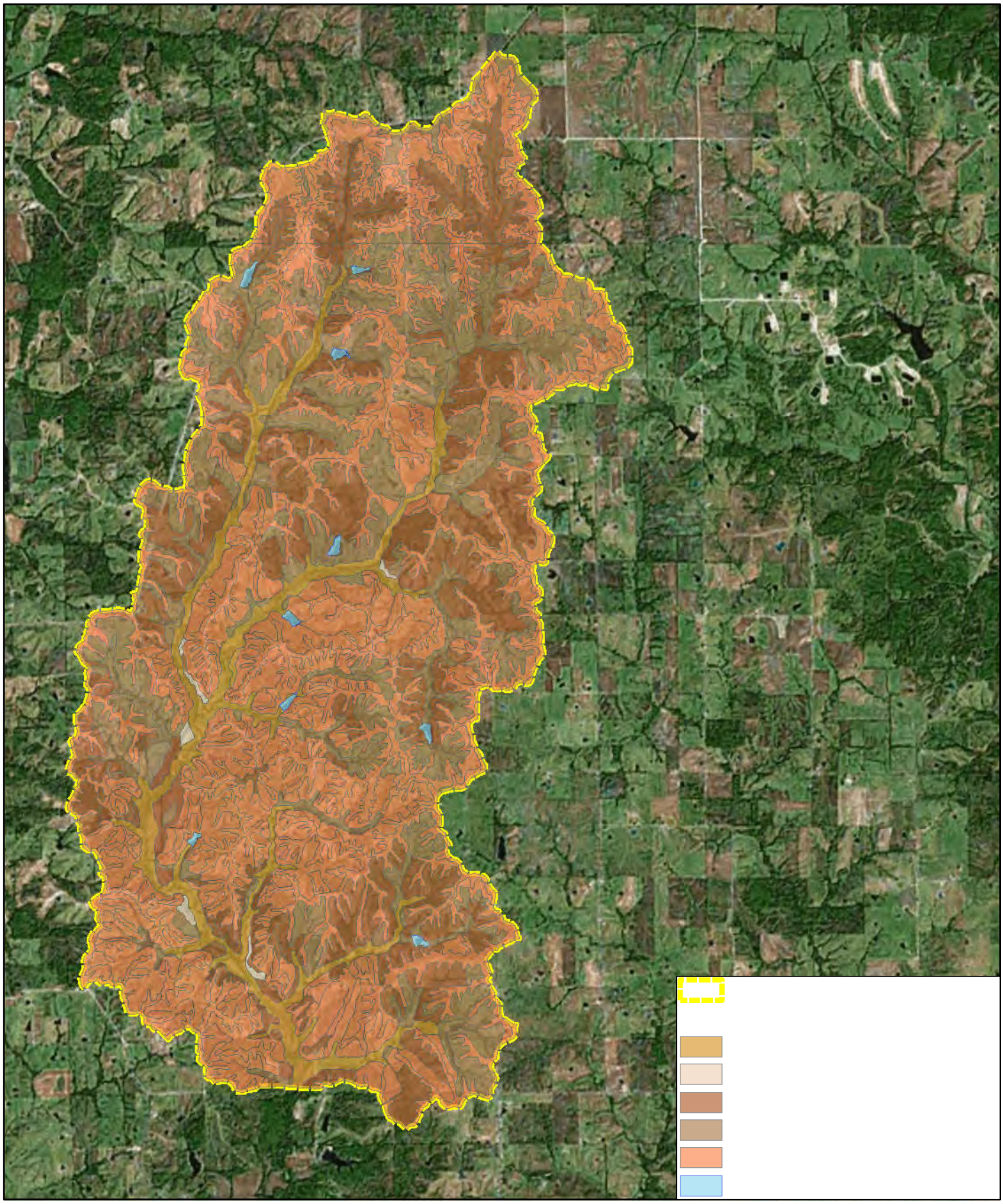

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FIGURE 4
Soil Survey Map

N

Miles

0 0.5 1

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A weighted curve number was calculated for the watershed and input into SITES. The weighted curve number for the watershed draining to the proposed reservoir is 82.1.

Climate Area Zone

Climate Zone 2 was selected for the watershed. Climate Zone 2 corresponds to a humid and sub-humid climate.

Time of Concentration

The velocity method in the NEH was selected for calculating the time of concentration. The velocity method uses different overland flow types to compute the time of concentration. The flow type at the top of the watershed is sheet flow and is limited to the first 300 feet on the upstream side of the watershed. The travel time for sheet flow is calculated with the modified Manning's equation provided in the NEH. The shallow concentrated flow occurs after sheet flow and represents the runoff collecting in swales or gullies. The tables in the NEH were used to calculate the travel time for shallow concentrated flow. Shallow concentrated flow eventually accumulates and becomes open channel flow. To calculate the travel time for the open channel flow, a representative cross section was taken from the LiDAR and a velocity for the cross section was calculated using Manning's equation. The flow path for the watershed included flow through the proposed reservoir. The wave velocity equation (NEH eq. 15-11) was used to calculate the travel time through the proposed reservoir. The cumulative time of concentration for the watershed is the sum of the travel times computed above, or 3.68 hours. The flow path and types of flow for the watershed can be seen in Figure 6.

Rainfall Data

Design Storm Simulation

The SCS curve number method requires the input of rainfall total depths to calculate a peak runoff value. The National Oceanic and Atmospheric Admiration (NOAA) Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 8, Version 2.0 (2013) was used for the 24-hour rainfall depths for SITES modeling. The 24-hour rainfall depths are used to size the principal

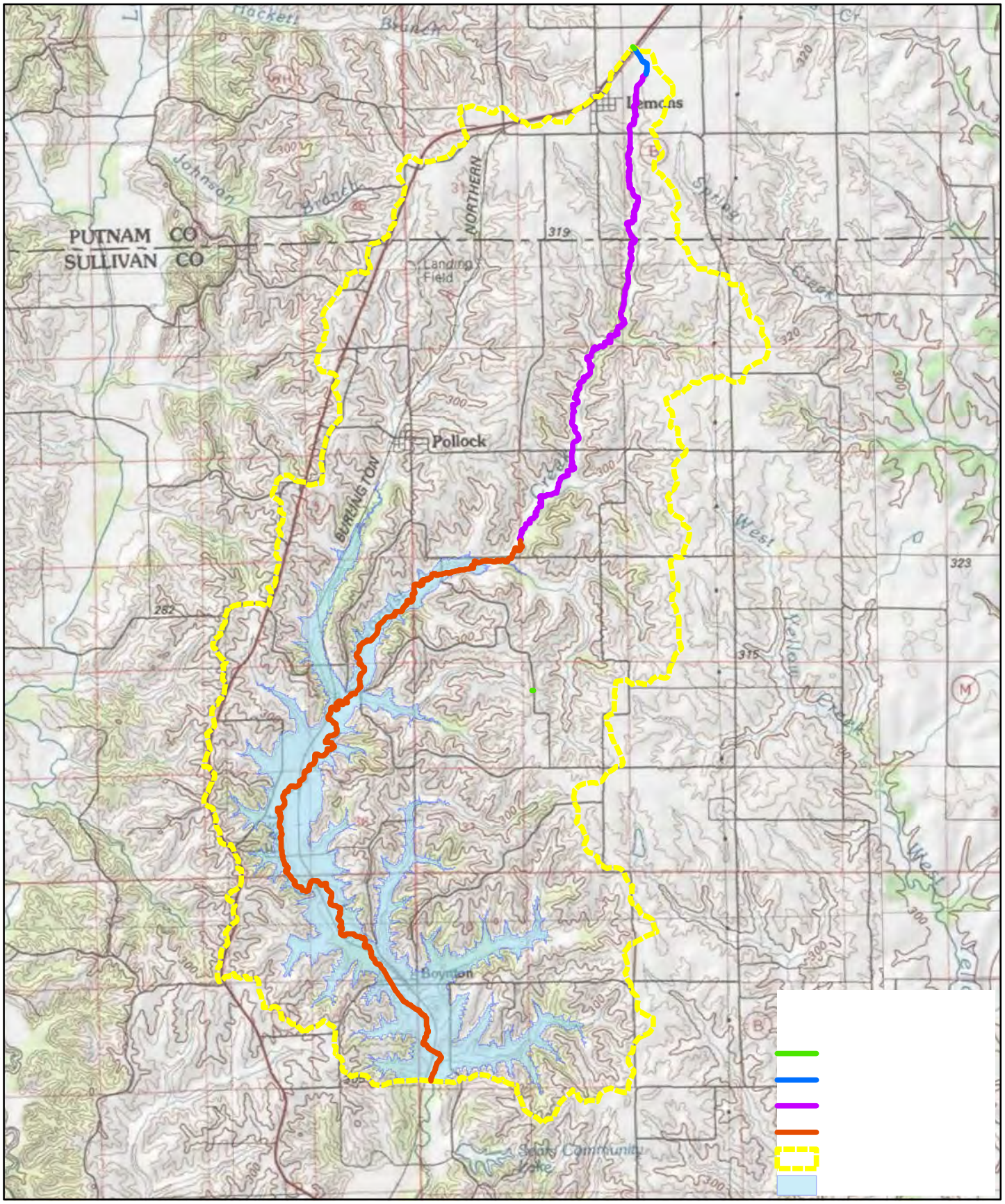

FIGURE 6
Time of Concentration and Flow Type

N

Miles
0 0.5 1

OLSSON ASSOCIATES

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spillway, and determine the elevation for the auxiliary spillway. The rainfall data from the station closest to the reservoir at Milan, Missouri was used for the SITES analysis. The rainfall depths for the analysis were areally adjusted by 0.959 for the 32.6 square miles drainage area per Table 2-3 in TR-60. Table 3 provides the adjusted rainfall depth for each return period analyzed.

Table 3 – Areally Adjusted 24-hr Rainfall Depths

Return Period	Adjusted Rainfall Depth (in)
1%	7.74
2%	6.75
10%	4.75
50%	3.23

The values from the SITES model with the parameters estimated for the contributing watershed are below in Table 4.

Table 4. SITES Peak Runoff Rates

Return Period	SITES Output (cfs)
1%	24,360
2%	20,393
10%	12,416
50%	6,649

Probable Maximum Precipitation

TR-60 was utilized to determine the design storm for the principal spillway, auxiliary spillway, and freeboard for the proposed dam. The proposed reservoir is classified as a high hazard dam, per TR-60. To determine the size of the auxiliary spillway and the freeboard required from the auxiliary spillway to the top of the dam, the Stability Design Hydrograph (SDH) and Freeboard Hydrograph (FBH) were used. Routing the SDH and FBH require the input of the Probable Maximum Precipitation (PMP) rainfall depth. The PMP depths for the proposed reservoir were estimated from Hydrometeorological Report No. 51 (HMR – 51) published by NOAA, 1978. PMP

rainfall depths for the 6-hour, 12-hour, and 24-hour durations were estimated from HMR – 51. The SDH value was computed from the equation SDH = P_{100}+0.26(PMP-P_{100}) and the FBH runoff depth is equal to the PMP rainfall depth for high hazard dams. Table 5 shows the rainfall depths for evaluating the auxiliary spillway and the required freeboard for the top of the dam.

Table 5 – Rainfall Depths for SDH and FBH Hydrographs

Storm Duration (hr)	PMP (in)	SDH (in)	FBH (in)
6	26.9	11.63	26.9
12	31.8	NA	31.8
24	33.4	14.66	33.4

Hydrometeorological Report No. 52 (HMR – 52), published by NOAA in 1982, was used to route the FBH storm. The 24-hour storm "5-point" rainfall distribution mass curve was used for the FBH modeling. The 5-point rainfall distribution method divides the 24-hour distribution into four quadrants with 5 points. The values in the 5 point distribution are calculated as a percentage of the total rainfall for the 6-hour and 24-hour storms. The first point in the distribution is 0, the second point is calculated by the equation (24_{HR-PMP} - 6_{HR-PMP})/(24_{HR-PMP} /2), the third point is calculated by (6_{HR-PMP})/(24_{HR-PMP}), the fourth point is the (12_{HR-PMP} - 6_{HR-PMP})/ 24_{HR-PMP}, the fifth point is the remainder of the rainfall for the storm.

Calibration Approach

The primary hydrologic method of analysis for the watershed is the Curve Number method using the SITES modeling software. To determine if the SITES model results represent the actual runoff rates for the contributing drainage area with reasonable accuracy, the SITES model output was compared to gages in the same region, rural regression equations, and sub watersheds within the contributing drainage area of the proposed reservoir.

Gage Data

Historical data for the contributing watershed was not available. However several gages near the area are available and have similar land use to the East Locust Creek watershed. To determine the flood flow frequency from the gage data for the return periods required for the design of the reservoir, the Corps of Engineers HEC-SSP ver. 2.0 software was utilized. HEC-SSP uses Bulletin 17B "Guidelines for Determining Flood Flow Frequency" (1982) as the basis for analysis. The flood flow frequency was calculated from the available data for seven gage stations. The location of the gage stations can be seen in Figure 7. The flood flow frequency for each station was weighted based on guidance provided in "The National Streamflow Statistics Program: Chapter 6 of Book 4, Hydrologic Analysis and Interpretation, Section A - Statistical Analysis" Published by U.S. Department of the Interior and U.S. Geological Survey. The recommendation for weighting the gage values uses the exponents from the Regression equations for the state of Missouri. The below values were weighted according to the procedure in the publication. Table 6 shows the comparison of the peak flood flow rates computed from gage stations to the values from the SITES model.

Table 6 - Weighted Gage Runoff Data

			Return Period			
		Drainage Area (mi^2)	1%	2%	10%	50%
Gage Station Locations	Linneus	550	4,829	4,359	3,103	1,465
	Reger	232	5,949	4,926	2,842	1,088
	Atlanta	23	12,594	10,188	5,457	1,787
	Chula	72	3,642	3,345	2,603	1,664
	Bethany	95	5,039	4,322	2,757	1,247
	Mendon	14	4,826	4,659	3,877	1,924
	Bedford	85	5,592	5,387	4,612	2,827
	SITES Output	32.6	24,360	20,393	12,416	6,649
	SITES Output No Lake	32.6	12,285	10,161	6,006	3,096

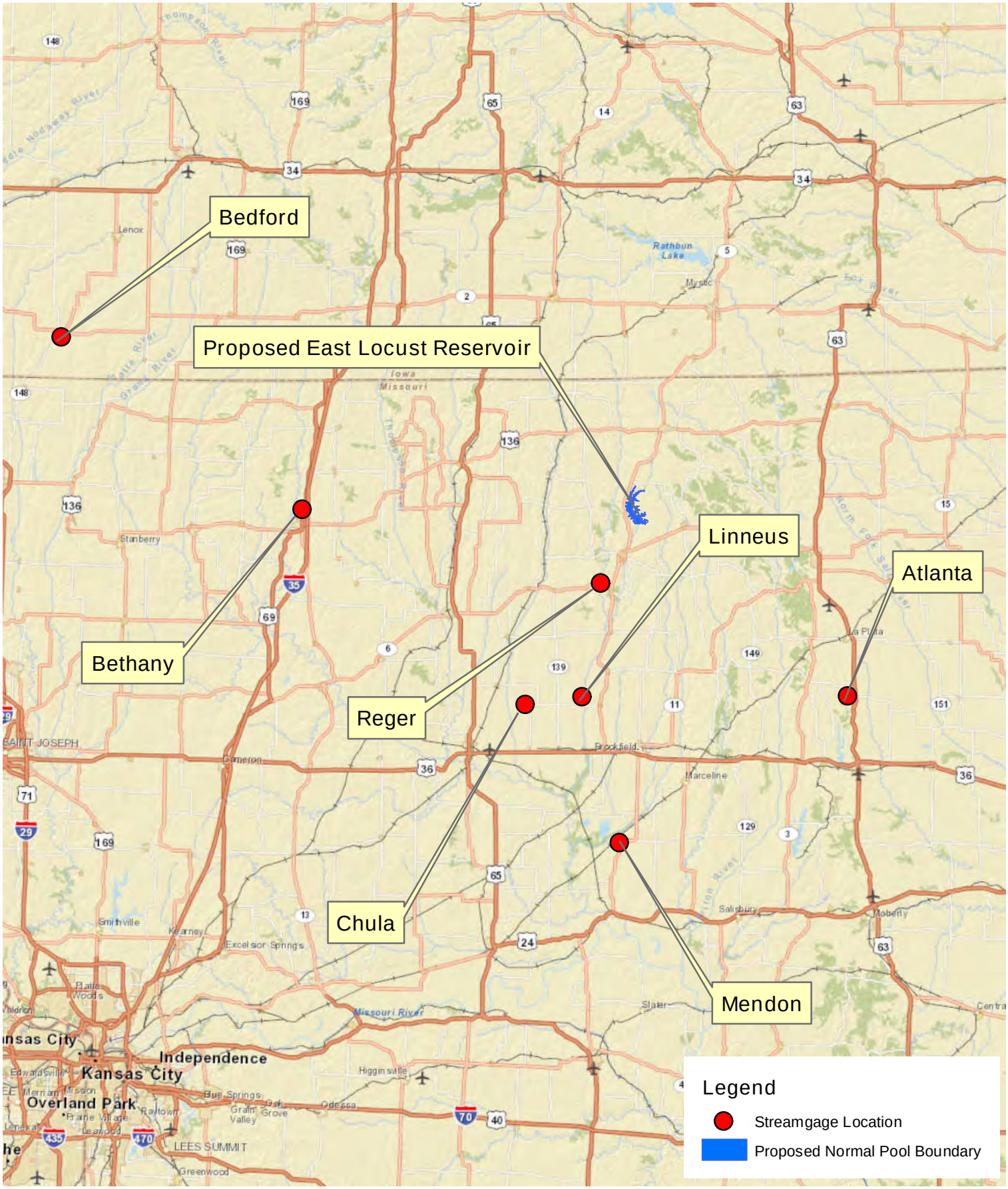

FIGURE 7
Streamgage Locations

N

Miles
0 10 20

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To compare the runoff rate for the proposed basin to the gage data, runoff rates were computed for the contributing watershed without the proposed reservoir. The curve number and time of concentration were computed using the same procedures used for the proposed conditions watershed, as described above. The curve number for the watershed without the reservoir is 79 and the time of concentration is 8.53 hours.

The National Streamflow Statistics Program also recommends limiting comparisons of gage data to locations that are between 0.5 and 1.5 times the drainage area of the proposed reservoir. The gages near Atlanta and Mendon have a ratio to the proposed reservoir of 0.71 and 0.43 respectively. The other gages all have a ratio above 2.2.

The shape of a watershed can also have an impact on the runoff rates for a given watershed. To determine the approximate length to width ratio of the watersheds, the centroid of the watershed was found and the lengths of lines passing through the centroid along the flow path and perpendicular to the flow path were calculated. The length to width ratios for those watersheds that are close in shape and size to the contributing watershed, are shown in Table 7.

Table 7 – Length to Width Ratio

	Length to Width Ratio
Atlanta	6.0
Mendon	2.2
Proposed Reservoir	2.6

The higher length to width ratio of the gage near Atlanta could be part of the reason that the flows at the Atlanta gage are higher than other weighted gages. The Mendon gage has a length to width ratio closer to that of the contributing drainage area of the proposed reservoir; however, the flow rates computed for the contributing drainage area (with no lake) are 2.5 times those

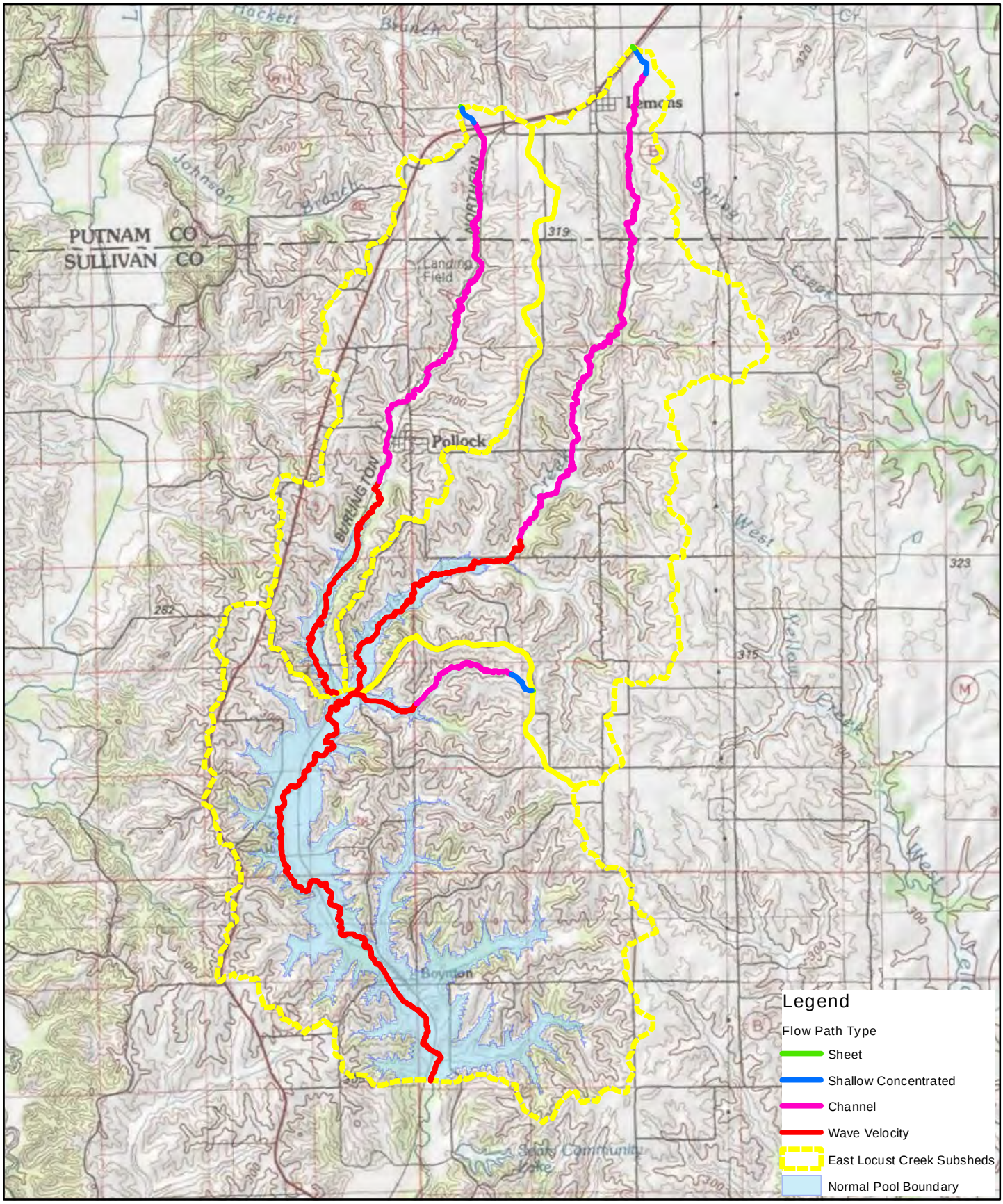

FIGURE 8
HEC-HMS Watersheds and Flow Types

Miles
0 0.5 1

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derived from the gaged data. A detailed study of the gaged watersheds was not completed for this study and many factors can contribute to lower runoff rates for an individual watershed.

Regional Regression Equations

Regional regression equations were also used to compute runoff rates which were compared to the runoff rates from the SITES model. The USGS "Techniques for Estimating the 2-to 500-Year Flood Discharges on Unregulated Streams in Rural Missouri" (1995) was used for the regional regression equations. The regional regression equations were generated using the least-squares regression technique. Runoff rates from 278 selected streamflow-gaging stations were compared to basin characteristics in order to determine which basin characteristics were statistically significant (USGS, 1995).The equations for Region 1 were used for estimating the peak flows. The regional regression equations require the area and slope of the watershed. The slope of the watershed between the 10% and 85% point on the watershed is 9.81 ft/mile (URS, 2014).

Table 8 - Regional Regression Equations Peak Runoff

Return Period	Regional Regression Equations (cfs)	SITES Output (cfs)
1%	8,043	24,360
2%	6,863	20,393
10%	4,313	12,416
50%	1,886	6,649

HEC-HMS Model Development

A U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) version 3.5 model was developed. Computed peak runoff rates from HEC-HMS were also compared to the calculated values from SITES. The curve number method was also used in the model development. For the development of the HEC-HMS model, the contributing watershed of the proposed reservoir was broken into 3 sub-watersheds, Figure 8.

The same techniques of computing the curve number, time of concentration, and rainfall depth that were used for the SITES model were used for the HEC-HMS model. The HEC-HMS model includes routing between the watersheds that was not included in the SITES model. The Lag method was used for routing within the watershed to the proposed reservoir. The lag time in the watershed was calculated using a representative cross section from the LiDAR information, a velocity was calculated using Manning's equation. The velocity was used to compute a lag time for the channel between the sub-areas.

Table 9 - HEC-HMS Peak Flows

Return Period	HEC-HMS (cfs)	SITES Output (cfs)
1%	31,327	24,360
2%	26,192	20,393
10%	15,982	12,416
50%	8,599	6,649

TR-60 guidance recommends that that highest value calculated for the watershed be used in the analysis of the dam and spillway. The HEC-HMS output is significantly higher than both the gage data and the rural regression equations. The TR-60 guidance does not recommend dividing the watershed into subareas unless the drainage area is over 50 square miles. While the HEC-HMS flows are higher than then SITES output the land use in the contributing watershed for the proposed reservoir does not differ significantly and does not warrant dividing the watershed into subareas. Therefore, the SITES output values will be used for the design and analysis of the proposed spillway and dam.

Appendix A

Hydrologic Parameters

East Locust - Time of Concentration Estimation

Time of Concentration (Tc) = T_{sheet} + $T_{shallow\ conc}$ + $T_{channel}$ + $T_{wave\ velocity}$

Reference: National Engineering Handbook, Part 630 Hydrology, Chapter 15, USDA NRCS, May 2010

T_{sheet}

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}\,S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

n =	0.17
L =	300 ft
P_2 =	3.3 in
Begin elev =	1076.97 ft
End elev =	1075.52 ft
s =	0.005 ft/ft
T_{sheet} =	**0.755** hr

$T_{shallow}$

Velocity =

v = 6.962*(slope)$^{0.5}$
(for short grass pasture)

(Table 15-3 and Figure 15-4)
(NEH Part 360 Hydrology, Chapter 15)

$T_{shallow}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1075.52 ft
End elev =	1062.99 ft
s =	0.00931 ft/ft
v =	0.67 ft/s
$L_{shallow}$ =	1346.47 ft
$T_{shallow}$ =	**0.557** hr

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:
T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

The Total Time of Concentration is the sum of all travel times:

(b) Velocity method

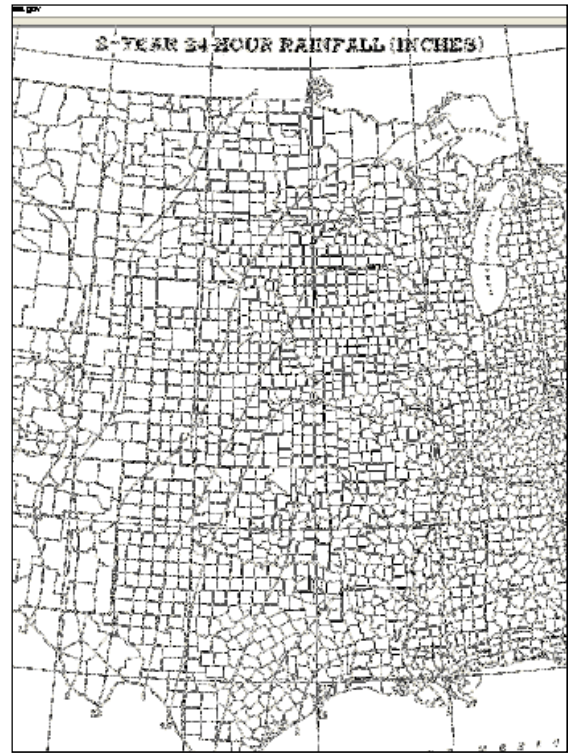
Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

P_2 Source for T_{sheet}:
http://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf



East Locust - Time of Concentration Estimation (Continued)

$T_{channel(1)}$		
$T_{channel}$ =	L (ft)/v (ft) * 1/3600	
Begin elev =	1062.99	ft
End elev =	922.30	ft
XS Flow Area =	155.35	ft^2
Wetted Perimeter =	56.64	ft
Hydraulic Radius =	2.74	ft
Manning's n =	0.040	
s =	0.00432	ft/ft
v =	4.78	ft/s
$L_{channel}$ =	32558	ft
$T_{channel}$ =	**1.892**	hr

$T_{wave\ velocity}$		
$V_w = \sqrt{gD_m}$ (eq. 15–11)		
where		
V_w = wave velocity, ft/s		
g = 32.2 ft/s^2		
D_m = mean depth of lake or reservoir, ft		
$T_{wave\ velocity}$ =	L (ft)/v (ft) * 1/3600	
Volume at elev. 922.3 =	54009	ac-ft
Surface Area at elev. 922.3 =	2331	acres
D_m (Mean Depth) =	23.2	ft
v_w =	27.3	ft/s
$L_{channel}$ =	46940	ft
$T_{channel}$ =	**0.477**	hr

Tc =	**3.68**	**hr**

Velocity for Channel Flow use Mannning's Eq:

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Wave Velocity through Dam Backwater

In other cases, such as with a watershed having a relatively large body of water in the flow path, time of concentration is computed to the upstream end of the water body using standard methods, and velocity for the flow segment through the water body may be computed using the wave velocity equation coupled with equation 15–1 to convert the velocity to a travel time through the water body. The wave equation is:

$$V_w = \sqrt{gD_m} \qquad \text{(eq. 15–11)}$$

where

V_w = wave velocity, ft/s

g = 32.2 ft/s^2

D_m = mean depth of lake or reservoir, ft

Generally, V_w will be high; however, equation 15–11 only provides for estimating travel time through the water body and for the inflow hydrograph to reach the outlet. It does not account for the time required for the

East Locust - Time of Concentration Estimation (Continued)

Figure 15–4 Velocity versus slope for shallow concentrated flow

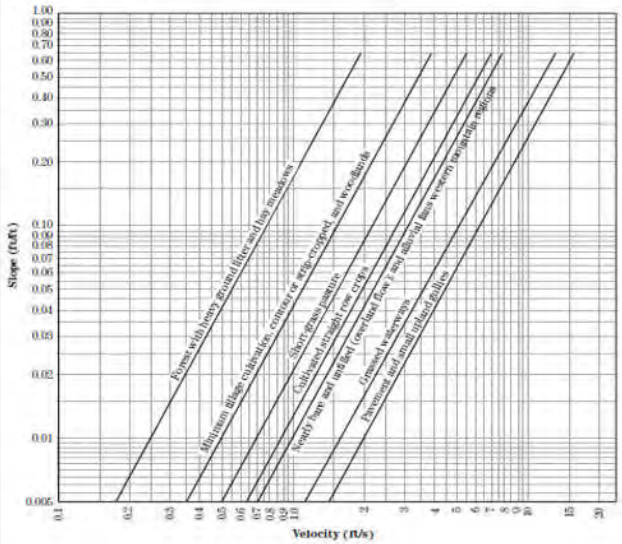


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.510(s)^{0.5}$

United States
Department of
Agriculture

**Natural
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Conservation
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**Conservation
Engineering
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Technical
Release 55

June 1986

Urban Hydrology for Small Watersheds

TR-55

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Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

NOAA Atlas 14, Volume 8, Version 2 MILAN
Station ID: 23-5578
Location name: Milan, Missouri, US*
Latitude: 40.2211°, Longitude: -93.1097°
Elevation:
Elevation (station metadata): 840 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.398 (0.315–0.514)	0.461 (0.364–0.595)	0.568 (0.447–0.735)	0.662 (0.517–0.858)	0.798 (0.604–1.06)	0.908 (0.669–1.21)	1.02 (0.727–1.39)	1.14 (0.777–1.57)	1.31 (0.855–1.83)	1.44 (0.913–2.03)
10-min	0.583 (0.461–0.753)	0.675 (0.533–0.871)	0.832 (0.655–1.08)	0.969 (0.758–1.26)	1.17 (0.884–1.55)	1.33 (0.980–1.78)	1.50 (1.06–2.03)	1.67 (1.14–2.30)	1.92 (1.25–2.68)	2.11 (1.34–2.97)
15-min	0.711 (0.562–0.918)	0.823 (0.650–1.06)	1.02 (0.798–1.31)	1.18 (0.924–1.53)	1.43 (1.08–1.89)	1.62 (1.20–2.17)	1.83 (1.30–2.47)	2.04 (1.39–2.81)	2.34 (1.53–3.27)	2.58 (1.63–3.62)
30-min	0.995 (0.786–1.28)	1.16 (0.913–1.49)	1.43 (1.13–1.85)	1.67 (1.31–2.17)	2.02 (1.53–2.68)	2.29 (1.69–3.06)	2.58 (1.84–3.50)	2.89 (1.96–3.97)	3.30 (2.16–4.61)	3.63 (2.30–5.10)
60-min	1.31 (1.04–1.70)	1.53 (1.21–1.98)	1.91 (1.50–2.47)	2.24 (1.75–2.90)	2.73 (2.07–3.63)	3.12 (2.30–4.17)	3.53 (2.51–4.79)	3.97 (2.70–5.46)	4.58 (2.99–6.40)	5.06 (3.20–7.10)
2-hr	1.63 (1.31–2.08)	1.91 (1.53–2.43)	2.39 (1.90–3.05)	2.81 (2.22–3.60)	3.43 (2.64–4.52)	3.94 (2.95–5.22)	4.48 (3.22–6.02)	5.05 (3.48–6.90)	5.85 (3.86–8.12)	6.48 (4.15–9.04)
3-hr	1.85 (1.49–2.34)	2.16 (1.74–2.73)	2.71 (2.17–3.43)	3.20 (2.55–4.06)	3.93 (3.04–5.15)	4.53 (3.41–5.97)	5.17 (3.75–6.91)	5.85 (4.06–7.96)	6.82 (4.53–9.43)	7.59 (4.89–10.5)
6-hr	2.21 (1.80–2.76)	2.58 (2.10–3.21)	3.23 (2.62–4.03)	3.82 (3.08–4.79)	4.72 (3.70–6.13)	5.47 (4.17–7.14)	6.27 (4.61–8.32)	7.14 (5.02–9.64)	8.38 (5.64–11.5)	9.38 (6.11–12.9)
12-hr	2.56 (2.11–3.14)	2.96 (2.44–3.64)	3.69 (3.04–4.55)	4.37 (3.57–5.39)	5.39 (4.29–6.93)	6.26 (4.84–8.09)	7.19 (5.35–9.46)	8.21 (5.84–11.0)	9.66 (6.58–13.2)	10.8 (7.15–14.8)
24-hr	2.91 (2.44–3.53)	3.37 (2.82–4.09)	4.20 (3.49–5.10)	4.95 (4.10–6.03)	6.09 (4.90–7.72)	7.04 (5.51–8.99)	8.07 (6.08–10.5)	9.19 (6.61–12.2)	10.8 (7.42–14.6)	12.1 (8.03–16.4)
2-day	3.33 (2.82–3.98)	3.88 (3.28–4.64)	4.83 (4.08–5.79)	5.68 (4.76–6.83)	6.93 (5.63–8.64)	7.96 (6.29–10.0)	9.04 (6.88–11.6)	10.2 (7.41–13.4)	11.8 (8.23–15.8)	13.1 (8.84–17.7)
3-day	3.65 (3.11–4.32)	4.24 (3.62–5.02)	5.26 (4.47–6.25)	6.15 (5.19–7.33)	7.45 (6.09–9.20)	8.51 (6.77–10.6)	9.61 (7.36–12.2)	10.8 (7.88–14.0)	12.4 (8.69–16.5)	13.7 (9.30–18.4)
4-day	3.92 (3.37–4.62)	4.54 (3.90–5.35)	5.60 (4.78–6.61)	6.52 (5.54–7.73)	7.85 (6.45–9.63)	8.92 (7.13–11.1)	10.0 (7.73–12.7)	11.2 (8.24–14.5)	12.9 (9.04–17.1)	14.1 (9.65–19.0)
7-day	4.65 (4.03–5.41)	5.32 (4.61–6.19)	6.45 (5.57–7.53)	7.43 (6.38–8.71)	8.84 (7.33–10.7)	9.97 (8.05–12.2)	11.1 (8.65–14.0)	12.4 (9.16–15.9)	14.0 (9.97–18.5)	15.4 (10.6–20.5)
10-day	5.30 (4.63–6.12)	6.02 (5.26–6.96)	7.25 (6.30–8.40)	8.30 (7.17–9.65)	9.79 (8.17–11.8)	11.0 (8.92–13.4)	12.2 (9.54–15.2)	13.5 (10.1–17.2)	15.2 (10.9–20.0)	16.6 (11.5–22.0)
20-day	7.16 (6.34–8.15)	8.11 (7.18–9.24)	9.68 (8.53–11.1)	11.0 (9.63–12.6)	12.8 (10.8–15.1)	14.2 (11.7–17.1)	15.7 (12.4–19.3)	17.1 (12.9–21.6)	19.1 (13.8–24.8)	20.6 (14.5–27.2)
30-day	8.70 (7.77–9.81)	9.86 (8.80–11.1)	11.8 (10.5–13.3)	13.3 (11.8–15.2)	15.5 (13.1–18.1)	17.1 (14.1–20.3)	18.7 (14.9–22.8)	20.3 (15.4–25.5)	22.5 (16.3–29.0)	24.1 (17.0–31.6)
45-day	10.6 (9.58–11.9)	12.1 (10.9–13.5)	14.4 (12.9–16.2)	16.3 (14.5–18.4)	18.8 (16.1–21.8)	20.7 (17.3–24.4)	22.6 (18.1–27.3)	24.4 (18.7–30.4)	26.8 (19.6–34.3)	28.5 (20.3–37.3)
60-day	12.3 (11.1–13.7)	14.0 (12.7–15.6)	16.7 (15.0–18.6)	18.8 (16.9–21.1)	21.7 (18.6–25.0)	23.8 (20.0–27.9)	25.9 (20.9–31.1)	27.9 (21.4–34.5)	30.5 (22.4–38.8)	32.3 (23.1–42.1)

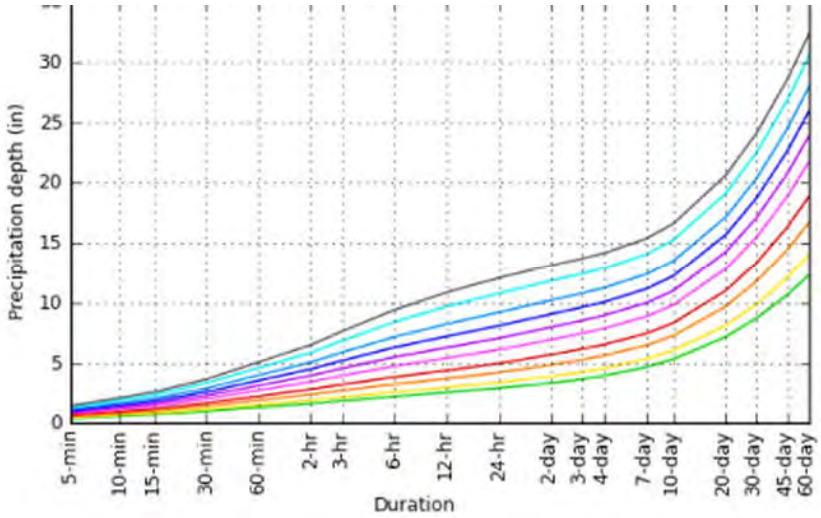
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

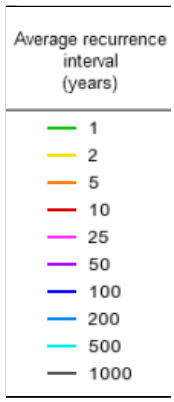
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

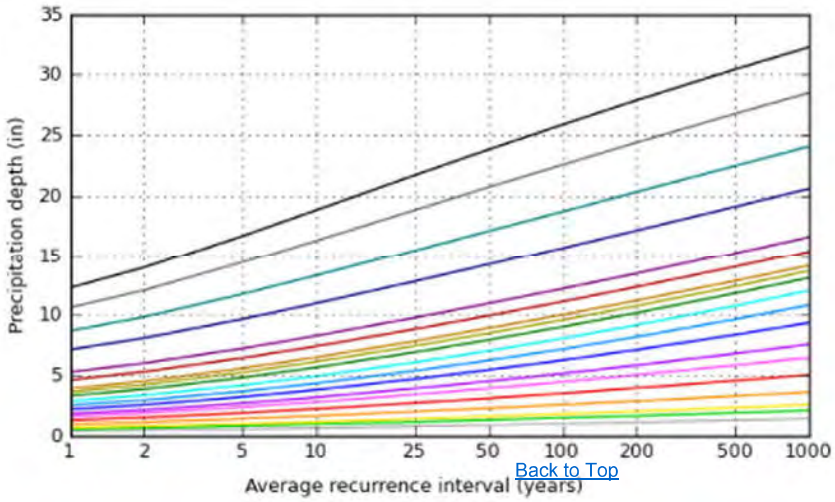
Please refer to NOAA Atlas 14 document for more information.

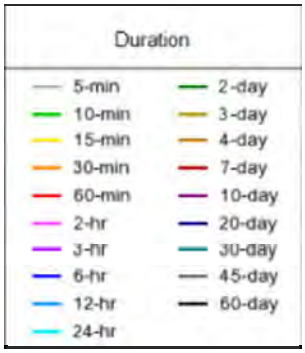
Back to Top

PF graphical









Back to Top

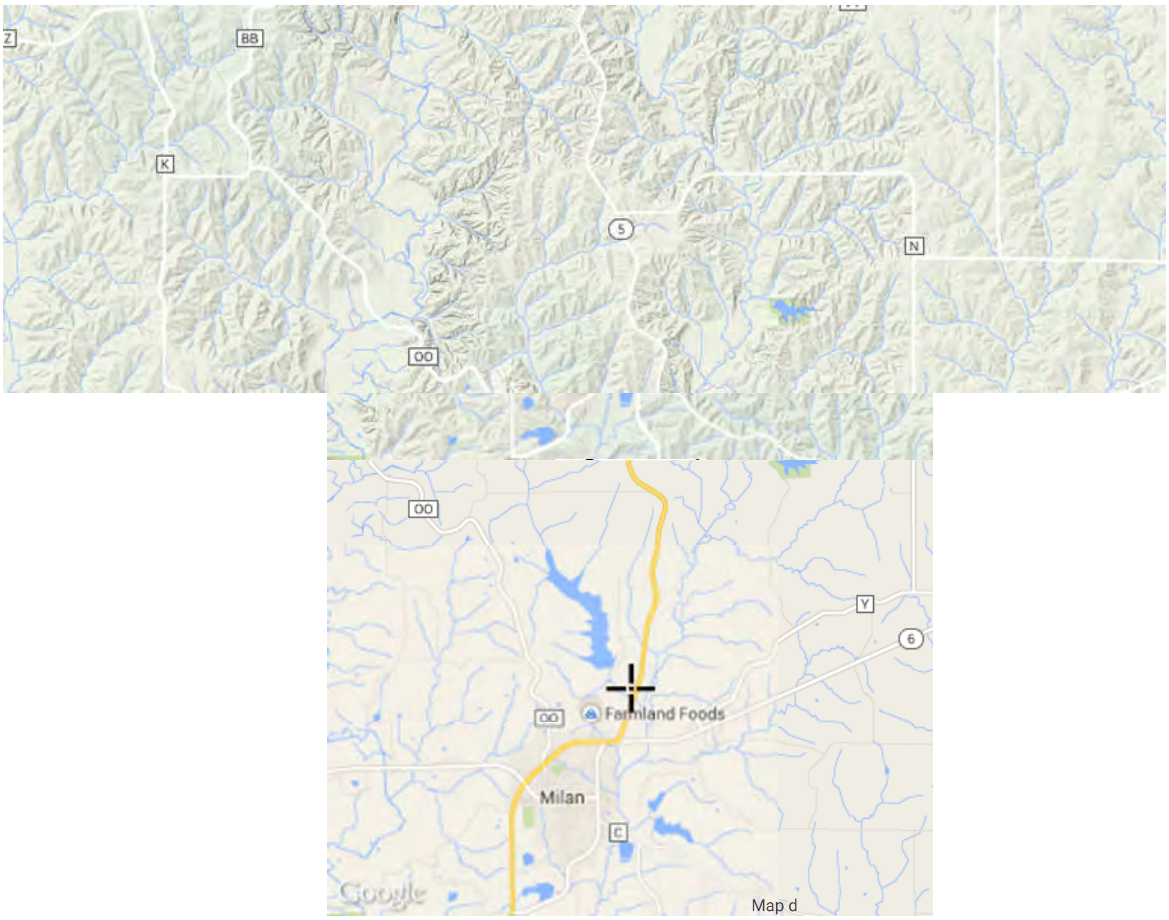
Maps & aerials

NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Wed Apr 8 14:23:06 2015

Small scale terrain

Large scale terrain



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

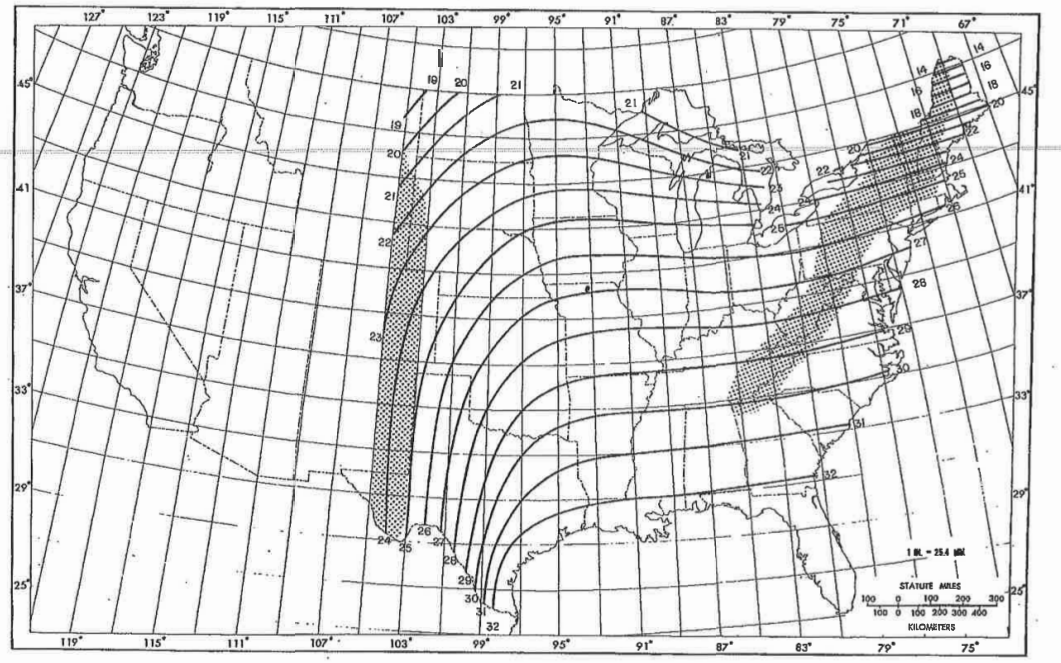
HYDROMETEOROLOGICAL REPORT NO. 51

Missouri - East Locust Creek
RW-1

Probable Maximum Precipitation Estimates, United States East of the 105th Meridian

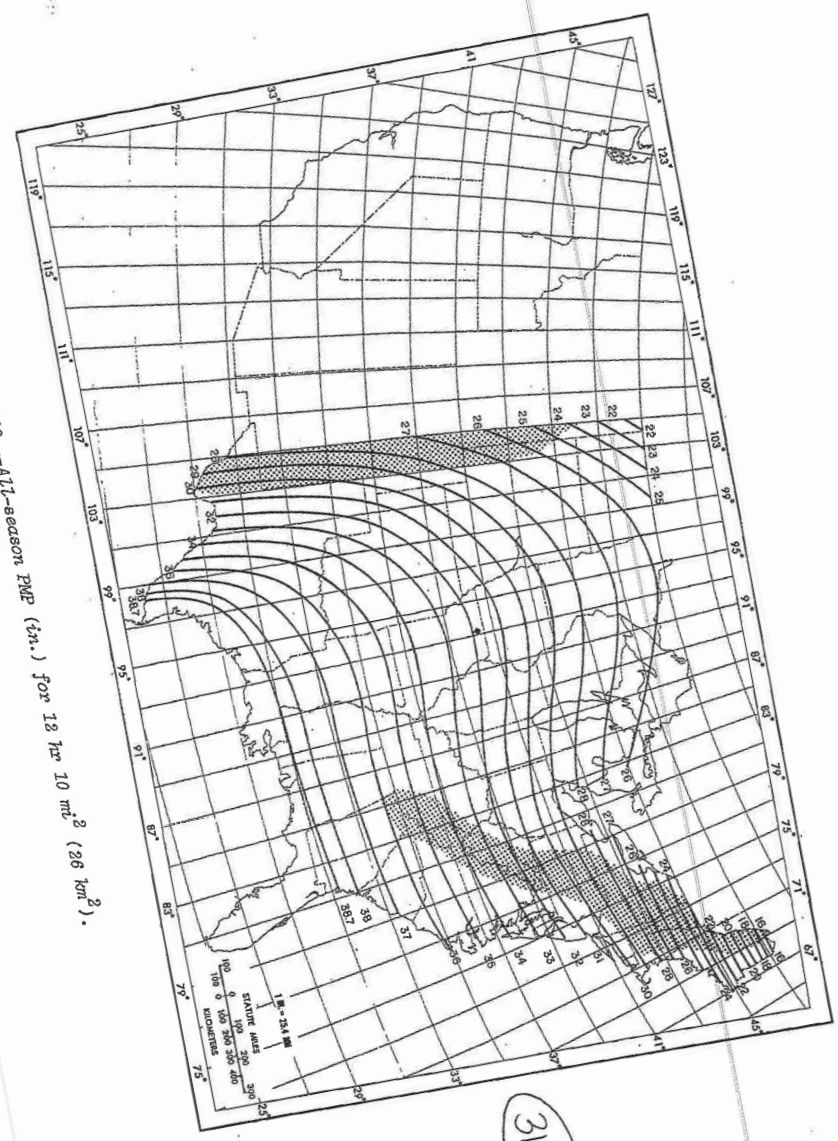
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Washington, D C
June 1978



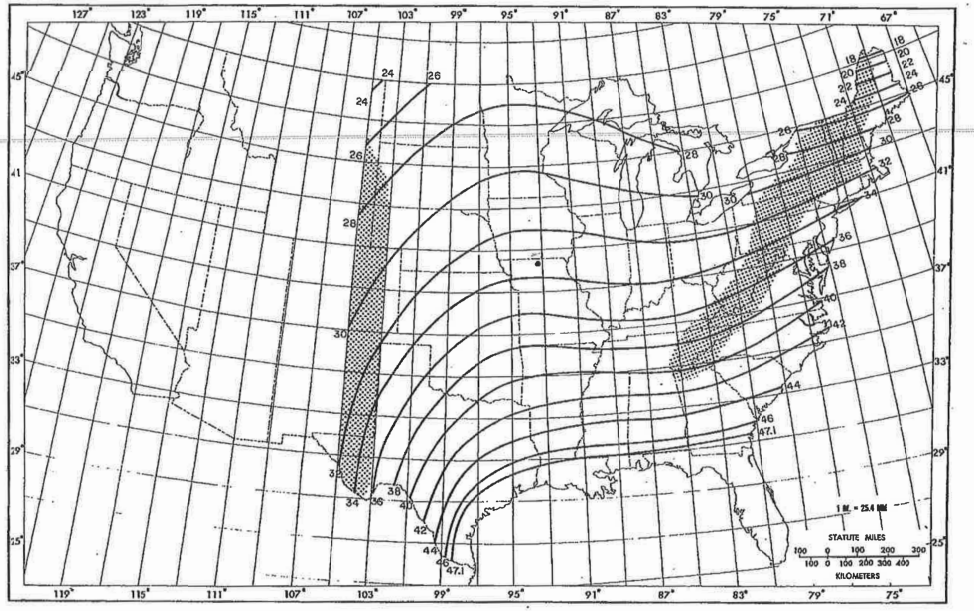
26.9 inches

Figure 18.--All-season PMP (in.) for 6 hr 10 mi^2 (26 km^2).



31.8 inches

Figure 19.--All-season PMP (in.) for 12 hr 10 mi^2 (26 km^2).



33.4 inches

Figure 20.--All-season PMP (in.) for 24 hr 10 mi^2 (26 km^2).

SITES Output

	RW-1_1YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	2.79
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	5115.5
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	923.35
Storage at Max. WS FBH or Storm (Acre-Ft)	56550.7
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	1.05
AS Peak Discharge FBH/Storm (CFS)	96
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_2YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	3.23
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	6649.6
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	923.59
Storage at Max. WS FBH or Storm (Acre-Ft)	57131.8
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	1.29
AS Peak Discharge FBH/Storm (CFS)	118
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_5YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	4.03
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	9617.1
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	924.03
Storage at Max. WS FBH or Storm (Acre-Ft)	58223.7
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	1.73
AS Peak Discharge FBH/Storm (CFS)	193
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_10YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	4.75
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	12416.2
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	924.44
Storage at Max. WS FBH or Storm (Acre-Ft)	59249.4
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	2.14
AS Peak Discharge FBH/Storm (CFS)	271
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_25YR24HR_PSNotch_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	5.84
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	16726.2
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	924.9
Storage at Max. WS FBH or Storm (Acre-Ft)	60402.6
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	2.6
AS Peak Discharge FBH/Storm (CFS)	767
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_50YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	6.75
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	20392.9
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	925.53
Storage at Max. WS FBH or Storm (Acre-Ft)	62036.5
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	3.23
AS Peak Discharge FBH/Storm (CFS)	763
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_100YR24HR_Jan2014_SingleStorm
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	N/A
SDH Rainfall Duration (Hours)	N/A
FBH or Storm Rainfall Total (Inches)	7.74
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	N/A
FBH or Storm Inflow Peak (CFS)	24359.7
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	N/A
Maximum WS FBH or Storm (Feet)	925.97
Storage at Max. WS FBH or Storm (Acre-Ft)	63183.1
Top Dam (Feet)	N/A
Storage, Top Dam (Acre-Ft)	N/A
PS Discharge for SDH (CFS)	N/A
PS Discharge FBH or Storm (CFS)	N/A
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	N/A
Hp FBH or Storm (Feet)	3.67
AS Peak Discharge FBH/Storm (CFS)	1161
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_TOD_6-HR_Labyrinth_Jan2014
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	10.48
SDH Rainfall Duration (Hours)	6
FBH or Storm Rainfall Total (Inches)	24.23
FBH or Storm Rainfall Duration (Hours)	6
SDH Inflow Peak (CFS)	40039.9
FBH or Storm Inflow Peak (CFS)	105968
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	927.69
Maximum WS FBH or Storm (Feet)	934.45
Storage at Max. WS FBH or Storm (Acre-Ft)	88092.1
Top Dam (Feet)	934.45
Storage, Top Dam (Acre-Ft)	88093
PS Discharge for SDH (CFS)	0.3
PS Discharge FBH or Storm (CFS)	0.5
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	5.39
Hp FBH or Storm (Feet)	12.15
AS Peak Discharge FBH/Storm (CFS)	9366
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_TOD_24-HR_5PT_Labyrinth_Jan2014
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	13.2
SDH Rainfall Duration (Hours)	24
FBH or Storm Rainfall Total (Inches)	30.08
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	32599.1
FBH or Storm Inflow Peak (CFS)	79352.6
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	928.67
Maximum WS FBH or Storm (Feet)	936.02
Storage at Max. WS FBH or Storm (Acre-Ft)	93327.1
Top Dam (Feet)	936.02
Storage, Top Dam (Acre-Ft)	93328
PS Discharge for SDH (CFS)	0.3
PS Discharge FBH or Storm (CFS)	0.6
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	6.37
Hp FBH or Storm (Feet)	13.72
AS Peak Discharge FBH/Storm (CFS)	10817
Uncontrolled Drainage Area (Sq.Miles)	32.66

SITES Output

	RW-1_TOD_24-HR_Labyrinth_Jan2014
Site Identification	RW1
Watershed Runoff Curve Number	82
Total Watershed Drainage Area (Sq.Miles)	32.66
Watershed Time of Concentration (Hours)	3.68
SDH Rainfall Total (Inches)	13.2
SDH Rainfall Duration (Hours)	24
FBH or Storm Rainfall Total (Inches)	30.08
FBH or Storm Rainfall Duration (Hours)	24
SDH Inflow Peak (CFS)	46595.7
FBH or Storm Inflow Peak (CFS)	114613.6
Initial Reservoir Elevation (Feet)	922.3
Maximum WS SDH (Feet)	928.66
Maximum WS FBH or Storm (Feet)	935.86
Storage at Max. WS FBH or Storm (Acre-Ft)	92789
Top Dam (Feet)	935.86
Storage, Top Dam (Acre-Ft)	92777
PS Discharge for SDH (CFS)	0.3
PS Discharge FBH or Storm (CFS)	0.6
AS Crest (Feet)	922.3
Storage, AS Crest (Acre-Ft)	54009
AS Max. Head SDH (Feet)	6.36
Hp FBH or Storm (Feet)	13.56
AS Peak Discharge FBH/Storm (CFS)	11000
Uncontrolled Drainage Area (Sq.Miles)	32.66

```
--------------------------------
Bulletin 17B Frequency Analysis
    14 Apr 2015   02:16 PM
--------------------------------


--- Input Data ---

Analysis Name: KC_Atlanta
Description:

Data Set Name: KC_Data_other-Atlanta, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /Long Branch Creek/Atlanta, MO/FLOW-ANNUAL
PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Atlanta\KC_Atlanta.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Atlanta\KC_Atlanta.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---



----------------------
<< Low Outlier Test >>
----------------------
 Based on 19 events, 10 percent outlier test deviate K(N) = 2.361
                         Computed low outlier test value = 155.84

           0 low outlier(s) identified below test value of 155.84



-----------------------
<< High Outlier Test >>
-----------------------
 Based on 19 events, 10 percent outlier test deviate K(N) = 2.361
                      Computed high outlier test value = 11,826.48

       0 high outlier(s) identified above test value of 11,826.48



--- Final Results ---
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<< Plotting Positions >>
KC_Data_other-Atlanta, MO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
27 May 1996	1,860.0	1	2014	5,350.0	3.61
12 Apr 1997	1,180.0	2	2008	4,870.0	8.76
04 Jul 1998	2,590.0	3	2010	4,110.0	13.92
05 Oct 1998	1,970.0	4	2002	3,360.0	19.07
26 Jun 2000	209.0	5	2013	3,070.0	24.23
07 Jun 2001	1,100.0	6	1998	2,590.0	29.38
12 May 2002	3,360.0	7	2009	2,550.0	34.54
05 May 2003	432.0	8	1999	1,970.0	39.69
10 Dec 2003	840.0	9	1996	1,860.0	44.85
12 Apr 2005	641.0	10	1997	1,180.0	50.00
14 Aug 2006	580.0	11	2001	1,100.0	55.15
25 Feb 2007	932.0	12	2007	932.0	60.31
25 Jul 2008	4,870.0	13	2004	840.0	65.46
16 May 2009	2,550.0	14	2011	642.0	70.62
20 Jul 2010	4,110.0	15	2005	641.0	75.77
11 Jun 2011	642.0	16	2006	580.0	80.93
26 Sep 2012	569.0	17	2012	569.0	86.08
18 Apr 2013	3,070.0	18	2003	432.0	91.24
10 Sep 2014	5,350.0	19	2000	209.0	96.39

<< Skew Weighting >>

Based on 19 events, mean-square error of station skew = 0.274
Mean-square error of regional skew = -?

<< Frequency Curve >>
KC_Data_other-Atlanta, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
15,298.7	22,167.6	0.2	41,580.1	8,344.0
12,166.3	16,176.7	0.5	30,563.7	6,916.6
10,032.0	12,567.8	1.0	23,612.7	5,899.3
8,093.3	9,605.6	2.0	17,743.6	4,934.3
5,818.3	6,490.1	5.0	11,484.3	3,734.3
4,305.0	4,613.2	10.0	7,767.7	2,878.1
2,958.7	3,068.7	20.0	4,833.3	2,055.6
1,398.7	1,398.7	50.0	2,009.4	978.4
633.9	607.8	80.0	911.1	389.7
412.0	378.9	90.0	619.2	225.8
286.0	249.4	95.0	452.5	140.4
141.1	103.3	99.0	251.4	54.8

<< Systematic Statistics >>
KC_Data_other-Atlanta, MO-FLOW-ANNUAL PEAK

Log Transform:	

FLOW, CFS		Number of Events	
Mean	3.133	Historic Events	0
Standard Dev	0.398	High Outliers	0
Station Skew	-0.196	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.196	Systematic Events	19

--- End of Analytical Frequency Curve ---

```
--------------------------------
Bulletin 17B Frequency Analysis
    14 Apr 2015   02:30 PM
--------------------------------


--- Input Data ---

Analysis Name: KC_Bedford
Description:

Data Set Name: Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /East Fork 102 River/Bedford, IA/FLOW-ANNUAL
PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Bedford\KC_Bedford.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Bedford\KC_Bedford.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---


<< Skew Weighting >>
-------------------------------------------------------------------
Based on 31 events, mean-square error of station skew =       0.7
Mean-square error of regional skew =                           -?
-------------------------------------------------------------------


<< Frequency Curve >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK
----------------------------------------------------------------------
|  Computed    Expected   |   Percent   |    Confidence Limits    |
|    Curve    Probability |   Chance    |        0.05        0.95 |
|        FLOW, CFS        | Exceedance  |        FLOW, CFS        |
|-------------------------|-------------|-------------------------|
|     9,755.4     9,760.6 |      0.2    |    13,909.7     7,386.8 |
|     9,740.9     9,751.4 |      0.5    |    13,885.5     7,376.7 |
|     9,714.4     9,732.5 |      1.0    |    13,841.1     7,358.2 |
|     9,656.9     9,683.8 |      2.0    |    13,745.1     7,318.1 |
|     9,466.3     9,515.7 |      5.0    |    13,427.7     7,184.7 |
|     9,116.5     9,163.7 |     10.0    |    12,849.6     6,938.6 |
|     8,348.6     8,391.8 |     20.0    |    11,601.3     6,391.7 |
```

5,709.8	5,709.8	50.0	7,555.8	4,428.7
2,612.3	2,521.3	80.0	3,385.9	1,921.4
1,426.7	1,312.1	90.0	1,937.8	945.8
774.8	667.9	95.0	1,134.6	449.7
185.4	121.6	99.0	337.4	75.7

<< Systematic Statistics >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.637	Historic Events	0
Standard Dev	0.373	High Outliers	0
Station Skew	-2.118	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-2.118	Systematic Events	31

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 31 events, 10 percent outlier test deviate K(N) = 2.577
Computed low outlier test value = 472.58

2 low outlier(s) identified below test value of 472.58

Statistics and frequency curve adjusted for 2 low outlier(s)

<< Systematic Statistics >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.716	Historic Events	0
Standard Dev	0.218	High Outliers	0
Station Skew	-1.288	Low Outliers	2
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-2.118	Systematic Events	31

<< High Outlier Test >>

Based on 29 events, 10 percent outlier test deviate K(N) = 2.549
Computed high outlier test value = 18,756.09

0 high outlier(s) identified above test value of 18,756.09

Note: Statistics and frequency curve were modified
using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
15 Jun 1984	4,930.0	1	2010	10,300.0	2.23
25 Jul 1985	1,160.0	2	1986	9,570.0	5.41
14 Jul 1986	9,570.0	3	1993	9,170.0	8.60
12 Jul 1987	5,660.0	4	2007	8,750.0	11.78
08 Dec 1987	328.0	5	2012	8,710.0	14.97
09 Sep 1989	6,740.0	6	2013	7,860.0	18.15
17 Jun 1990	4,150.0	7	2008	7,180.0	21.34
18 Apr 1991	3,140.0	8	2014	7,080.0	24.52
20 Apr 1992	6,380.0	9	1989	6,740.0	27.71
05 Jul 1993	9,170.0	10	1992	6,380.0	30.89
18 Jun 1994	1,730.0	11	1999	6,350.0	34.08
04 Jul 1995	5,880.0	12	2006	6,320.0	37.26
09 May 1996	5,390.0	13	2009	6,060.0	40.45
07 May 1997	4,400.0	14	2011	5,950.0	43.63
30 Mar 1998	4,270.0	15	2004	5,910.0	46.82
31 Jul 1999	6,350.0	16	1995	5,880.0	50.00
25 Jun 2000	3,560.0	17	1987	5,660.0	53.18
10 May 2001	4,390.0	18	1996	5,390.0	56.37
11 May 2002	2,380.0	19	1984	4,930.0	59.55
04 May 2003	282.0	20	1997	4,400.0	62.74
04 Aug 2004	5,910.0	21	2001	4,390.0	65.92
12 Jun 2005	3,650.0	22	1998	4,270.0	69.11
28 Aug 2006	6,320.0	23	1990	4,150.0	72.29
07 May 2007	8,750.0	24	2005	3,650.0	75.48
06 Jun 2008	7,180.0	25	2000	3,560.0	78.66
24 Mar 2009	6,060.0	26	1991	3,140.0	81.85
05 Jun 2010	10,300.0	27	2002	2,380.0	85.03
27 Jun 2011	5,950.0	28	1994	1,730.0	88.22
30 Mar 2012	8,710.0	29	1985	1,160.0	91.40
15 Jun 2013	7,860.0	30	1988	328.0*	94.59
04 Jun 2014	7,080.0	31	2003	282.0*	97.77

* Outlier

<< Skew Weighting >>

Based on 31 events, mean-square error of station skew = 0.396
Mean-square error of regional skew = -?

<< Frequency Curve >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK

Computed	Expected	Percent	Confidence Limits

Curve FLOW, CFS	Probability	Chance Exceedance	0.05 FLOW, CFS	0.95
10,863.9	10,995.7	0.2	14,410.5	8,828.8
10,665.2	10,808.2	0.5	14,093.0	8,685.3
10,446.2	10,595.1	1.0	13,745.1	8,526.5
10,140.7	10,282.5	2.0	13,263.2	8,303.6
9,537.5	9,667.6	5.0	12,324.5	7,859.0
8,848.8	8,940.3	10.0	11,274.3	7,343.1
7,835.8	7,891.9	20.0	9,774.8	6,565.5
5,545.1	5,545.1	50.0	6,622.2	4,697.2
3,291.3	3,224.2	80.0	3,911.1	2,667.3
2,316.6	2,213.1	90.0	2,836.4	1,762.6
1,659.9	1,534.3	95.0	2,117.5	1,174.6
795.5	645.4	99.0	1,131.9	470.8

<< Synthetic Statistics >>
Bedford IA-Bedford, IA-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.691	Historic Events	0
Standard Dev	0.244	High Outliers	0
Station Skew	-1.354	Low Outliers	2
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.354	Systematic Events	31

--- End of Analytical Frequency Curve ---

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Bulletin 17B Frequency Analysis
    14 Apr 2015   02:18 PM
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--- Input Data ---

Analysis Name: KC_Bethany
Description:

Data Set Name: KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /East Fork Big Creek/Bethany, MO/FLOW-ANNUAL
PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Bethany\KC_Bethany.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Bethany\KC_Bethany.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.



<< Frequency Curve >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK
```

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits FLOW, CFS 0.05	0.95
9,788.0	10,113.4	0.2	13,190.5	7,764.8
9,083.4	9,342.9	0.5	12,102.2	7,261.5
8,468.6	8,683.9	1.0	11,165.0	6,817.8
7,771.1	7,937.8	2.0	10,117.1	6,308.8
6,698.1	6,808.2	5.0	8,539.2	5,512.3
5,746.3	5,811.2	10.0	7,178.7	4,789.3
4,637.5	4,668.9	20.0	5,648.5	3,922.5
2,797.0	2,797.0	50.0	3,276.5	2,399.1
1,471.4	1,453.2	80.0	1,734.2	1,215.1

992.1	966.5	90.0	1,202.6	781.3
694.3	664.6	95.0	870.6	519.3
328.2	294.7	99.0	447.6	217.5

<< Conditional Statistics >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.405	Historic Events	0
Standard Dev	0.305	High Outliers	0
Station Skew	-0.829	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.829	Systematic Events	58

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
9,774.8	---	0.2	---	---
9,068.1	---	0.5	---	---
8,451.1	---	1.0	---	---
7,752.1	---	2.0	---	---
6,674.3	---	5.0	---	---
5,718.5	---	10.0	---	---
4,605.6	---	20.0	---	---
2,754.5	---	50.0	---	---
1,405.4	---	80.0	---	---
903.1	---	90.0	---	---
569.3	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 57 events, 10 percent outlier test deviate K(N) = 2.818
Computed low outlier test value = 350.16

1 low outlier(s) identified below test value of 350.16

Based on statistics after 0 zero events and 1 missing events were deleted.

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Conditional Statistics >>

KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.424	Historic Events	0
Standard Dev	0.271	High Outliers	0
Station Skew	-0.229	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.829	Systematic Events	58

<< High Outlier Test >>

Based on 56 events, 10 percent outlier test deviate K(N) = 2.811
Computed high outlier test value = 15,320.95

0 high outlier(s) identified above test value of 15,320.95

Note: Statistics and frequency curve were modified
using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
06 Jul 1909	---	1	1974	13,000.0	1.20
23 Jun 1934	590.0	2	1947	8,120.0	2.91
31 May 1935	3,500.0	3	1946	6,770.0	4.62
23 May 1936	980.0	4	1942	6,600.0	6.34
30 Jan 1937	1,610.0	5	2004	5,760.0	8.05
21 Aug 1938	210.0	6	1961	5,700.0	9.76
02 Aug 1939	2,060.0	7	1959	5,100.0	11.47
08 May 1940	1,780.0	8	2014	5,080.0	13.18
09 Jun 1941	2,950.0	9	2008	4,820.0	14.90
26 Jun 1942	6,600.0	10	2007	4,800.0	16.61
16 May 1943	3,110.0	11	2010	4,760.0	18.32
22 Apr 1944	3,210.0	12	1960	4,740.0	20.03
15 May 1945	4,120.0	13	1945	4,120.0	21.75
30 Jun 1946	6,770.0	14	2009	4,080.0	23.46
06 Jun 1947	8,120.0	15	1962	3,880.0	25.17
06 May 1948	2,310.0	16	2013	3,850.0	26.88
24 Feb 1949	2,000.0	17	1935	3,500.0	28.60
20 Sep 1950	1,300.0	18	1965	3,480.0	30.31
01 May 1951	2,920.0	19	1967	3,350.0	32.02
21 Jun 1952	2,970.0	20	1944	3,210.0	33.73
31 Mar 1953	925.0	21	1972	3,190.0	35.45
01 Jun 1954	1,330.0	22	1968	3,150.0	37.16
25 Jun 1955	2,240.0	23	1969	3,110.0	38.87
02 Aug 1956	2,500.0	24	1943	3,110.0	40.58

21 May 1957	1,620.0	25	1970	3,070.0	42.29
15 Jul 1958	1,780.0	26	1971	2,970.0	44.01
30 May 1959	5,100.0	27	1952	2,970.0	45.72
30 Jun 1960	4,740.0	28	1941	2,950.0	47.43
13 Sep 1961	5,700.0	29	1951	2,920.0	49.14
11 Jun 1962	3,880.0	30	2001	2,660.0	50.86
04 Mar 1963	2,100.0	31	1956	2,500.0	52.57
06 Sep 1964	1,910.0	32	1966	2,430.0	54.28
21 Sep 1965	3,480.0	33	1999	2,420.0	55.99
13 Jun 1966	2,430.0	34	1998	2,380.0	57.71
13 Jun 1967	3,350.0	35	1948	2,310.0	59.42
23 Apr 1968	3,150.0	36	1955	2,240.0	61.13
30 Jun 1969	3,110.0	37	1963	2,100.0	62.84
17 Sep 1970	3,070.0	38	1939	2,060.0	64.55
18 Feb 1971	2,970.0	39	1949	2,000.0	66.27
07 May 1972	3,190.0	40	1964	1,910.0	67.98
13 Oct 1973	13,000.0	41	2005	1,850.0	69.69
15 Apr 1997	1,790.0	42	1997	1,790.0	71.40
04 Jul 1998	2,380.0	43	2002	1,780.0	73.12
17 Oct 1998	2,420.0	44	1958	1,780.0	74.83
24 Feb 2001	2,660.0	45	1940	1,780.0	76.54
12 May 2002	1,780.0	46	2011	1,660.0	78.25
01 May 2003	543.0	47	1957	1,620.0	79.97
30 May 2004	5,760.0	48	1937	1,610.0	81.68
11 Jun 2005	1,850.0	49	1954	1,330.0	83.39
30 Apr 2006	1,110.0	50	1950	1,300.0	85.10
07 May 2007	4,800.0	51	2006	1,110.0	86.82
25 Jul 2008	4,820.0	52	2012	1,030.0	88.53
15 May 2009	4,080.0	53	1936	980.0	90.24
05 Jun 2010	4,760.0	54	1953	925.0	91.95
25 May 2011	1,660.0	55	1934	590.0	93.66
04 May 2012	1,030.0	56	2003	543.0	95.38
18 Apr 2013	3,850.0	57	1938	210.0*	97.09
10 Sep 2014	5,080.0	58	1909	---	98.80

* Outlier

<< Skew Weighting >>

Based on 58 events, mean-square error of station skew = 0.103
Mean-square error of regional skew = -?

<< Frequency Curve >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits FLOW, CFS 0.05	0.95
13,447.6	14,474.8	0.2	18,788.2	10,428.3
11,527.0	12,203.7	0.5	15,707.2	9,096.8
10,121.3	10,595.1	1.0	13,509.6	8,103.0
8,754.4	9,067.9	2.0	11,425.1	7,117.7
7,000.4	7,163.1	5.0	8,838.4	5,819.7
5,704.6	5,789.3	10.0	7,003.2	4,829.0
4,417.9	4,453.0	20.0	5,260.6	3,808.1
2,645.1	2,645.1	50.0	3,037.3	2,306.0
1,533.7	1,519.6	80.0	1,778.0	1,289.8
1,138.6	1,118.0	90.0	1,348.2	923.9

884.2	858.6	95.0	1,071.5	692.5
541.0	506.8	99.0	690.9	392.6

<< Synthetic Statistics >>
KC_Data_other-Bethany, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.413	Historic Events	0
Standard Dev	0.274	High Outliers	0
Station Skew	-0.216	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.216	Systematic Events	58

--- End of Analytical Frequency Curve ---

```
-------------------------------
Bulletin 17B Frequency Analysis
    14 Apr 2015   02:17 PM
-------------------------------


--- Input Data ---

Analysis Name: KC_Chula
Description:

Data Set Name: KC_Data_other-Chula, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /Muddy Creek/Chula, MO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Chula\KC_Chula.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Chula\KC_Chula.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


Warning: Less than 10 events for analysis,
  Bulletin 17B procedures are not applicable.



-----------------------
<< Low Outlier Test >>
-----------------------
  Based on 4 events, 10 percent outlier test deviate K(N) = 1.425
                       Computed low outlier test value = 1,721.56

         0 low outlier(s) identified below test value of 1,721.56



------------------------
<< High Outlier Test >>
------------------------
  Based on 4 events, 10 percent outlier test deviate K(N) = 1.425
                      Computed high outlier test value = 4,749.52

        0 high outlier(s) identified above test value of 4,749.52
```

--- Final Results ---

<< Plotting Positions >>
KC_Data_other-Chula, MO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events		
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
17 Feb 2011	2,520.0	1	2014	4,220.0	15.91
29 Mar 2012	1,860.0	2	2013	3,380.0	38.64
18 Apr 2013	3,380.0	3	2011	2,520.0	61.36
10 Sep 2014	4,220.0	4	2012	1,860.0	84.09

<< Skew Weighting >>

Based on 4 events, mean-square error of station skew = 1.091
Mean-square error of regional skew = -?

<< Frequency Curve >>
KC_Data_other-Chula, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits FLOW, CFS 0.05	0.95
7,113.6	33,452.3	0.2	49,060.0	4,608.4
6,549.1	17,940.0	0.5	38,385.3	4,358.3
6,105.2	12,437.8	1.0	31,199.1	4,152.7
5,643.1	9,229.9	2.0	24,760.0	3,928.2
4,994.3	6,648.9	5.0	17,366.0	3,589.6
4,462.2	5,282.8	10.0	12,600.2	3,282.2
3,872.7	4,200.6	20.0	8,542.4	2,889.3
2,904.7	2,904.7	50.0	4,370.5	1,980.9
2,130.8	1,931.6	80.0	2,855.7	980.7
1,795.8	1,437.1	90.0	2,450.1	613.1
1,551.8	1,020.9	95.0	2,188.1	403.3
1,166.2	326.8	99.0	1,791.6	174.0

<< Systematic Statistics >>
KC_Data_other-Chula, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.456	Historic Events	0
Standard Dev	0.155	High Outliers	0
Station Skew	-0.265	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.265	Systematic Events	4

--- End of Analytical Frequency Curve ---

```
-------------------------------
Bulletin 17B Frequency Analysis
    14 Apr 2015   02:25 PM
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--- Input Data ---

Analysis Name: KC_Hickory Branch
Description:

Data Set Name: Hickory Branch-Mendon, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /Hickory Branch/Mendon, MO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Hickory_Branch\KC_Hickory_Branch.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Hickory_Branch\KC_Hickory_Branch.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


Warning: Less than 10 events for analysis,
  Bulletin 17B procedures are not applicable.



-----------------------
<< Low Outlier Test >>
-----------------------
  Based on 4 events, 10 percent outlier test deviate K(N) = 1.425
                         Computed low outlier test value = 245.87

           0 low outlier(s) identified below test value of 245.87



------------------------
<< High Outlier Test >>
------------------------
  Based on 4 events, 10 percent outlier test deviate K(N) = 1.425
                       Computed high outlier test value = 3,069.98

        0 high outlier(s) identified above test value of 3,069.98
```

--- Final Results ---

<< Plotting Positions >>
Hickory Branch-Mendon, MO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events		
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
28 Feb 2011	1,480.0	1	2013	1,760.0	15.91
29 Mar 2012	882.0	2	2011	1,480.0	38.64
18 Apr 2013	1,760.0	3	2012	882.0	61.36
03 Apr 2014	248.0	4	2014	248.0	84.09

<< Skew Weighting >>

Based on 4 events, mean-square error of station skew = 1.351
Mean-square error of regional skew = -?

<< Frequency Curve >>
Hickory Branch-Mendon, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits FLOW, CFS 0.05	0.95
2,934.5	3,494.9	0.2	47,468.7	1,339.3
2,862.3	3,269.9	0.5	44,230.0	1,312.8
2,781.3	3,144.4	1.0	40,774.4	1,282.6
2,666.7	3,045.8	2.0	36,212.8	1,239.0
2,439.4	2,875.4	5.0	28,215.3	1,149.5
2,182.3	2,548.8	10.0	20,734.6	1,042.5
1,815.0	2,017.4	20.0	12,613.3	876.0
1,061.8	1,061.8	50.0	3,448.7	454.5
465.7	337.7	80.0	968.4	80.4
265.9	115.2	90.0	578.9	17.5
155.9	25.9	95.0	386.9	3.7
47.7	0.1	99.0	175.0	0.1

<< Systematic Statistics >>
Hickory Branch-Mendon, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	2.939	Historic Events	0
Standard Dev	0.385	High Outliers	0
Station Skew	-1.407	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.407	Systematic Events	4

--- End of Analytical Frequency Curve ---

```
-------------------------------
Bulletin 17B Frequency Analysis
    14 Apr 2015   01:47 PM
-------------------------------


--- Input Data ---

Analysis Name: KC_Linneus
Description:

Data Set Name: KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /Locust Creek/Linneus, MO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Linneus\KC_Linneus.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Linneus\KC_Linneus.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---


<< Skew Weighting >>
-------------------------------------------------------------------
Based on 65 events, mean-square error of station skew =     0.229
Mean-square error of regional skew =                           -?
-------------------------------------------------------------------


<< Frequency Curve >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK
-----------------------------------------------------------------------
|  Computed    Expected    |   Percent    |    Confidence Limits     |
|    Curve    Probability  |   Chance     |        0.05        0.95  |
|        FLOW, CFS         | Exceedance   |        FLOW, CFS         |
|--------------------------|--------------|--------------------------|
|    31,122.2    31,472.2  |      0.2     |    40,683.6    25,069.6  |
|    30,084.1    30,421.4  |      0.5     |    39,153.7    24,304.7  |
|    29,003.2    29,336.8  |      1.0     |    37,570.2    23,504.5  |
|    27,573.8    27,875.9  |      2.0     |    35,491.5    22,440.1  |
|    24,942.3    25,196.6  |      5.0     |    31,712.6    20,460.5  |
|    22,163.9    22,332.3  |     10.0     |    27,796.1    18,338.7  |
|    18,409.6    18,504.2  |     20.0     |    22,639.0    15,410.2  |
|    11,079.0    11,079.0  |     50.0     |    13,129.4     9,414.8  |
```

5,280.6	5,209.5	80.0	6,278.5	4,331.7
3,233.1	3,138.8	90.0	3,970.8	2,513.7
2,037.1	1,936.9	95.0	2,609.4	1,488.6
741.4	650.5	99.0	1,059.3	464.9

<< Systematic Statistics >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.974	Historic Events	0
Standard Dev	0.346	High Outliers	0
Station Skew	-1.259	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.259	Systematic Events	65

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 65 events, 10 percent outlier test deviate K(N) = 2.866
Computed low outlier test value = 956.64

2 low outlier(s) identified below test value of 956.64

Statistics and frequency curve adjusted for 2 low outlier(s)

<< Systematic Statistics >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	4.009	Historic Events	0
Standard Dev	0.290	High Outliers	0
Station Skew	-0.780	Low Outliers	2
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-1.259	Systematic Events	65

<< High Outlier Test >>

Based on 63 events, 10 percent outlier test deviate K(N) = 2.854
Computed high outlier test value = 68,437.95

0 high outlier(s) identified above test value of 68,437.95

Note: Statistics and frequency curve were modified

using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK

Events Analyzed			Ordered Events			
Day	Mon	Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
30	Jun	1909	18,000.0	1	1947	38,000.0	1.07
30	Jun	1930	7,920.0	2	2014	32,500.0	2.60
20	Apr	1931	8,800.0	3	2004	27,700.0	4.13
23	Nov	1931	8,900.0	4	2008	26,900.0	5.66
24	Dec	1932	4,390.0	5	1969	24,400.0	7.19
05	Apr	1934	900.0	6	1958	24,000.0	8.72
02	Jun	1935	11,800.0	7	2009	23,900.0	10.24
26	Sep	1936	3,100.0	8	2007	20,500.0	11.77
30	Jan	1937	5,110.0	9	1944	20,100.0	13.30
10	Apr	1938	639.0	10	2010	19,300.0	14.83
21	Jun	1939	15,400.0	11	2002	19,200.0	16.36
18	Aug	1940	3,110.0	12	1942	19,000.0	17.89
11	Jun	1941	11,800.0	13	1909	18,000.0	19.42
26	Jun	1942	19,000.0	14	1967	17,800.0	20.95
10	Jun	1943	10,800.0	15	2013	16,700.0	22.48
23	Apr	1944	20,100.0	16	1945	16,500.0	24.01
16	Jun	1945	16,500.0	17	2001	15,600.0	25.54
06	Jan	1946	8,920.0	18	1939	15,400.0	27.06
06	Jun	1947	38,000.0	19	1973	15,000.0	28.59
20	Mar	1948	11,900.0	20	1970	14,800.0	30.12
15	Jun	1949	9,570.0	21	1953	14,000.0	31.65
16	Jun	1950	13,200.0	22	1960	13,800.0	33.18
24	Jul	1951	12,300.0	23	1950	13,200.0	34.71
22	Jun	1952	8,200.0	24	1965	13,000.0	36.24
31	Mar	1953	14,000.0	25	1951	12,300.0	37.77
02	Jun	1954	7,280.0	26	1948	11,900.0	39.30
25	Jun	1955	8,000.0	27	1941	11,800.0	40.83
03	Jul	1956	5,640.0	28	1935	11,800.0	42.35
04	Apr	1957	1,910.0	29	2011	11,200.0	43.88
15	Jul	1958	24,000.0	30	1943	10,800.0	45.41
17	Nov	1958	10,300.0	31	1962	10,700.0	46.94
30	Jun	1960	13,800.0	32	1959	10,300.0	48.47
13	Sep	1961	9,690.0	33	1961	9,690.0	50.00
17	Nov	1961	10,700.0	34	1949	9,570.0	51.53
04	Mar	1963	9,520.0	35	1963	9,520.0	53.06
21	Apr	1964	5,180.0	36	1974	9,200.0	54.59
01	Jan	1965	13,000.0	37	1977	9,000.0	56.12
13	Jun	1966	7,080.0	38	1946	8,920.0	57.65
13	Jun	1967	17,800.0	39	1932	8,900.0	59.17
23	Apr	1968	7,700.0	40	1931	8,800.0	60.70
10	Jul	1969	24,400.0	41	2005	8,700.0	62.23
23	Sep	1970	14,800.0	42	1952	8,200.0	63.76
09	Oct	1970	7,010.0	43	1978	8,000.0	65.29
15	Dec	1971	5,680.0	44	1955	8,000.0	66.82
01	May	1973	15,000.0	45	1930	7,920.0	68.35
18	May	1974	9,200.0	46	1968	7,700.0	69.88
23	Apr	1975	6,700.0	47	1954	7,280.0	71.41
20	Apr	1976	4,500.0	48	1966	7,080.0	72.94

28 Mar 1977	9,000.0	49	1971	7,010.0	74.46
10 Apr 1978	8,000.0	50	1979	6,800.0	75.99
03 Mar 1979	6,800.0	51	1975	6,700.0	77.52
06 Jun 2001	15,600.0	52	2006	6,000.0	79.05
12 May 2002	19,200.0	53	1972	5,680.0	80.58
10 May 2003	984.0	54	1956	5,640.0	82.11
29 Aug 2004	27,700.0	55	1964	5,180.0	83.64
08 Jun 2005	8,700.0	56	1937	5,110.0	85.17
11 Jun 2006	6,000.0	57	2012	5,090.0	86.70
07 May 2007	20,500.0	58	1976	4,500.0	88.23
25 Jun 2008	26,900.0	59	1933	4,390.0	89.76
16 May 2009	23,900.0	60	1940	3,110.0	91.28
13 May 2010	19,300.0	61	1936	3,100.0	92.81
17 Feb 2011	11,200.0	62	1957	1,910.0	94.34
03 May 2012	5,090.0	63	2003	984.0	95.87
28 May 2013	16,700.0	64	1934	900.0*	97.40
10 Sep 2014	32,500.0	65	1938	639.0*	98.93

* Outlier

<< Skew Weighting >>

Based on 65 events, mean-square error of station skew = 0.137
Mean-square error of regional skew = -?

<< Frequency Curve >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
37,876.0	39,027.5	0.2	49,774.5	30,541.3
35,041.0	35,948.5	0.5	45,544.4	28,472.4
32,596.6	33,341.7	1.0	41,943.5	26,670.4
29,852.3	30,423.7	2.0	37,955.7	24,625.1
25,679.4	26,051.4	5.0	32,014.3	21,463.6
22,018.1	22,236.3	10.0	26,938.7	18,628.4
17,789.6	17,894.7	20.0	21,265.9	15,263.1
10,822.9	10,822.9	50.0	12,495.4	9,410.4
5,800.6	5,740.0	80.0	6,742.1	4,876.7
3,967.1	3,880.9	90.0	4,731.2	3,197.6
2,815.6	2,714.4	95.0	3,463.0	2,168.3
1,375.4	1,257.5	99.0	1,824.9	952.0

<< Synthetic Statistics >>
KC_StreamData-Linneus, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.996	Historic Events	0
Standard Dev	0.297	High Outliers	0
Station Skew	-0.789	Low Outliers	2
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.789	Systematic Events	65

```
|-------------------------------|-------------------------------|

--- End of Analytical Frequency Curve ---
```

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Bulletin 17B Frequency Analysis
    14 Apr 2015   01:48 PM
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--- Input Data ---

Analysis Name: KC_Reger
Description:

Data Set Name: KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK
DSS File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Locust_Creek.dss
DSS Pathname: /Locust Creek/Reger, MO/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Reger\KC_Reger.rpt
XML File Name: F:\PROJECTS\A11-1513\40-Design\Calcs\WTRS\Stream
Gauges\Locust_Creek\Bulletin17bResults\KC_Reger\KC_Reger.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---


--- Preliminary Results ---

Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.



<< Frequency Curve >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK
----------------------------------------------------------------------
```

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
21,827.2	24,088.7	0.2	40,115.0	14,489.7
19,845.2	21,650.4	0.5	35,564.9	13,357.5
18,160.1	19,604.5	1.0	31,801.1	12,377.2
16,297.7	17,371.8	2.0	27,761.3	11,272.6
14,240.8	14,993.0	4.0	23,458.3	10,022.8
11,187.8	11,559.6	10.0	17,414.5	8,096.2
8,586.5	8,754.5	20.0	12,641.5	6,365.0
4,624.2	4,624.2	50.0	6,227.3	3,480.5
2,120.8	2,048.2	80.0	2,847.8	1,458.5
1,317.8	1,224.1	90.0	1,850.9	818.6
857.4	757.2	95.0	1,274.3	478.1
348.8	255.6	99.0	597.5	151.5

<< Conditional Statistics >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.616	Historic Events	0
Standard Dev	0.371	High Outliers	0
Station Skew	-0.801	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.801	Systematic Events	26

<< Conditional Probability Adjusted Ordinates >>

<< Frequency Curve >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
21,742.2	---	0.2	---	---
19,749.5	---	0.5	---	---
18,054.1	---	1.0	---	---
16,184.9	---	2.0	---	---
14,116.2	---	4.0	---	---
11,037.6	---	10.0	---	---
8,423.5	---	20.0	---	---
4,431.6	---	50.0	---	---
1,861.7	---	80.0	---	---
991.5	---	90.0	---	---
383.6	---	95.0	---	---
---	---	99.0	---	---

--- End of Preliminary Results ---

<< Low Outlier Test >>

Based on 25 events, 10 percent outlier test deviate K(N) = 2.486
Computed low outlier test value = 493.25

1 low outlier(s) identified below test value of 493.25

Based on statistics after 0 zero events and 1 missing events were deleted.

Statistics and frequency curve adjusted for 1 low outlier(s)

<< Conditional Statistics >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.659	Historic Events	0
Standard Dev	0.310	High Outliers	0
Station Skew	-0.185	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.801	Systematic Events	26

<< High Outlier Test >>

Based on 24 events, 10 percent outlier test deviate K(N) = 2.467
Computed high outlier test value = 26,571.25

0 high outlier(s) identified above test value of 26,571.25

Note: Statistics and frequency curve were modified
using conditional probablity adjustment.

--- Final Results ---

<< Plotting Positions >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Events Analyzed		Ordered Events			
Day Mon Year	FLOW CFS	Rank	Water Year	FLOW CFS	Median Plot Pos
20 Dec 1987	1,900.0	1	1993	19,700.0	2.65
29 May 1989	2,320.0	2	1991	10,800.0	6.44
30 Nov 1989	3,940.0	3	2008	10,200.0	10.23
05 May 1991	10,800.0	4	2004	9,500.0	14.02
19 Apr 1992	4,470.0	5	1996	8,030.0	17.80
07 Jul 1993	19,700.0	6	1995	7,820.0	21.59
09 Oct 1993	2,710.0	7	2009	7,810.0	25.38
26 May 1995	7,820.0	8	2013	7,660.0	29.17
28 May 1996	8,030.0	9	2002	6,390.0	32.95
17 Apr 1997	3,890.0	10	1999	6,390.0	36.74
02 Apr 1998	3,800.0	11	2010	5,770.0	40.53

07 Oct 1998	6,390.0	12	2007	4,720.0	44.32
26 Jun 2000	1,800.0	13	1992	4,470.0	48.11
08 Nov 2000	---	14	1990	3,940.0	51.89
14 May 2002	6,390.0	15	1997	3,890.0	55.68
11 May 2003	391.0	16	1998	3,800.0	59.47
29 Aug 2004	9,500.0	17	2011	2,840.0	63.26
12 Apr 2005	2,420.0	18	1994	2,710.0	67.05
11 Jun 2006	919.0	19	2005	2,420.0	70.83
08 May 2007	4,720.0	20	1989	2,320.0	74.62
26 Jul 2008	10,200.0	21	2012	2,110.0	78.41
16 May 2009	7,810.0	22	1988	1,900.0	82.20
06 Jun 2010	5,770.0	23	2000	1,800.0	85.98
17 Feb 2011	2,840.0	24	2006	919.0	89.77
03 May 2012	2,110.0	25	2003	391.0*	93.56
19 Apr 2013	7,660.0	26	2001	---	97.35

* Outlier

<< Skew Weighting >>

Based on 26 events, mean-square error of station skew = 0.209
Mean-square error of regional skew = -?

<< Frequency Curve >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	0.95
30,018.1	36,973.2	0.2	57,837.9	19,506.8
24,975.0	29,338.8	0.5	45,759.8	16,711.7
21,385.6	24,310.2	1.0	37,583.4	14,656.4
17,986.9	19,835.8	2.0	30,205.8	12,647.6
14,773.8	15,860.4	4.0	23,599.5	10,677.8
10,794.5	11,237.4	10.0	16,003.6	8,109.6
7,960.4	8,132.6	20.0	11,077.6	6,153.1
4,321.4	4,321.4	50.0	5,550.5	3,374.8
2,259.2	2,203.6	80.0	2,919.4	1,628.2
1,585.1	1,508.4	90.0	2,118.0	1,060.9
1,173.4	1,082.6	95.0	1,628.2	730.7
654.4	545.5	99.0	990.5	349.5

<< Synthetic Statistics >>
KC_StreamData-Reger, MO-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.624	Historic Events	0
Standard Dev	0.326	High Outliers	0
Station Skew	-0.214	Low Outliers	1
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	1
Adopted Skew	-0.214	Systematic Events	26

--- End of Analytical Frequency Curve ---

Techniques for Estimating the 2- to 500-Year Flood Discharges on Unregulated Streams in Rural Missouri
USGS - Water Resources Investigations Report 95-4231

Site: East Locust Creek
Existing Conditions
ELC 0
Project No. A11-1515

Equations:

Region I	Region II	Region III
$Q_2 = 69.4A^{0.703}S^{0.373}$	$Q_2 = 77.9A^{0.733}S^{0.265}$	$Q_2 = 88.0A^{0.658}$
$Q_5 = 123A^{0.690}S^{0.383}$	$Q_5 = 99.6A^{0.763}S^{0.355}$	$Q_5 = 145A^{0.627}$
$Q_{10} = 170A^{0.680}S^{0.378}$	$Q_{10} = 117A^{0.774}S^{0.395}$	$Q_{10} = 187A^{0.612}$
$Q_{25} = 243A^{0.668}S^{0.366}$	$Q_{25} = 140A^{0.784}S^{0.432}$	$Q_{25} = 244A^{0.595}$
$Q_{50} = 305A^{0.660}S^{0.356}$	$Q_{50} = 155A^{0.789}S^{0.453}$	$Q_{50} = 288A^{0.585}$
$Q_{100} = 376A^{0.652}S^{0.346}$	$Q_{100} = 170A^{0.794}S^{0.471}$	$Q_{100} = 334A^{0.576}$
$Q_{500} = 569A^{0.636}S^{0.321}$	$Q_{500} = 203A^{0.804}S^{0.503}$	$Q_{500} = 448A^{0.557}$

Input Data:

A =	32.66	mi^2	Area contributing to surface runoff.
S =	9.81	ft/mile	Between 10% and 85%, measured from site to ridge along low-water channel.
Region =	1		Figure 1

Output Data:

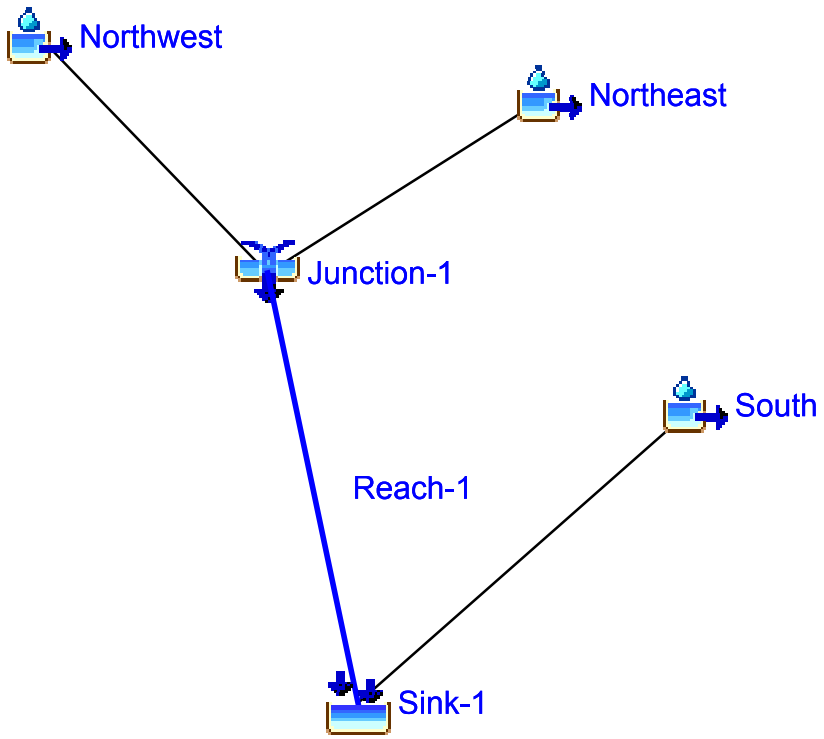
Q_2 =	1,886	cfs
Q_5 =	3,268	cfs
Q_{10} =	4,313	cfs
Q_{25} =	5,753	cfs
Q_{50} =	**6,863**	**cfs**
Q_{100} =	**8,043**	**cfs**
Q_{500} =	10,872	cfs

HEC-HMS

Project : E. Locust Crk

Basin Model : Propsed w/ Lake

May 28 13:38:27 CDT 2015



2-year, 24 hour

Simulation Run:	2-Yr 24 hours
Basin Model:	Proposed w/ Lake
Meteorologic Model:	2-Year
Control Specifications:	24-hr

Hydrologic Element	Drainage Area (mi2)	Peak Discharge	Time of Peak	Volume (ac-ft)
Northeast	11.68	2765	15May2015, 01:40	883
Northwest	7.11	1866	15May2015, 01:25	538
Junction-1	18.79	4592	15May2015, 01:35	1421
Reach-1	18.79	4587	15May2015, 01:55	1413
South	13.84	4079	15May2015, 01:40	1266
Sink-1	32.63	8600	15May2015, 01:45	2679

10-year, 24 hour

Simulation Run:	10-Yr 24 hours
Basin Model:	Proposed w/ Lake
Meteorologic Model:	10-Year
Control Specifications:	24-hr

Hydrologic Element	Drainage Area (mi2)	Peak Discharge	Time of Peak	Volume (ac-ft)
Northeast	11.68	5304	15May2015, 01:40	1654
Northwest	7.11	3585	15May2015, 01:25	1009
Junction-1	18.79	8811	15May2015, 01:30	2663
Reach-1	18.79	8809	15May2015, 01:50	2649
South	13.84	7282	15May2015, 01:35	2244
Sink-1	32.63	15983	15May2015, 01:45	4894

50-year, 24 hour

Simulation Run:	50-Yr 24 hours
Basin Model:	Proposed w/ Lake
Meteorologic Model:	50-Year
Control Specifications:	24-hr

Hydrologic Element	Drainage Area (mi2)	Peak Discharge	Time of Peak	Volume (ac-ft)
Northeast	11.68	8861	15May2015, 01:35	2754
Northwest	7.11	5991	15May2015, 01:25	1681
Junction-1	18.79	14751	15May2015, 01:30	4435
Reach-1	18.79	14733	15May2015, 01:50	4415
South	13.84	11639	15May2015, 01:35	3604
Sink-1	32.63	26192	15May2015, 01:45	8019

100-year, 24 hour

Simulation Run:	100-Yr 24 hours
Basin Model:	Proposed w/ Lake
Meteorologic Model:	100-Year
Control Specifications:	24-hr

Hydrologic Element	Drainage Area (mi2)	Peak Discharge	Time of Peak	Volume (ac-ft)
Northeast	11.68	10665	15May2015, 01:35	3319
Northwest	7.11	7208	15May2015, 01:20	2026
Junction-1	18.79	17751	15May2015, 01:30	5344
Reach-1	18.79	17723	15May2015, 01:50	5321
South	13.84	13810	15May2015, 01:35	4292
Sink-1	32.63	31328	15May2015, 01:40	9613

East Locust - Time of Concentration Estimation - Northeast Drainage Area

Time of Concentration (Tc) = T_{sheet} + $T_{shallow\ conc}$ + $T_{channel}$ + $T_{wave\ velocity}$

Reference: National Engineering Handbook, Part 630 Hydrology, Chapter 15, USDA NRCS, May 2010

P_2 Source for T_{sheet}:
NOAA Atlas 14 - Milan MO Station
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo

T_{sheet}

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}\,S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

n =	0.03
L =	100 ft
P_2 =	3.37 in
Begin elev =	1076.97 ft
End elev =	1076 ft
s =	0.010 ft/ft
T_{sheet} =	**0.059** hr

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:
T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

The Total Time of Concentration is the sum of all travel times:

(b) Velocity method

Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

$T_{shallow}$

Velocity =

v = 6.962*(slope)$^{0.5}$
(for short grass pasture)

(Table 15-3 and Figure 15-4)
(NEH Part 360 Hydrology, Chapter 15)

$T_{shallow}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1076 ft
End elev =	1062.99 ft
s =	0.00840 ft/ft
v =	0.64 ft/s
$L_{shallow}$ =	1549 ft
$T_{shallow}$ =	**0.674** hr

East Locust - Time of Concentration Estimation (Continued)

$T_{channel(1)}$		
$T_{channel}$ =	L (ft)/v (ft) * 1/3600	
Begin elev =	1062.99	ft
End elev =	922.30	ft
XS Flow Area =	155.35	ft^2
Wetted Perimeter =	56.64	ft
Hydraulic Radius =	2.74	ft
Manning's n =	0.040	
s =	0.00432	ft/ft
v =	4.78	ft/s
$L_{channel}$ =	32558	ft
$T_{channel}$ =	**1.892**	hr

$T_{wave\ velocity}$		
$V_w = \sqrt{gD_m}$ (eq. 15–11)		
where		
V_w = wave velocity, ft/s		
g = 32.2 ft/s^2		
D_m = mean depth of lake or reservoir, ft		
$T_{wave\ velocity}$ =	L (ft)/v (ft) * 1/3600	
Volume at elev. 922.3 =	54009	ac-ft
Surface Area at elev. 922.3 =	2331	acres
D_m (Mean Depth) =	23.2	ft
v_w =	27.3	ft/s
$L_{channel}$ =	15442	ft
$T_{channel}$ =	**0.157**	hr

Tc =	**2.78**	**hr**

Velocity for Channel Flow use Mannning's Eq:

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Wave Velocity through Dam Backwater

In other cases, such as with a watershed having a relatively large body of water in the flow path, time of concentration is computed to the upstream end of the water body using standard methods, and velocity for the flow segment through the water body may be computed using the wave velocity equation coupled with equation 15–1 to convert the velocity to a travel time through the water body. The wave equation is:

$$V_w = \sqrt{gD_m} \qquad \text{(eq. 15–11)}$$

where

V_w = wave velocity, ft/s

g = 32.2 ft/s^2

D_m = mean depth of lake or reservoir, ft

Generally, V_w will be high; however, equation 15–11 only provides for estimating travel time through the water body and for the inflow hydrograph to reach the outlet. It does not account for the time required for the

East Locust - Time of Concentration Estimation (Continued)

Figure 15–4 Velocity versus slope for shallow concentrated flow

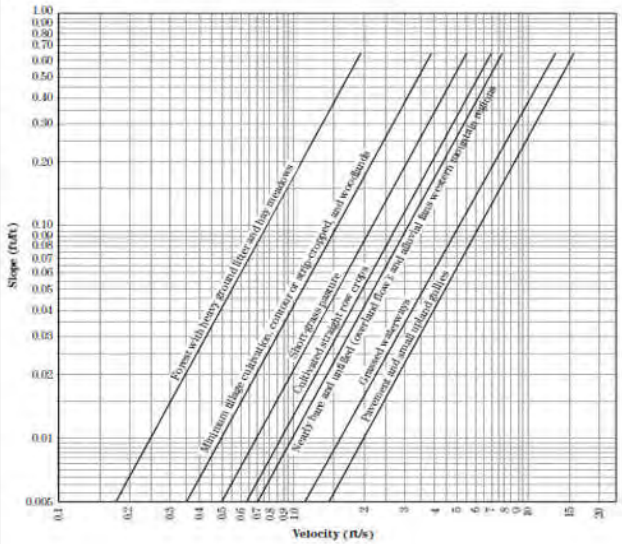


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.510(s)^{0.5}$

East Locust - Time of Concentration Estimation - Northwest Drainage Area

Time of Concentration (Tc) = T_{sheet} + $T_{shallow\ conc}$ + $T_{channel}$ + $T_{wave\ velocity}$

Reference: National Engineering Handbook, Part 630 Hydrology, Chapter 15, USDA NRCS, May 2010

P_2 Source for T_{sheet}:
NOAA Atlas 14 - Milan MO Station
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo

T_{sheet}

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}\,S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manrang's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

n =	0.03
L =	105 ft
P_2 =	3.37 in
Begin elev =	1070 ft
End elev =	1068 ft
s =	0.019 ft/ft
T_{sheet} =	**0.047** hr

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:
T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

The Total Time of Concentration is the sum of all travel times:

(b) Velocity method

Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

$T_{shallow}$

Velocity =

v = 6.962*(slope)$^{0.5}$
(for short grass pasture)

(Table 15-3 and Figure 15-4)
(NEH Part 360 Hydrology, Chapter 15)

$T_{shallow}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1068 ft
End elev =	1048 ft
s =	0.02000 ft/ft
v =	0.98 ft/s
$L_{shallow}$ =	1000 ft
$T_{shallow}$ =	**0.282** hr

East Locust - Time of Concentration Estimation (Continued)

$T_{channel(1)}$		
$T_{channel}$ =	L (ft)/v (ft) * 1/3600	
Begin elev =	1048	ft
End elev =	922.88	ft
XS Flow Area =	199	ft^2
Wetted Perimeter =	116	ft
Hydraulic Radius =	1.72	ft
Manning's n =	0.040	
s =	0.00485	ft/ft
v =	3.71	ft/s
$L_{channel}$ =	25778	ft
$T_{channel}$ =	**1.933**	hr

$T_{wave\ velocity}$		
$V_w = \sqrt{gD_m}$ (eq. 15–11)		
where		
V_w = wave velocity, ft/s		
g = 32.2 ft/s^2		
D_m = mean depth of lake or reservoir, ft		
$T_{wave\ velocity}$ =	L (ft)/v (ft) * 1/3600	
Volume at elev. 922.3 =	54009	ac-ft
Surface Area at elev. 922.3 =	2331	acres
D_m (Mean Depth) =	23.2	ft
v_w =	27.3	ft/s
$L_{channel}$ =	14731	ft
$T_{channel}$ =	**0.150**	hr

Tc =	**2.41**	**hr**

Velocity for Channel Flow use Mannning's Eq:

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Wave Velocity through Dam Backwater

In other cases, such as with a watershed having a relatively large body of water in the flow path, time of concentration is computed to the upstream end of the water body using standard methods, and velocity for the flow segment through the water body may be computed using the wave velocity equation coupled with equation 15–1 to convert the velocity to a travel time through the water body. The wave equation is:

$$V_w = \sqrt{gD_m} \qquad \text{(eq. 15–11)}$$

where

V_w = wave velocity, ft/s

g = 32.2 ft/s^2

D_m = mean depth of lake or reservoir, ft

Generally, V_w will be high; however, equation 15–11 only provides for estimating travel time through the water body and for the inflow hydrograph to reach the outlet. It does not account for the time required for the

East Locust - Time of Concentration Estimation (Continued)

Figure 15–4 Velocity versus slope for shallow concentrated flow

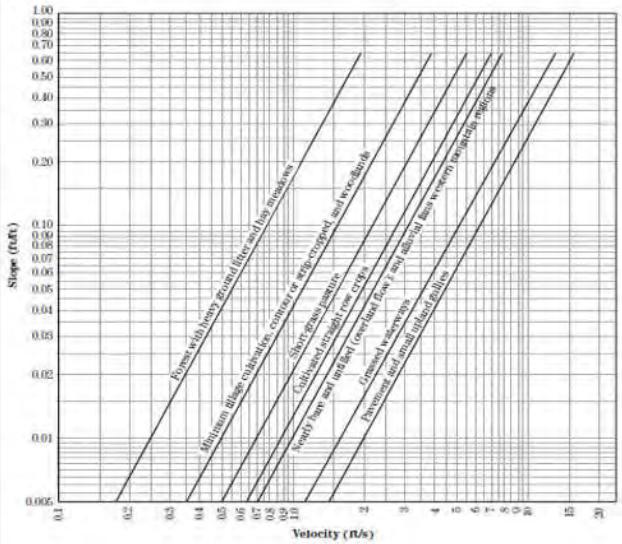


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.510(s)^{0.5}$

East Locust - Time of Concentration Estimation - South Drainage Area

Time of Concentration (Tc) = $T_{sheet} + T_{shallow\ conc} + T_{channel} + T_{wave\ velocity}$

Reference: National Engineering Handbook, Part 630 Hydrology, Chapter 15, USDA NRCS, May 2010

P_2 Source for T_{sheet}:
NOAA Atlas 14 - Milan MO Station
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo

T_{sheet}

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}\, S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

n =	0.03
L =	105 ft
P_2 =	3.37 in
Begin elev =	1058.28 ft
End elev =	1056.8 ft
s =	0.014 ft/ft
T_{sheet} =	**0.053** hr

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:
T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

The Total Time of Concentration is the sum of all travel times:

(b) Velocity method

Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

$T_{shallow}$

Velocity =

v = 6.962*(slope)$^{0.5}$
(for short grass pasture)

(Table 15-3 and Figure 15-4)
(NEH Part 360 Hydrology, Chapter 15)

$T_{shallow}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1056.8 ft
End elev =	1000.36 ft
s =	0.05644 ft/ft
v =	1.65 ft/s
$L_{shallow}$ =	1000 ft
$T_{shallow}$ =	**0.168** hr

East Locust - Time of Concentration Estimation (Continued)

$T_{channel(1)}$	
$T_{channel}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1000.36 ft
End elev =	918.00 ft
XS Flow Area =	225.56 ft^2
Wetted Perimeter =	114.67 ft
Hydraulic Radius =	1.97 ft
Manning's n =	0.040
s =	0.00319 ft/ft
v =	3.29 ft/s
$L_{channel}$ =	25778 ft
$T_{channel}$ =	**2.174** hr

$T_{wave\ velocity}$	
$V_w = \sqrt{gD_m}$ (eq. 15–11)	
where	
V_w = wave velocity, ft/s	
g = 32.2 ft/s^2	
D_m = mean depth of lake or reservoir, ft	
$T_{wave\ velocity}$ =	L (ft)/v (ft) * 1/3600
Volume at elev. 922.3 =	54009 ac-ft
Surface Area at elev. 922.3 =	2331 acres
D_m (Mean Depth) =	23.2 ft
v_w =	27.3 ft/s
$L_{channel}$ =	35087 ft
$T_{channel}$ =	**0.357** hr

Tc =	**2.75 hr**

Velocity for Channel Flow use Mannning's Eq:

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Wave Velocity through Dam Backwater

In other cases, such as with a watershed having a relatively large body of water in the flow path, time of concentration is computed to the upstream end of the water body using standard methods, and velocity for the flow segment through the water body may be computed using the wave velocity equation coupled with equation 15–1 to convert the velocity to a travel time through the water body. The wave equation is:

$$V_w = \sqrt{gD_m} \qquad \text{(eq. 15–11)}$$

where

V_w = wave velocity, ft/s

g = 32.2 ft/s^2

D_m = mean depth of lake or reservoir, ft

Generally, V_w will be high; however, equation 15–11 only provides for estimating travel time through the water body and for the inflow hydrograph to reach the outlet. It does not account for the time required for the

East Locust - Time of Concentration Estimation (Continued)

Figure 15–4 Velocity versus slope for shallow concentrated flow

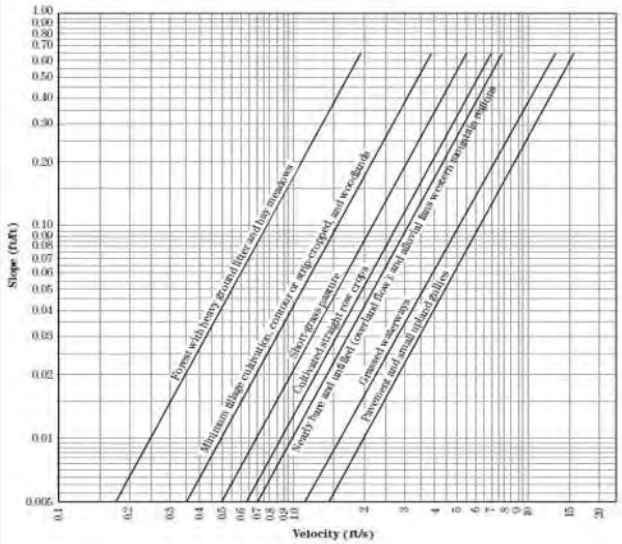


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.510(s)^{0.5}$

East Locust - Time of Concentration Estimation - No Lake

Time of Concentration (Tc) = T_{sheet} + $T_{shallow\ conc}$ + $T_{channel}$ + $T_{wave\ velocity}$

Reference: National Engineering Handbook, Part 630 Hydrology, Chapter 15, USDA NRCS, May 2010

T_{sheet}

$$T_t = \frac{0.007(n\ell)^{0.8}}{(P_2)^{0.5}\,S^{0.4}} \qquad \text{(eq. 15–8)}$$

where:
T_t = travel time, h
n = Manning's roughness coefficient (table 15–1)
ℓ = sheet flow length, ft
P_2 = 2-year, 24-hour rainfall, in
S = slope of land surface, ft/ft

n =	0.17
L =	300 ft
P_2 =	3.3 in
Begin elev =	1076.97 ft
End elev =	1075.52 ft
s =	0.005 ft/ft
T_{sheet} =	**0.755** hr

$T_{shallow}$

Velocity =

v = 6.962*(slope)$^{0.5}$
(for short grass pasture)

(Table 15-3 and Figure 15-4)
(NEH Part 360 Hydrology, Chapter 15)

$T_{shallow}$ =	L (ft)/v (ft) * 1/3600
Begin elev =	1075.52 ft
End elev =	1062.99 ft
s =	0.00931 ft/ft
v =	0.67 ft/s
$L_{shallow}$ =	1346.47 ft
$T_{shallow}$ =	**0.557** hr

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:
T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

The Total Time of Concentration is the sum of all travel times:

(b) Velocity method

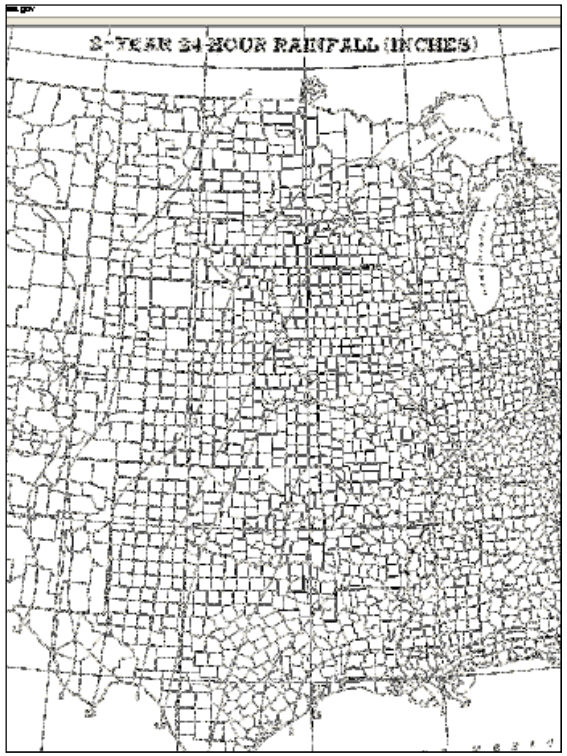
Another method for determining time of concentration normally used within the NRCS is called the velocity method. The velocity method assumes that time of concentration is the sum of travel times for segments along the hydraulically most distant flow path.

$$T_c = T_{t1} + T_{t2} + T_{t3} + \ldots T_{tn} \qquad \text{(eq. 15–7)}$$

where:
T_c = time of concentration, h
T_{tn} = travel time of a segment n, h
n = number of segments comprising the total hydraulic length

The segments used in the velocity method may be of three types: sheet flow, shallow concentrated flow, and open channel flow.

P_2 Source for T_{sheet}:
http://www.nws.noaa.gov/oh/hdsc/PF_documents/TechnicalPaper_No40.pdf



East Locust - Time of Concentration Estimation - No Lake(Continued)

$T_{channel(1)}$		
$T_{channel}$ =	L (ft)/v (ft) * 1/3600	
Begin elev =	1062.99	ft
End elev =	922.30	ft
XS Flow Area =	155.35	ft^2
Wetted Perimeter =	56.64	ft
Hydraulic Radius =	2.74	ft
Manning's n =	0.040	
s =	0.00177	ft/ft
v =	3.06	ft/s
$L_{channel}$ =	79498	ft
$T_{channel}$ =	**7.219**	hr

$T_{wave\ velocity}$		
$V_w = \sqrt{gD_m}$ (eq. 15–11)		
where		
V_w = wave velocity, ft/s		
g = 32.2 ft/s^2		
D_m = mean depth of lake or reservoir, ft		
$T_{wave\ velocity}$ =	L (ft)/v (ft) * 1/3600	
Volume at elev. 922.3 =	54009	ac-ft
Surface Area at elev. 922.3 =	2331	acres
D_m (Mean Depth) =	23.2	ft
v_w =	27.3	ft/s
$L_{channel}$ =		ft
$T_{channel}$ =	**0.000**	hr

Tc =	**8.53**	**hr**

Velocity for Channel Flow use Mannning's Eq:

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{(eq. 15–10)}$$

where:

V = average velocity, ft/s

r = hydraulic radius, ft

$= \frac{a}{P_w}$

a = cross-sectional flow area, ft^2

P_w = wetted perimeter, ft

s = slope of the hydraulic grade line (channel slope), ft/ft

n = Manning's n value for open channel flow

Manning's n values for open channel flow can be obtained from standard hydraulics textbooks, such as Chow (1959), and Linsley, Kohler, and Paulhus (1982). Publications dealing specifically with Manning's n values are Barnes (1967); Arcement and Schneider (1989); Phillips and Ingersoll (1998); and Cowen (1956). For guidance on calculating Manning's n values, see NEH630.14, Stage Discharge Relations.

Wave Velocity through Dam Backwater

In other cases, such as with a watershed having a relatively large body of water in the flow path, time of concentration is computed to the upstream end of the water body using standard methods, and velocity for the flow segment through the water body may be computed using the wave velocity equation coupled with equation 15–1 to convert the velocity to a travel time through the water body. The wave equation is:

$$V_w = \sqrt{gD_m} \qquad \text{(eq. 15–11)}$$

where

V_w = wave velocity, ft/s

g = 32.2 ft/s^2

D_m = mean depth of lake or reservoir, ft

Generally, V_w will be high; however, equation 15–11 only provides for estimating travel time through the water body and for the inflow hydrograph to reach the outlet. It does not account for the time required for the

East Locust - Time of Concentration Estimation (Continued)

Figure 15–4 Velocity versus slope for shallow concentrated flow

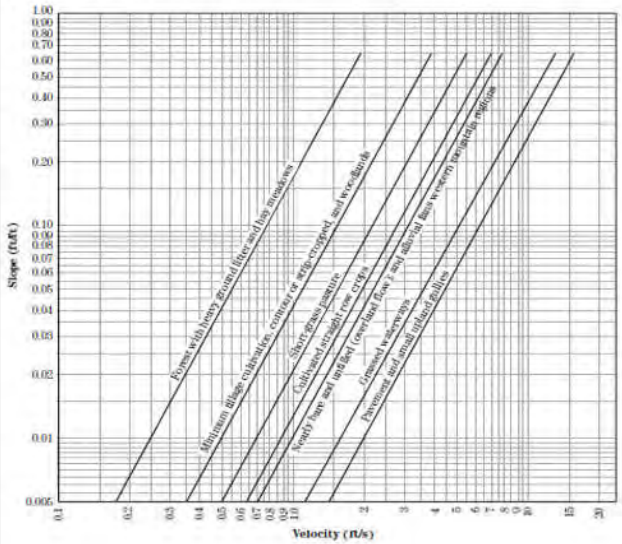


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	Depth (ft)	Manning's *n*	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.510(s)^{0.5}$

Appendix E

BUILD Grant Road Improvements and Relocations

1. INTRODUCTION

The East Locust Creek Reservoir (ELCR, Project) would include roadway improvements and new roads to facilitate construction access, allow for east to west transportation, and provide access to recreational benefits provided by the reservoir. This appendix is intended to focus on the roadway projects, provide additional roadway details, and support the SEIS document. Please refer to the SEIS for non-roadway impacts and for impacts related to dam construction and inundation of the normal pool.

Because the roadway projects are components of the larger proposed Project, and would not be constructed “but for” the proposed Project, the purpose and need for the roadway projects are the same as the proposed Project: water supply, water-based recreation, and flood damage reduction. The proposed Project purpose and need are described in the Supplemental Environmental Impact Statement (SEIS) East Locust Creek Watershed Revised Plan section 1.5.

The roadway projects would be partially funded by a Better Utilizing Investments to Leverage Development (BUILD) grant which was awarded in November 2019. The BUILD grant, with funds totaling $13,459,009, would be overseen by the Federal Highway Administration (FHWA, cooperating agency) and administered by the Missouri Department of Transportation (MoDOT). Additional funding sources for the roadway projects include the North Central Missouri Regional Water Commission (NCMRWC, Project sponsor), NRCS (lead federal agency), USDA RD (cooperating agency), and state of Missouri funds. Information provided in this appendix is inclusive of all roadway projects, regardless of funding source. Figure 1 shows the proposed roadway projects and references the plan sets that describe the improvements. Descriptions of each of the six plan sets are provided in Section 2, below. The six plan sets are included in Attachment A.

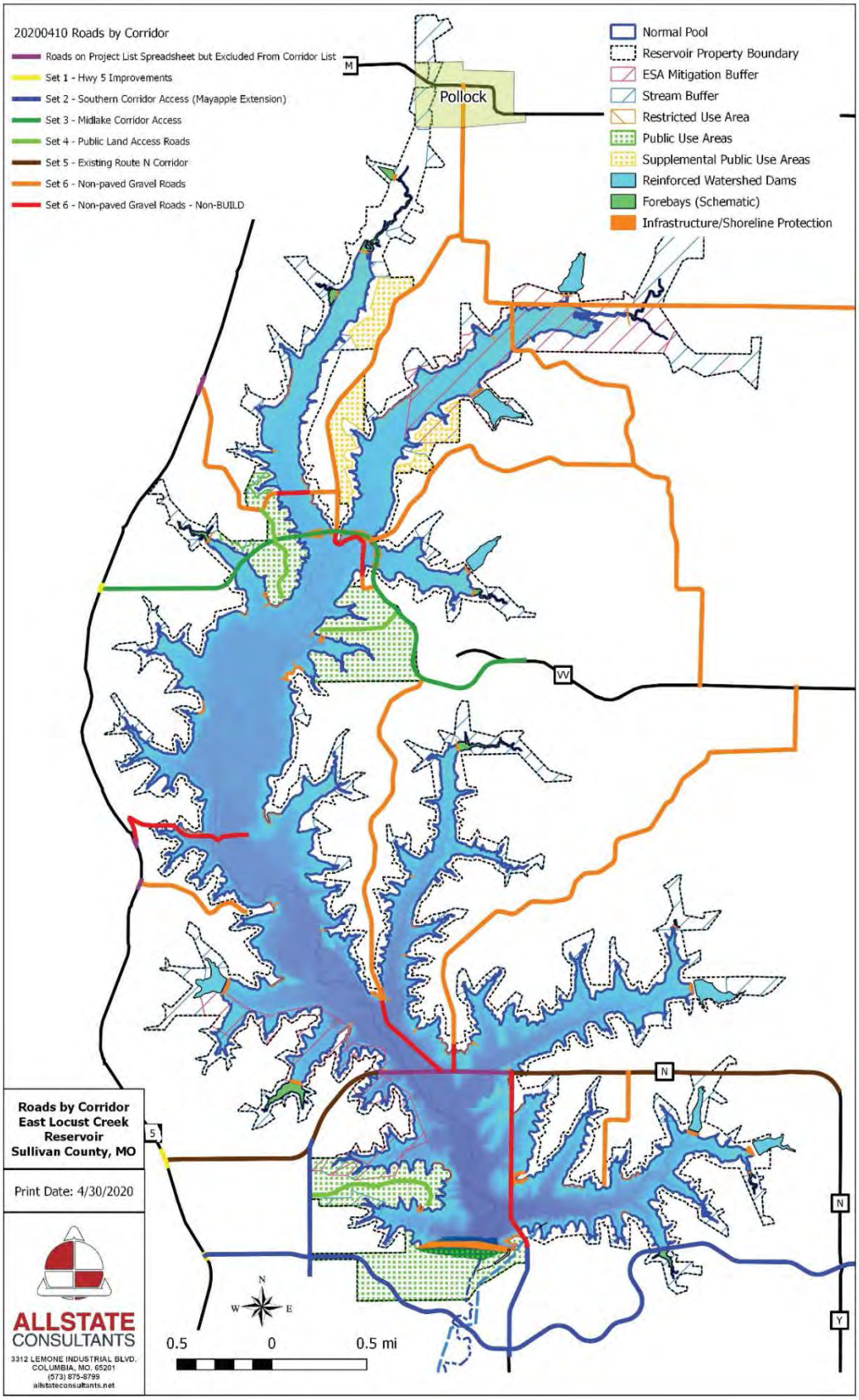


Figure 1. East Locust Creek Roads by Corridor.

2. ROADWAY IMPROVEMENT DESCRIPTIONS

Roadway Plan Set 1 - Highway 5 Intersection Improvements (Total Length 1.3 miles)

Roadway plan set 1 includes improvements to four intersections along State Highway 5. The proposed improvements total 1.3 miles in length. Intersection improvements at these four locations, detailed below, include the construction of new intersections, addition of new left turn lanes, and other minor intersection improvements. Roadway improvements included in plan set 1 include the following:

- Intersection of Highway 5 and Mid Lake Road
- Intersection of Highway 5 and Route N
- Intersection of Highway 5 and Mayapple Road
- Intersection of Highway 5 and Highway 6

Roadway Plan Set 2 - Southern Corridor Access (Total Length 5.4 miles)

Roadway plan set 2 includes 5.4 miles of improvements that will provide southern corridor access around the reservoir. There are three roadway projects associated with plat set 2, each of which is described in the bulleted list below. There is one crossing of East Locust Creek associated with plan set 2. Proposed roadway improvements include:

- Mayapple Road Improvements (3 segments)
    - *Mayapple Road to England Drive*: Widening and improvements to existing gravel road
    - *Mayapple Road from England Drive to Finch Drive*: Widening and improvements to existing gravel road
    - *Mayapple Road from Finch Drive to Highway Y:* Construction of new roadway
- England Drive Improvements
    - Reconstruction of existing gravel road and replacement with pavement
- Finch Drive Improvements
    - Construction of a dead end that serves the ELCR/NCRWC raw water intake and spillway structures (currently a gravel road)

Plan Set 3 - Mid-Lake Corridor Access (Total Length 2.9 miles)

Roadway plan set 3 includes 2.9 miles of improvements which are designed to provide east-west access across the middle of the proposed reservoir, creating a connection between Highway 5 and Route VV. There is one roadway project associated with plan set 3, which will cross the two main tributaries to ELCR and two smaller tributaries. The roadway will tie into two planned public use areas. Plan set 3 contains the following roadway project:

- Mid-Lake Road
    - Construction of a new roadway (with exception of a small amount of existing gravel road tie-ins) to connect Highway 5 to Route VV.

Plan Set 4 - Public Access Roads (Total Length 1.9 miles)

Roadway plan set 4 includes 1.9 miles of improvements that will provide access to four public use areas owned by the NCRWC. Plan set 4 includes the following four roadway projects:

- Marina Road
  - Construction of a new roadway to provide access to proposed marina
- Knob Hill Connector
  - Construction of a new roadway and improvements to a small section of gravel road to connect Knob Hill Road to the proposed mid-lake road
- East Public Access Road
  - Construction of a new roadway to provide access to the northeastern portion of the reservoir
- West Public Access Road
  - Construction of a new road to provide access to the north portion of the reservoir from the Knob Hill Road connector southward

Plan Set 5 - Route N Improvements (Total Length 4.1 miles)

Roadway plan set 5 includes 4.1 miles of maintenance along existing route N, as well as two terminations where Route N will be inundated by ELCR. The two projects associated with plan set 5 include:

- Intersection of Route N & England Drive
  - Construction of a new intersection
- Route N (East, West, Mid)
  - Construction of cul-de-sacs/trailhead areas at termini on the east and west sides of ELCR where existing roadway will be inundated.

Plan Set 6 - Non-Paved Gravel Roads (Total Length 11.9 miles)

Roadway plan set 6 includes maintenance to 11.9 miles of existing gravel roads. The 11 existing gravel roads associated with plan set 6 are low-volume, basic access roads used for agriculture. Proposed improvements include minor grading work and new gravel. The following roadways are included in plan set 6:

- Eagle Drive
- Finch Drive
- Forum Drive
- Friend Drive
- Front Drive
- Knob Hill Road
- Kentucky Road
- Log Road
- Lyric Road
- May Ridge Road
- Mulberry Road

3. ENVIRONMENTAL RESOURCE EVALUATIONS

3.1. CULTURAL RESOURCES: SECTION 106

The East Locust Creek Reservoir cultural resource survey for the proposed road improvements recorded 35 properties with at least one building over 40 years old (constructed prior to 1981). These buildings are within 200 feet of the proposed road center line and may be affected by indirect impacts. MoDOT and SHPO are determining if any of these buildings are eligible for the NRHP. Also, within the viewshed, there are four cemeteries: Mt. Zion, Hamilton-Gridstaff, Campbell, and Pollack. A previously unknown family plot, the Bingham family plot, was identified just south of Route N. The Bingham family plot is within the proposed construction corridor but will not be impacted by the proposed road improvements. In addition to the Bingham family plot, the survey resulted in the identification of six other previously unknown archaeological sites: two Precontact camp sites, three farmsteads, and the Fairview School.

3.2. PUBLIC LANDS: SECTION 4(F) AND 6(F)

Google Earth imagery, the U.S. Geological Survey (USGS) Protected Areas Database, and the Missouri State Parks list of Land and Water Conservation Fund (LWCF) Grants were used to identify Section 4(f) and Section 6(f) resources in and around proposed roadway projects. According to these resources, there is one public lands resource is located in the vicinity of the roadway projects. Sears Conservation Area, a Section 4(f) resource, is located along the southern boundary of the of the proposed construction of Mayapple Road and is managed by the Missouri Department of Conservation (MDC). However, the roadway improvements will not require new right of way or easements from and will not restrict access to this resource. The proposed construction of Mayapple Road will be built on property owned by the NCMRWC and no impacts to this Section 4(f) resource will occur as a result of the roadway improvements. In addition to Sears Conservation Area, there are five additional public lands resources located more than four miles from the project area. These resources include: Union Ridge Conservation Area (Forest Grove Park (City of Milan; 4.5-miles southwest), Dark Hollow Natural Area (MDC; 7.4-miles east), Morris Prairie Conservation Area (MDC; 7.5-miles northeast), Mineral Hills Conservation Area (MDC; 7.6-miles northeast), and Union Ridge Conservation Area (MDC; 10.1-miles east). None of these resources will be impacted by the project.

Based on this information, the roadway projects will not result in a use to any Section 4(f) properties and no conversion of any Section 6(f) lands.

3.3. WETLANDS AND STREAMS: SECTION 404 AND 401

A wetland delineation and stream assessment were completed along all roadways shown in in Figure 1 between June and September 2020. The wetland delineation was conducted per methodology outlined by the *Corps of Engineers Wetland Delineation Manual (1987)* and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region, Version 2.0 (2010).* Wetland delineations were performed for all sites that were composed of hydric vegetation, hydric soils, and wetland hydrology.

Stream assessments were conducted to collect data to aid the USACE in making a preliminary jurisdictional determination of the stream reach. The assessments were conducted and were consistent with the Missouri Stream Mitigation Method (MSMM) for compensatory mitigation as necessary. Guidance for the stream assessments is contained in the *U.S. Army Corps of Engineers Jurisdictional Determination Form Instructional Guidebook* (2007) and the *State of Missouri Stream Mitigation Method*, last revised April 2013.

The area delineated for wetlands and streams in the field is larger than the roadway impacts to allow for adjustments in road alignment should they occur. The wetlands and stream identified below may be impacted by the road improvements.

The wetland delineation identified seven palustrine emergent (PEM) wetlands, one palustrine scrub-shrub (PSS) wetland, and two palustrine open water features in the footprint of proposed roadway projects (Figure 2). Based on the new Navigable Waters Protection Rule (NWPR) published in the Federal Register on June 22, 2020, four PEM wetlands (totaling 0.30 acre), one PSS wetland (0.05 acre), and one PUB feature (totaling 0.21 acre) are considered jurisdictional features because they abut or are adjacent to an intermittent or perennial stream which ultimately flows to the Missouri River. The Missouri River is designated as a Traditional Navigable Water (TNW). All other wetlands and open water features delineated within the Project area are likely non-jurisdictional, as they are either isolated features or are adjacent to ephemeral streams. Table 1, below, summarizes the wetland features documented in the roadway footprints.

The stream assessment identified one perennial stream, one intermittent stream, and three ephemeral streams in the footprint of the proposed roadway projects. Of the delineated stream features, the perennial stream (209 linear feet) and intermittent stream (104 linear feet) are considered jurisdictional features under the NWPR because they flow to tributaries of the Missouri River. The three delineated ephemeral streams are non-jurisdictional under the NWPR. Table 2, below, summarizes the streams documented in the surveyed area.

Table 1. Wetland Delineation Summary.

Wetland ID	Data Point	Classification[1]	Jurisdictional[2]	Size (acres)
Wetland 22	w22	PSS	Y	0.05
Wetland 24	w24	PEM	Y	0.17
Wetland 25	w25	PEM	Y	0.10
Wetland 26	w26	PAB	N	0.04
Wetland 27	w27	PEM	Y	<0.01
Wetland 28	w28	PEM	N	0.01
Wetland 30	w30	PEM	N	0.02
Wetland 32	w32	PUB	Y	0.21
Wetland 33	w33	PEM	Y	0.03
Wetland 34	w34	PEM	N	0.18
			TOTAL	**0.81**
			JURISDICTIONAL ACRES	**0.56**

[1]PEM = Palustrine emergent wetland; PSS = Palustrine scrub-shrub wetland; PAB = palustrine aquatic bottom; PUB: Palustrine unconsolidated bottom
[2]Based on the new Navigable Water Protection Rule (NWPR)

Table 2. Stream Assessment Summary.

Feature ID	Data Point	Stream Type	Stream Length (linear feet)	Jurisdictional[1]
Tributary 6	t6	Perennial	209	Y
Tributary 8	t8	Intermittent	104	Y
Tributary 9	t9	Ephemeral	133	N
Tributary 11	t11	Ephemeral	260	N
Tributary 12	t12	Ephemeral	107	N
		TOTAL	**813**	
		JURISDICTIONAL LENGTH	**303**	

[1] Based on the new Navigable Water Protection Rule (NWPR)

The streams and wetlands identified in the field study have been submitted to the USACE for preliminary jurisdictional determinations and subsequent Clean Water Act Section 404 Permit for impacts to jurisdictional features. The design plans will be reviewed to determine potential impacts to jurisdictional streams and wetlands found in the field survey. Avoidance and minimization measures and mitigation will be detailed in the Section 404 permit application.

3.4. THREATENED AND ENDANGERED SPECIES

Threatened and endangered species impacts for the roads receiving funding under the BUILD grant are covered under the biological assessment submitted to the USFWS in May 2020 and currently in formal consultation. A biological opinion is anticipated in October 2020.

The biological assessment lists four potential species to occur within the project limits (including the road improvements receiving BUILD funds): Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), gray bat (*Myotis grisescens*), and Mead's milkweed (*Asclepias meadii*). These species, their habitat, and ranges are described in the biological assessment and are summarized below.

<u>Mead's Milkweed</u>

Mead's milkweed habitat includes mesic to moderately dry upland tallgrass prairies throughout the eastern tallgrass prairie, from Kansas through Missouri and Illinois and north to southern Iowa and northwestern Indiana. Mead's milkweed is found in virgin, tallgrass prairies that are managed for light grazing and hay production (USFWS 2003). USFWS (1988) cited personal communication with Ronald McGregor (University of Kansas) that he has only found Mead's milkweed in tallgrass prairies. Similarly, an unpublished report by S.W. Morgan at MDC in 1980 stated that Mead's milkweed in Missouri is found in unplowed bluestem prairie (USFWS 1988).

Sullivan County does not have a known current or historic Mead's milkweed population, but three extant populations are in the Missouri glaciated plains physiographic region, in which Sullivan County is located (USFWS 2012). Habitat assessments for the roadway improvements did not identify any native, undisturbed, tallgrass prairie. Because Mead's milkweed has not been identified in Sullivan County and the habitat assessment did not identify any native, undisturbed, tall grass prairie, there will be No Effect on Mead's milkweed as a result of the roadway improvements.

<u>Gray Bat</u>

Gray Bat inhabits caves year-round and occupies cold hibernating caves in the winter and warm caves during the summer (USFWS 2009). Wintering caves tend to be deep and vertical. During the summer months, pregnant females form maternity colonies in caves that have domed ceilings. Gray bat does not use houses or barns for habitat (USFWS 2018; MDC 2000). Maternity colonies are formed on the cave ceilings and range from a few hundred individuals to a few thousand individuals. Summer foraging habitat includes open water of rivers, streams, and lakes or reservoirs. Gray bats may travel up to 35 kilometers between maternity colonies and foraging areas; however, most foraging areas are located 1 to 4 kilometers from a maternity colony's cave (USFWS 2009).

Because Sullivan County has potential gray foraging habitat, Olsson conducted mist netting and acoustic monitoring from June 2 – July 10, 2016, to determine the presence or probable

absence of gray bats. The sampling methodology followed the Indiana Bat Draft Recovery Plan and the Range-wide Indiana Bat Summer Survey Guidelines (USFWS 2015). The 2016 sampling did not identify gray bats, based on 81 net nights and 35 detector nights (Olsson 2017). Because no gray bats were detected during the mist netting or acoustic monitoring, there will be no effect on gray bat as a result of the roadway improvements.

Indiana Bat

The Indiana bat (MYSO) is a migratory species that migrates from summer foraging and maternity roost habitat to winter hibernating habitat. Summer roost trees for MYSO are typically large, often dead, with exfoliating bark. The tree species primarily associated with MYSOs are ash (*Fraxinus*), elm (*Ulmus*), hickory (*Carya*), maple (*Acer*), poplar (*Populus*), or oak (*Quercus*). Roost trees typically receive sunlight for part of the day and are often in open forest canopies (USFWS 2007). In Missouri, the average roost tree diameter is 22 inches. The average height of roost trees ranges from 52 to 85 feet, and the minimum height exceeded 12 feet for a primary roost (USFWS 2007).

The female MYSO uses a maternity roost tree to give birth to a single pup in June or early July. Maternity roosts can be primary or alternate, based on the number of individuals using the roost. In Missouri, primary roost trees are typically dead trees in open, interior woodlands. Shagbark hickory trees are more likely to provide alternative maternity roosts (USFWS 2007). A maternity colony may roost in 10 to 20 trees per year, but only one to three trees may be primary roost trees (USFWS 2007). MYSOs switch roost trees an average of every two to three days, which may vary based on reproductive condition and roost type (USFWS 2007). MYSOs return to maternity roosts annually. All roost trees eventually decay and become unusable by MYSOs. Having alternative maternity roosting options may provide replacements for primary maternity roost trees (USFWS 2007).

Because Sullivan County has potential MYSO habitat, mist netting and acoustic monitoring was conducted from June 2 – July 10, 2016, to determine the presence or probable absence of MYSOs. The sampling methodology followed the Indiana Bat Draft Recovery Plan and the Range-wide Indiana Bat Summer Survey Guidelines (USFWS 2007; 2015). Results of the sampling included the capture of 10 MYSO within the Project boundary based on 81 net nights, and there was positive detection in eight of the nine regions based on 35 detector nights (Olsson 2017).

Four maternity roost trees were identified that were clustered in two groups of two maternity roost trees. A maternity roost tree was identified as having more than five bats identified during the emergence count (Olsson 2017). Callahan (1993) defined primary roost trees in Missouri as having 30 or more bats on multiple nights. However, Kurta et al. (1996) determined this number might not be applicable to small to moderate sized maternity colonies.

Maternity roost trees A and C (see Figure 2) were 0.6 mile apart from one another, and maternity roost trees E and F were 0.1 mile apart. The two groups of maternity roost trees were 4.9 miles apart at the farthest distance and 4.5 miles apart at the closest distance. Maternity roost sites C and F may be alternative maternity roost sites because of the low bat numbers (seven) recorded during the emergence counts. Additionally, they are near a maternity roost tree with emergence counts over 30 bats.

The home ranges for the Laela and Sushi colonies were determined based on a 2.5-mile buffer around the primary maternity roost trees (Figure 3). The forested areas within the 2.5-mile buffers totals 6,611 acres with 3,778 forested acres within Laela's home range and 2,925 forested acres within Sushi's home range. There are 92 forested acres of overlap between the two home ranges.

Nine alternative maternity roost trees were identified three of which were located in the normal pool. The nine alternative maternity roost trees had emergence counts of fewer than five bats.

The utilities and road relocations would cause the loss of 34 acres of forest including 27 acres within the home range of the two maternity roosts identified in the field study. Because Indiana bats were identified within the normal pool and the road improvements will cause forest loss within the home range of the Indiana bat maternity roost trees, the road improvements May Affect, and are likely to Adversely Affect Indiana bats. The road improvements are included in the biological assessment submitted to USFWS in June 2020 and NRCS has requested formal consultation with USFWS. A draft biological opinion has been received by NRCS and concludes that the proposed Project will not jeopardize the continued existence of the Indiana bat.

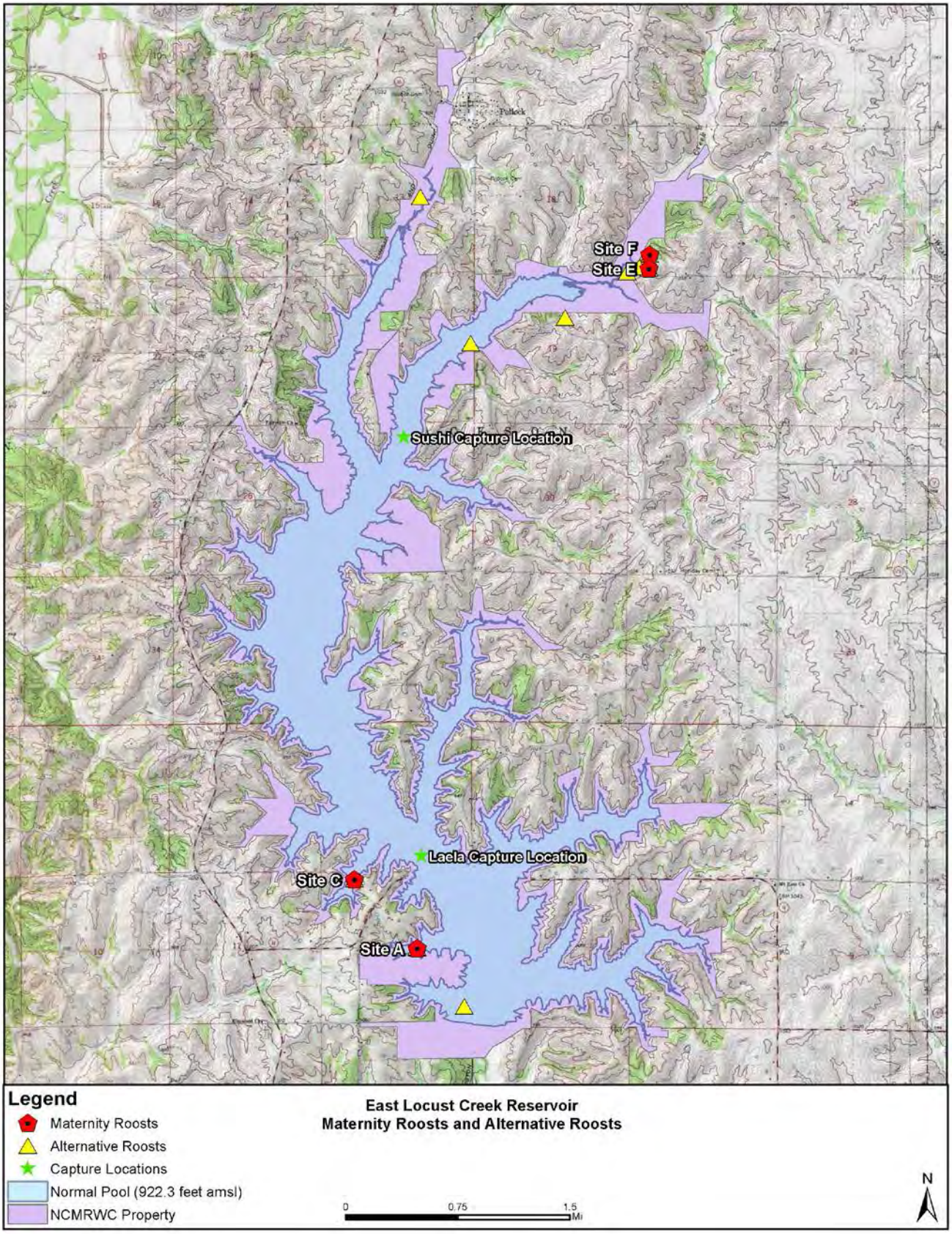


Figure 2. Maternity Roost Trees Identified for the East Locust Creek Project.

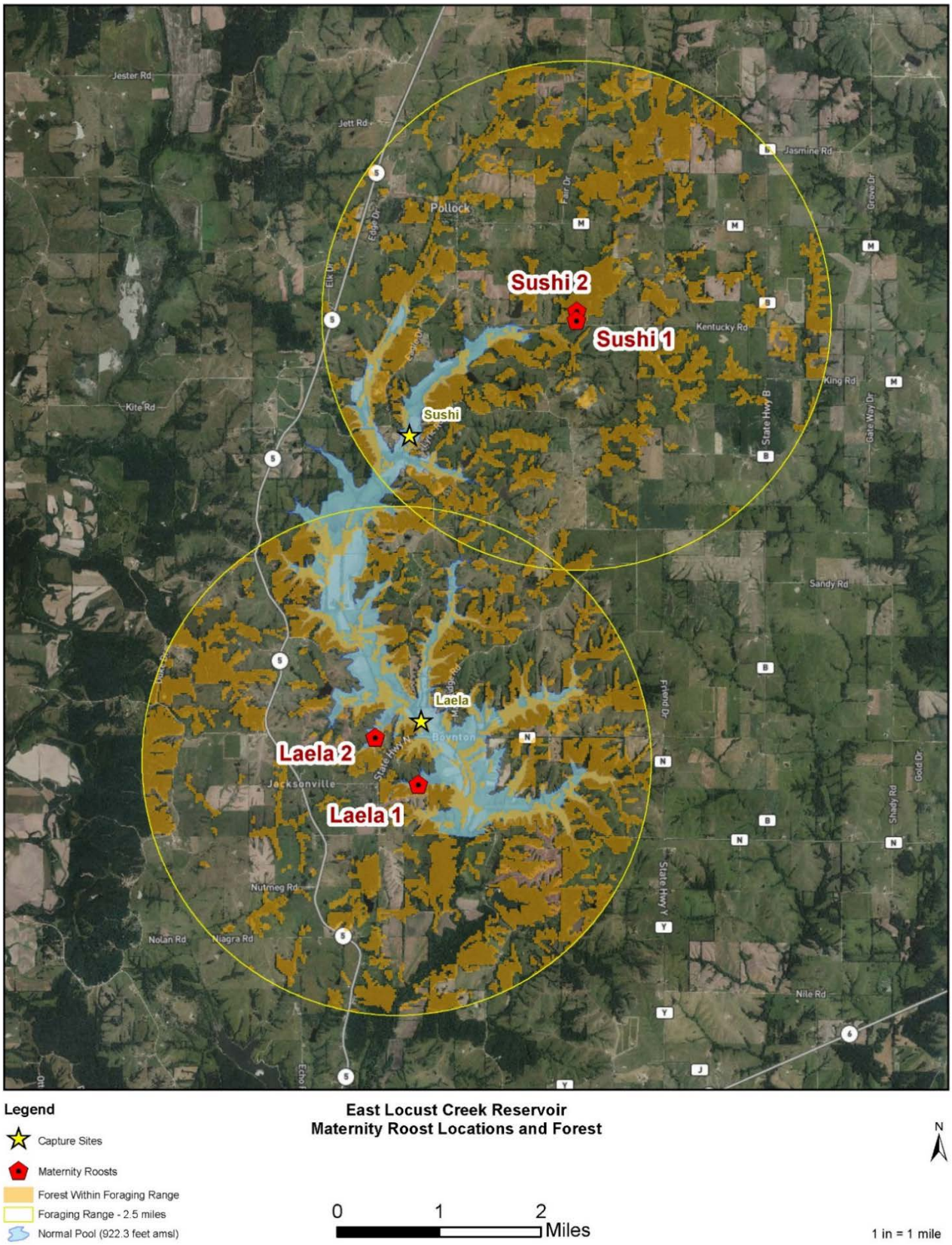


Figure 3. Laela and Sushi Colony's Home Range.

Northern Long-Eared Bat

Northern long-eared bat (MYSE) was listed as a threatened species under the Endangered Species Act on April 2, 2015, and a final 4(d) rule was published on January 14, 2016. The primary threat to the northern long-eared bat is white-nose syndrome, which is a fungal disease that causes bats to leave their hibernacula during winter. The final 4(d) rule accounted white-nose syndrome as the primary cause of northern long-eared bat decline, and not necessarily habitat loss. The 4(d) rule allows for tree clearing if it is does not take place within 0.25 mile of a known hibernaculum or within 150 feet of a known maternity roost tree during the pup season (June 1 through July 31; USFWS 2016).

As with Indiana bats, Sullivan County has potential northern long-eared bat habitat; therefore, mist netting and acoustic monitoring were conducted from June 2 – July 10, 2016, to determine the presence or probable absence of northern long-eared bats. The sampling methodology followed the Indiana Bat Draft Recovery Plan and the Range-wide Indiana Bat Summer Survey Guidelines (USFWS 2015). Results of the sampling included the capture of six northern long-eared bats within the Project boundary based on 81 net nights and had positive acoustic detection in seven of the nine regions based on 35 detector nights.

Assuming a 3-mile home range from the lactating female capture sites, a northern long-eared bat maternity roost may be located in the Project area. There are known northern long-eared bat maternity roost trees in Adair, Putnam, and Schuyler counties. The roadway improvements include the loss of 34 acres including 25 acres within the 3-mile home range. This Project May Affect the northern long-eared bat; however, there are no effects beyond those previously disclosed in the Service's programmatic biological opinion for the final 4(d) rule dated January 5, 2016. Any taking that may occur incidental to this project is not prohibited under the final 4(d) rule (50 CFR §17.40[o]).

3.5. FARMLAND

The Project is located outside of a designated urbanized area as indicated on the 2010 U.S. Census Bureau Urban Area Reference Map and requires new right of way and easements. Therefore, the project is subject to the Farmland Protection Policy Act. A Farmland Conversion Impact Rating Form AD-1006 will be submitted to the NRCS for a determination of impacts to prime, unique, or farmland of statewide importance once the exact disturbance footprints are determined.

3.6. FLOODPLAIN

According to the attached FEMA floodplain maps portions of the proposed roadway projects are in the 100-year floodplain. In these areas, the floodplain is under the jurisdiction of Sullivan

County. According to FEMA's Community Status Book of NFIP memberships, Sullivan County is not a current member of the NFIP. Because Sullivan County is not a current member of the NFIP, the county has not adopted floodplain permitting ordinances.

3.7. FEMA/SEMA BUYOUT PROPERTIES

The Project proponent is not aware of any FEMA/SEMA buyout properties in the vicinity of the proposed roadway projects. The roadway projects will not result in development on any FEMA/SEMA buyout properties.

3.8. SOCIOECONOMIC

The road improvements do not include commercial or residential displacements but will require new right of way and temporary easements that are subject to the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended.

Mayapple Road, England Road, and Eagle Road may require short-term roadway closures. However, these are gravel roads with low average daily traffic (ADT) that have multiple access points in and out of the area. Possible access points for these roads include: Route VV, Route N, Lyric Road, and Hwy 5. The short-term detours for these routes would utilize the local gravel roads in the area of project construction. Right of way negotiations are still ongoing at this time, but any changes or supplements that would occur will be located at the roadway intersections on Hwy 5 (Mayapple Road, Mid Lake Road, and State Route N).

Long-term detours will use MoDOT Routes 6, RA, VV, and N. These routes will be signed and used to detour to Eagle Road, May Ridge Road, Finch Road, Kentucky Road, Lyric Road, Mayapple Road, and England Road. Once the construction of Mayapple Road has been completed, occasional detours will be needed but generally the roads will remain open to local traffic. At this time, the final traffic control plan has not been developed. The duration of each road closure and lengths of each detour will be based on construction progress, weather, final plans, and bid documents.

A joint public meeting will be held by NRCS and USACE for review of the Clean Water Act Section 404 permit and supplemental environmental impact statement. Socioeconomic impacts are anticipated to be temporary and limited to traffic disruptions, construction noise, and fugitive dust and emissions in the area of project construction.

3.9. HAZARDOUS WASTE

According to the DNR E-START map (Figure 4), there are hazardous substance investigation and cleanup sites located along the proposed roadway improvements. All 24 sites are listed as “Complete” and no further cleanup action is required. Based on this information, there are no hazardous waste concerns related to the proposed roadway projects, as all potentially hazardous sites have been previously evaluated and addressed in accordance with state and federal regulations.

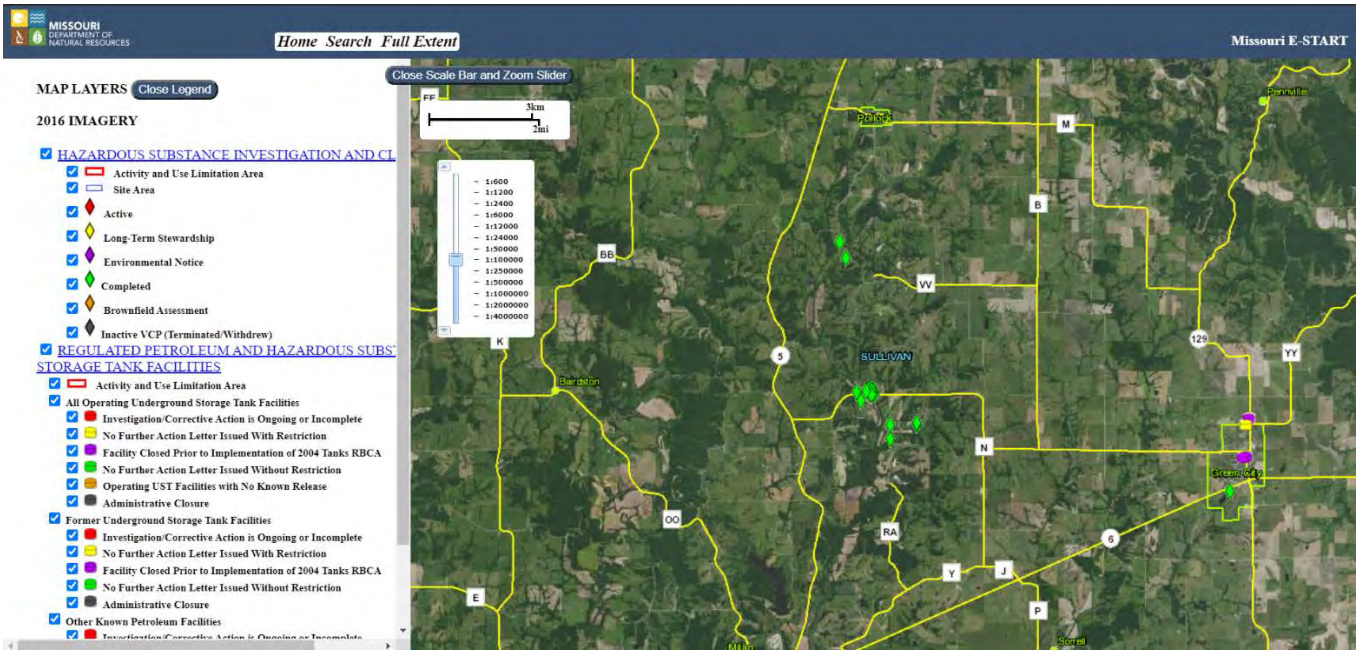


Figure 4. MDNR ESTART Map

3.10. NOISE

Based on the Federal Highway Administration (FHWA) Noise Standard in 23 Code of Federal Regulations (CFR) Part 772, the roadway improvements would classify as a Type I project because of the construction of a highway at a new location. This occurs where Route N is relocated south of the proposed dam location. Because the proposed roadway improvements are classified as a Type I activity, a noise study will be required.

3.11. REFERENCES

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Appendix F

Emergency Wetland Reserve Program Replacement

Appendix G

Shoreline Protection Plan

Appendix H

Source Water Protection Plan

SOURCE WATER PROTECTION PLAN

HEADWATERS OF EAST LOCUST CREEK WATERSHED

Prepared for the North Central Missouri
Regional Water Commission

Greg Pitchford
Allstate Consultants
gpitchford@allstateconsultants.net

Table of Contents

I. INTRODUCTIONS / SUMMARY OVERVIEW 1

II. SOURCE WATER PROTECTION PLAN ELEMENTS 11

III. PROTECTION AREA MANAGEMENT PLAN 23

IV. SUMMARY & CONCLUSION 29

APPENDICES 32

APPENDIX A. Lake Authority Background & Legislation

APPENDIX B. Water System Details

APPENDIX C. MDNR Source Water Assessment Report, March 2016

APPENDIX D. Bathymetric & Volume Information for Elmwood Lake and Old East Reservoir in Sullivan County

APPENDIX E. Sullivan County Soil & Water Conservation District Letter of Support

APPENDIX F. The Commission's Emergency Operations Plan

APPENDIX G. Quality Assurance Project Plan

APPENDIX H. Definitions & Acronyms

I. INTRODUCTION / SUMMARY OVERVIEW

A. INTRODUCTION / PURPOSE STATEMENT

EXECUTIVE SUMMARY

The 49-square mile Headwaters of East Locust Creek HUC12 Watershed (HELC) lies at the upper end of East Locust Creek in Sullivan and Putnam Counties of Missouri. Within the HELC are the current and future sources of raw water for the North Central Missouri Regional Water Commission (the Commission).

The Commission was established in 2001 as part of Missouri Department of Natural Resources' (MDNR) effort to encourage consolidation of water supply resources across north central Missouri, and to phase out small, under-resourced, and inadequate water supply systems. They were given the additional charge of constructing a new water supply, the East Locust Creek Reservoir (ELCR). The Commission currently serves Sullivan and Linn Counties, which have limited groundwater resources, and is forced to rely on surface water supplies that are presently inadequate during drought conditions. In addition to providing wholesale water to three buyers, the Commission was also charged with developing a plan to provide a consistent and reliable water resource for the 10 county region. A plan was developed to construct a large surface water reservoir in Sullivan County that would consistently supply the county and surrounding region with high-quality water. The future ELCR, will be located approximately five miles north of the town of Milan, the county seat of Sullivan County (Figure 1). This Source Water Protection Plan (SWPP) is unique because both the existing Elmwood Lake and future ELCR raw water sources are in the HELC. We believe this is Missouri's first SWPP that will address water quality protection prior to construction of a reservoir.

This SWPP is also the first step toward future source water protection planning efforts. It follows the Guidelines for Developing a Source Water Protection Plan (MDNR 2014) and Minimum Design Standards for Missouri Community Water Systems (MDNR 2013). It will not only provide guidance for protecting water quality but should also help reduce treatment costs. The steering committee consisted of seven community members, most of whom live within the boundaries of the source water protection area and have an interest in local water supply, as well as resource professionals.

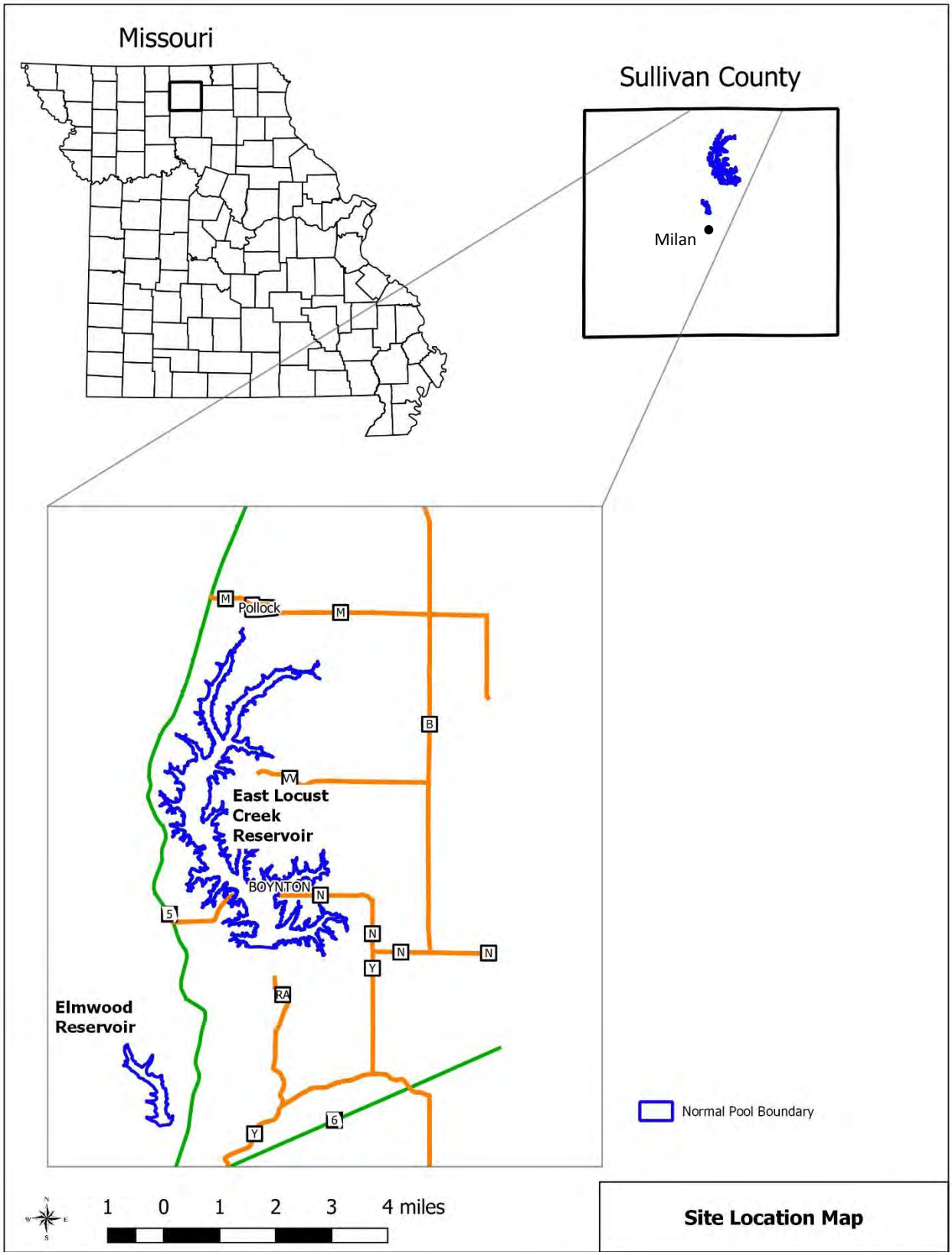

Figure 1. Project area (Published by Allstate Consultants LLC, 2018)

SOURCE WATER PROTECTION STEERING COMMITTEE

The Steering Committee was made up of citizens, most of whom live within the source water protection area, and are known to have an interest in the local water supply.

Cully Cowgill
Locust Creek Watershed Board Treasurer
Milan, MO

Phyllis Blondefield
Resident
Pollock, MO

Andy Herington
Mayor of Milan
Milan, MO

John Watt
Farmer
Green City, MO

Robert Jaques
Farmer
Milan, MO

Donnie Campbell
Farmer
Unionville, MO

Jim Hoselton
Locust Creek Watershed Board/President
Sullivan County SWCD
Humphreys, MO

Affiliate Members

Affiliate members are resource professionals who agreed to assist with the source water protection planning process.

Terri Bruner
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23487 Eclipse Dr.
Milan, MO 63556
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Mill Spring, MO 63952
573-429-1383
efuchs@moruralwater.org

Approval of Source Water Protection Plan for Headwaters of East Locust Creek

Source Water Protection Working Group

Name	Signature
Cully Cowgill	Cully Cowgill
John Watt	John Watt
Phyllis Blondefield	Phyllis Blondefield
Robert Jaques	Robert Jaques
Andy Herington	Andy Herington
Donnie Campbell	Donnie Campbell
Jim Hoselton	Jimmy Hoselton

PRIMARY CONTACT FOR PLANNING

Brad Scott
NCMRWC General Manager
201 North Market St.
Milan, MO 63556
660-265-4448

Brad Scott

PURPOSE STATEMENT OF PLAN

Purpose

With the understanding that clean water is a limited resource, the purpose of this plan is to protect existing sources, which include Elmwood Reservoir and the headwaters of the proposed East Locust Creek Reservoir, in order to protect public health and keep water treatment costs to a minimum.

Goals & Objectives

This plan was developed by discussions, data collection, research, and a consensus of both the Commission and the Source Water Protection Steering Committee. Affiliate members of the steering committee reviewed and provided expertise related to their various disciplines. The primary goal of this effort was to develop a preliminary source water protection plan for the Commission to protect and improve drinking water sources of the Headwaters of East Locust Creek HUC12 prior to, during, and after construction of ELCR.

Objectives of this plan are as follows:

a. To provide a platform for local stakeholders to guide the Commission toward water quality protection practices that will likely be embraced and utilized by the local property owners.

b. To function as an initial step in documenting, educating and communicating the importance of water quality to the general public, especially to the landowners and residents living in the watersheds of Elmwood Reservoir and the Headwaters of East Locust Creek.

c. To describe the water quality and quantity conditions in the existing watershed.

d. To serve as a foundation for future source water protection efforts that will be incorporated into a comprehensive Water Quality Assurance Plan.

e. To develop and document local priorities for water quality protection targets and practices so that the community can obtain funding for implementation to improve water quality in East Locust Creek, Elmwood Lake, and the future ELCR.

f. To assist with contingency planning to address water quality and water quantity emergencies.

g. To develop a coalition of partners to assist with the Commission source water planning efforts.

h. To fulfill the water quality protection requirements of Section 3.1.2 of the Minimum Design Standards for Community Water Systems (MDNR 2013).

i. To ensure that the East Locust Creek and Elmwood Reservoirs remain in compliance with the proposed nutrient criteria in the State Water Quality Standards. In the event the criteria are exceeded, this document will provide a framework for addressing the issue.

This plan will be dynamic and should evolve over time to best serve the Commission and its customers.

B. PUBLIC WATER SYSTEM SUMMARY OVERVIEW

GENERAL/CONTACT INFORMATION

a. North Central Missouri Regional Water Commission (the Commission)

b. Public Water Supply System (PWSS) #2021537

c. Date of Inception
2001

d. Ownership Code
L = local government

e. Primary Contact
Bradley M. Scott, General Manager
North Central Missouri Regional Water Commission
201 North Market St.
Milan, MO 63556
660-265-4448

f. Public Water System Mailing Address
The Commission, PWS #2021537 (Mailing)
201 North Market St.
Milan, MO 63556

Physical Address
Water Treatment Plant (Physical)
21299 MO Hwy 5
Milan, Missouri 63556

g. Designated Operator
Christopher (Mike) Ward
201 North Market St.
Milan, MO 63556
660-265-3807
Operator Certification Level: A

h. Primary Contact for this plan
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Allstate Consultants, LLC
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i. Responsible Party Contact Information
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MO Department of Natural Resources
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PUBLIC WATER SYSTEM GENERAL SERVICE CHARACTERISTICS

a. Sullivan and Linn Counties are the principal counties served by the Commission.

b. The principal communities served are Milan, Green City, and Sullivan County PWSD #1. These communities and water district serve the following municipalities, including Green Castle, Humphreys, Newtown, Browning, and Pollock, as well as Smithfield Foods, Inc. (See Appendix B, p. B-4)

c. 7,539 population served

d. 3,115 service connections

e. The average consumption per day is 0.600 million gallons of potable water and another 1.0 million gallons of raw water per day to Smithfield Foods, Inc.

f. 2.8 million gallon per day treatment and supply capacity

g. 1.4 million gallons per day finished water storage

- 360,000 gallons in Clearwell
- 300,000 in Old City Elevated Tank
- 750,000 in Big Tower

h. Type of Source Water

- Groundwater 0%
- Surface Water – 100%
- GWUDISW – 0%
- Purchase groundwater - 0%
- Purchased Surface – 0%
- Purchased GWUDISW – 0%

i. Raw Water Intake Device Inventory

Elmwood Lake Intake – active
Facility ID No. IN 20216

East Reservoir Intake (South Lake) – active
Facility ID No. IN 20217

Locust Creek Intake – active
Facility ID No. IN 30117

East Fork Locust Creek Intake – active
Emergency only

Golf Course Lake (North)– active
Emergency only

j. Legal Ordinances

The Lake Authority (RSMo, Sections 67.500 to 67.4520) is a Political Subdivision created by statute specifically for the East Locust Creek Reservoir Project (the "Reservoir"). The purpose is to promote the general welfare of the local communities and provide a safe drinking water supply through the construction, operation, and maintenance of the Reservoir. Specifically, the Lake Authority has the power to acquire, own, construct, lease, and maintain recreational or water quality projects. In addition, it has zoning and planning powers exactly like any municipality within the State of Missouri. The jurisdiction of the Lake Authority extends to the watershed of the ELCR. It does not include the watershed of Elmwood Lake. For more information regarding the Lake Authority and accompanying legislation, see Appendix A.

II. SOURCE WATER PROTECTION PLAN ELEMENTS

A. WATER QUALITY AND QUANTITY DESCRIPTION

The United States is divided into watersheds that are identified by a Hydrologic Unit Code (HUC) used by conservation planners to identify drainage areas throughout the country. The code numbers get larger as the watershed gets smaller. The Headwaters of the East Locust Creek HUC12 (#102801030601, Figure 2) is located entirely within the Lower Grand HUC8 watershed (#10280103). The Locust Creek watershed, which includes the main stem of Locust Creek and both the East and West Forks of Locust Creek, has been identified by agencies such as the Missouri Department of Conservation (MDC), MDNR, and Natural Resources Conservation Service (NRCS) as a priority watershed.

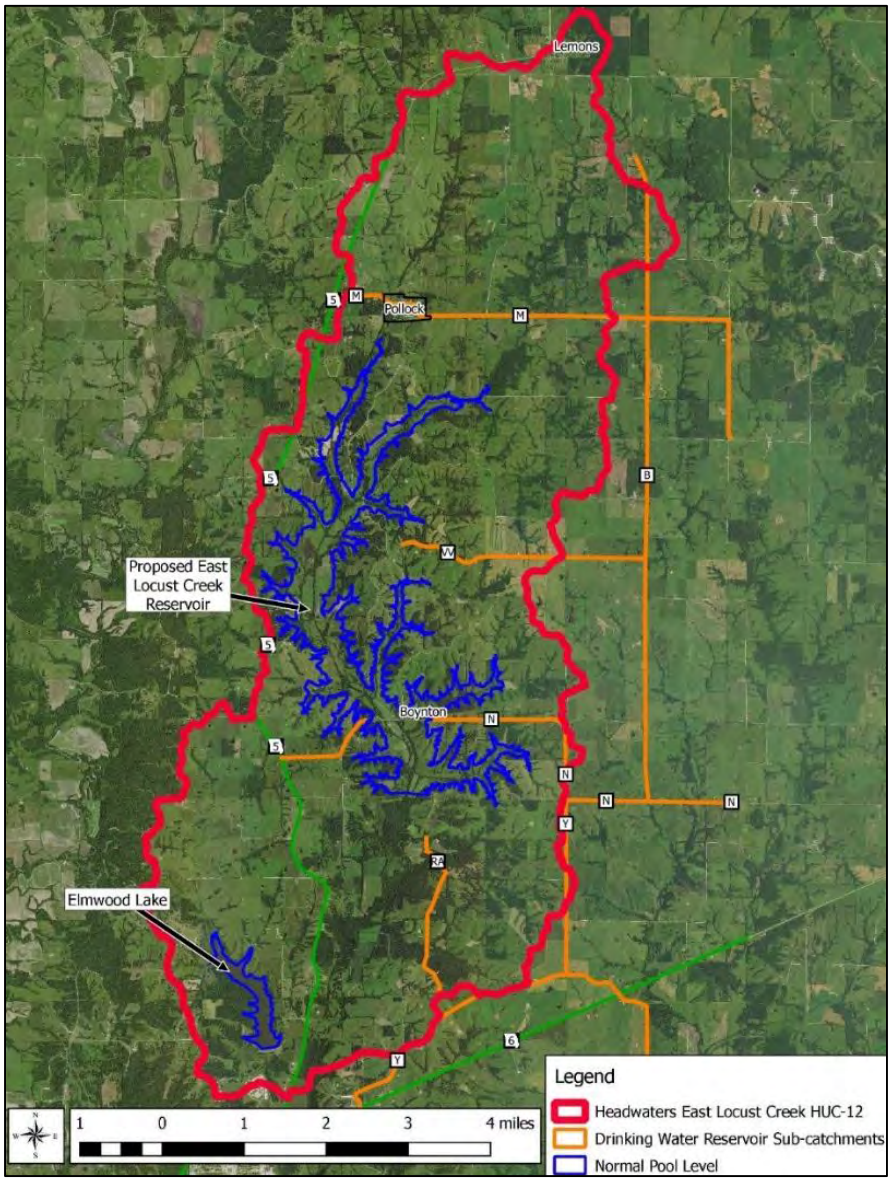

Figure 2. Headwaters of East Locust Creek (HUC12) Source Water Protection Area (Published by Allstate Consultants LLC, 2018)

According to Todd et al. (1994), the Locust Creek basin is located in the Dissected Till Plains physiographic region of Missouri. This mix of hills and plains is composed of glacial deposits on Pennsylvanian sedimentary rock. The till is predominately clay with some rock and gravel and is highly variable in depth but generally less than 200 feet. Top soils of the basin consist of loess and drift 4-8 feet deep with transitional slopes containing both prairie- and forest-derived soils. Historically, prairie grasses were the native vegetation of the region and helped develop deep, organic-rich soils favorable for agricultural row crops in the bottoms, haying, and grazing on the steeper slopes. Predominant soils in the basin are grouped by parent material, slope and soil texture into soil associations (USDA 1982). Soils in the bottoms along Locust Creek and East Locust Creek are typically a Kennebre-Nodaway-Colb-Zook association. Headwater regions and uplands have a variety of soil associations with Weller-Keswick-Lindley-Mandeville and Pershing-Armstrong-Gora being dominant. These soil associations can generally be described as silty-clay loam and highly erodible. They are in part responsible for the turbid nature of streams in the basin.

There is very little groundwater available in Northwest and North Central Missouri. The Northwest Missouri Groundwater Province, which includes Sullivan County, only contains 2.2% of Missouri's groundwater (MDNR 2018). The province has geologic characteristics similar to those in the northeastern part of the state. However, in northwest Missouri there are no high-yield, potable bedrock aquifers available, and the glacial drift in the western portion of the province is typically more water productive than to the east. Water from wells in the glacial till and the underlying consolidated bedrock in Sullivan County is mineralized and of marginal quality for domestic use (NRCS 1995). Surface water from streams and impoundments is less mineralized and of better quality for domestic use. Low flow conditions during the summer make streams unreliable as a sole water supply. Impoundments are the primary source of water for municipal uses (NRCS 1995). The East Fork of Locust Creek is on the impaired waters list for elevated levels of *E. coli* bacteria and low dissolved oxygen levels. Locust Creek in Sullivan and Putnam Counties is also listed for elevated *E. coli* levels.

WATER SYSTEM DETAILS

The North Central Missouri Regional Water Commission (The Commission) was established in 2001 as part of MDNR's effort to encourage consolidation of water supply resources across north central Missouri in anticipation of the continuing trend for small water supply systems to close due to the high cost of more protective water supply standards. The Commission serves Sullivan and Linn counties, which have limited groundwater resources. It is forced to rely entirely on surface water supplies that are presently inadequate during drought conditions. In addition to providing wholesale water to three communities and one water district in Sullivan County, the Commission was also charged with developing a plan to provide a consistent water resource for the 10-county area, including Sullivan, Schuyler, Putnam, Mercer, Grundy, Adair, Macon, Linn, Livingston and Chariton Counties. A plan was developed to construct a large surface water reservoir in Sullivan County that would consistently supply the county and surrounding region with high-quality water. The future ELCR will be located approximately five miles north of the town of Milan, the county seat of Sullivan County. The Commission's facilities all lie within Sullivan County, Missouri (Figure 1).

Currently, the Commission provides wholesale drinking water to three buyers, Milan, Green City, and Sullivan County PWSD #1. These buyers provide water to seven communities. The Commission also provides raw water to the Smithfield Farmland Corporation, a major employer in Milan, MO. It serves a population of approximately 7,539 residents and has approximately 3,115 service connections (HDR 2016). The Commission has water rights to Elmwood Lake, approximately 222 acres, and the Old East Reservoir (South Lake), approximately 38 acres. The Old East Reservoir is also known as Golf Course Lake and Lake 41. Elmwood Lake drains 6.4 square miles, and the Old East Reservoir drains approximately one square mile (MDNR 2000).

The Commission currently has three raw water sources that are routinely used and one emergency raw water intake. When Elmwood Lake levels get low, water is pumped from Locust Creek to Elmwood Lake. Under emergency situations, the Commission purchases a limited supply of finished water from Trenton, MO, approximately 25 miles west of Milan. For more details regarding the Commission's system, see Appendix B. During severe drought conditions, water is pumped from the East Fork Locust Creek and the North Golf Course Lake into the Old East Reservoir. The water treatment facility has the capacity to produce up to 2.4 million gallons of potable water per day (Jones et al. 2016). It currently produces approximately 600,000 gallons of potable water per day and another one million gallons of raw water per day to the Smithfield Farmland Corporation (Jones et al. 2016). Other infrastructure includes nine miles of 10-inch line serving Green City and Green Castle, and 18 miles of 8-inch line serving western Sullivan County. Upon completion, ELCR (approximately 2,352 acres) will allow the Commission to serve a 10-county area. Both Elmwood Lake and the site of the future ELCR lie north of the town of Milan in Sullivan County, Missouri (Figure 1). The proposed reservoir and water treatment plant will have a maximum capacity of 6.5 million gallons per day (Jones et al. 2016).

The Commission uses a conventional surface water two-stage coagulation, sedimentation, filtration, and disinfection process. Currently, the source water supplies available to the Commission are inadequate to meet potential demands, especially during a drought. The proposed East Locust Creek Reservoir is in the planning, cleanup and preparation phase, having completed all required land acquisition. It should not only provide adequate water supplies but economic development opportunities associated with recreation. This plan will include the drainage areas of Elmwood Lake and the future ELCR.

The MDNR Source Water Assessment Report (Appendix C) includes threats to these raw water supplies including the Locust Creek intake. Threats in the upper Locust Creek watershed will not be addressed by this plan. Detailed volume information on Elmwood Lake and Old East Reservoir is located in Appendix

D. The water treatment plant staff are currently producing high-quality water. Contaminant levels are well below the thresholds for concern (MDNR 2017).

In 2011, the state legislature approved special "Lake Authority" legislation (RSMo, Sections 67.500 to 67.4520) which gives the Commission authority to institute land use restrictions in the watershed of ELCR as needed to protect water quality (Appendix A). This was a way to minimize land purchases for a lake buffer by the Commission while having the ability to protect this valuable community asset. It is the hope of the Commission that very few Lake Authority regulations will be necessary. This plan focuses on a collaborative and voluntary approach to source water protection and does not assume that any land use restrictions will be implemented unless specific threats to water quality are identified and collaborative efforts to resolve them are exhausted.

B. SOURCE WATER PROTECTION AREA DELINEATIONS

The protection area includes the entire Headwaters of East Locust Creek HUC12 (Figure 2). This watershed is approximately 31,585 acres and includes a small amount of land below the dam of the proposed ELCR. The Steering Committee decided to include the entire hydrologic unit to remain consistent with the MDNR Source Water Protection Plan Grant, awarded to the Commission on November 9, 2016, rather than seek an amendment. The watersheds of Elmwood Lake and ELCR will be the priority for management recommendations. Elmwood Lake is approximately 222 surface acres and drains 6.4 square miles (Edwards et al. 2010), which results in a watershed ratio of 19:1 (Figure 2). The lake has approximately five miles of shoreline. The ELCR will be approximately 2,328 acres of surface area that drains approximately 36.6 square miles, resulting in a watershed ratio of approximately 9:1 (Figure 2). The reservoir will have approximately 82 miles of shoreline.

The Commission has an intake on Locust Creek (Appendix B). The MDNR Source Water Assessment Report (Appendix C) includes threats to the Locust Creek intake. Since this plan will focus on the Headwaters of East Locust Creek HUC12, potential contaminant sources above the Locust Creek intake are not addressed.

DETAILED CHARACTERISTICS

The watershed is characterized by steep upland topography. Sloping soils in these areas are subject to severe erosion (NRCS 1995). For detailed geologic description, see Section A. Water Quality and Quantity Description above. Pasture and hay are the predominant land uses, followed by deciduous forest (Figure 3). Land use in the ELCR watershed (Table 1) is representative of the entire source water protection area. The predominant land uses are pasture/hay (52.5%) and deciduous forest (24.8%). Only 2% of the watershed is cropland. The towns of Pollock, Boynton, and Lemons lie within the watershed of ELCR. The town of Boynton will be inundated by the reservoir. Demolition and cleanup efforts are nearly complete.

Area (Ac)	Percent (100%)*	Land Use
2,483	11.8%	Open Water
735	3.5%	Developed, Open Space
95	0.5%	Developed, Low Intensity
4	0.02%	Barren Land (Rock/Sand/Clay)
5,255	24.8%	Deciduous Forest
8	0.04%	Evergreen Forest
197	0.93%	Mixed Forest
341	1.62%	Shrub/Scrub
473	2.24%	Grassland/Herbaceous
11,068	52.5%	Pasture/Hay
426	2.02%	Cultivated Crops
8	0.04%	Woody Wetlands
3	0.01%	Emergent Herbaceous Wetlands

Table 1. East Locust Creek Reservoir Watershed Land Use
**Land use percentages add up to more than 100% due to rounding.*

The following wastewater treatment facilities operate within the Headwaters of East Locust Creek HUC12. None of these facilities discharge in the watersheds of Elmwood Lake or the ELCR.

- City of Milan Wastewater Treatment Facility
  Permit No. MO-0048151

- Auburn Hills Commonwealth Association Wastewater Treatment Facility
  Permit No. MO-0119318
  **The Auburn Hills WWTF will be closed and tied into the Milan WTF by December 1, 2018.*

- Farmland Foods, Inc. (Now Smithfield Foods, Inc.)
  Permit No. MO-0115487

C. CONTAMINANT INVENTORIES & VULNERABILITY ASSESSMENTS

The quality of the water in reservoirs and streams is impacted by management decisions on land above the water source (the watershed). A survey of reservoirs throughout the United States found non-point source pollution, excessive nutrients, and sedimentation to be the top threats to reservoirs in the Midwestern United States (Miranda 2017). The MDNR provides preliminary online Source Water Assessment Reports for drinking water supplies.

The contaminant data for these reports was compiled in 2003 and has not been regularly updated. The Source Water Protection Steering Committee also used local knowledge and expert opinion of the affiliate members to identify potential threats to water quality. The MDNR Source Water Assessment Report for the Commission (Appendix C) contained no listings of potential contaminant sources in the watershed of Elmwood Lake or the Old East Reservoir. There were five above-ground fuel storage tanks and one cemetery listed in the watershed of the Locust Creek intake. The report did not include the watershed of the ELCR.

Potential Contaminants

Recognizing that most potential contaminants for these watersheds would be subtle and non-point source, Allstate Consultants LLC, the Commission's engineering firm, and the Steering Committee investigated potential non-point source pollutants in the ELCR watershed (Figure 3). The following threats were identified:

- Nutrient loading: Small amounts of nitrogen and phosphorus can result in nuisance levels of aquatic plants, including algae, which can cause taste and odor issues. In certain instances, they can be toxic. Potential sources of nutrients throughout the watershed include agricultural runoff and inadequate sewer systems associated with farmsteads and the communities of Pollock and Lemons. Due to its size and distance from the reservoir, Lemons does not appear to be a significant threat for contamination. Some residences in Pollock have been identified as a potential threat to water quality in ELCR because the community has no centralized sewer system and a branch of East Locust Creek runs through town approximately one half mile upstream of the reservoir. Many homes in Pollock and the surrounding region simply have a straight pipe to a ditch. The eight unit USDA Multi-Family Housing Development run by the Pollock Housing Corporation has a small lagoon. A desk review of aerial photos indicates there may be a couple additional lagoons, but their condition is unknown. The watershed contains at least two small feedlots.

  As development begins around the ELCR, lawn fertilizer can become a significant source of nitrogen and phosphorus. USGS personnel have conducted extensive water quality sampling throughout the Lower Grand HUC8 watershed. They have found that 97% of the total nitrogen and phosphorus load for streams in the area occurred from February through June (Wilkison and Armstong 2015). This coincided with the time of year when the majority of stream flow occurs (Krempa and Flickinger 2017). "This likely indicates that increased nitrogen and phosphorus loads are more strongly related to streamflow than to a particular period of the year, indicating runoff, within-bank nutrients that are suspended during higher streamflows, or both are a substantial source of nutrients regardless of timing"(Krempa and Flickinger 2017). Best management practices that focus on streambank stabilization and controlling runoff during late winter and early spring will be important (Wilkison and Armstrong 2015).

The Missouri Department of Natural Resources has proposed new nutrient criteria that will be applicable to both reservoirs. The criteria specifies screening thresholds for nitrogen, phosphorous, and chlorophyll. Under these proposed criteria, the reservoirs will be classified as impaired and placed on the 303(d) list if the geometric mean of samples taken between May and September in a calendar year exceeds the Chlorophyll-a Response Impairment Threshold Value (30 ug/L more than once in three years' time. Alternatively, a reservoir will be listed as impaired if it exceeds a screening threshold value for Chlorophyll-a (18 ug/L), Total Nitrogen (843 ug/L) or Total Phosphorous (49 ug/L) in the same year that certain assessment endpoints are identified.

MDNR will derive the schedule for monitoring based on their understanding of which bodies of water are likely to be impaired; but, for the purposes of this document, it should be assumed that monitoring will occur annually.

- Sedimentation: Excessive sediment can result in the reduction of reservoir storage, increased water treatment costs, and nuisance algae levels due to nutrients associated with soil particles. It can also reduce property values and inhibit fish production. Much of the watershed is in permanent vegetative cover. Initial investigations by HDR, Inc. (2013) suggest that much of the watershed has low to moderate potential for sediment loading (Figure 4). However, some of the steeper areas have a moderate to high potential to contribute sediment to ELCR. The watershed of Elmwood Reservoir has a relatively high percentage of land with the potential to erode sediment at moderate and high rates.

  Gullies and streambank erosion are significant sources of sediment throughout North Missouri; however, this analysis did not examine it. In addition to gullies and streambank erosion, road ditches can be significant sources of sediment in a watershed as well. Conservation groups, such as the Nature Conservancy, are beginning to recognize the impacts of gravel roads on water bodies and are collaborating with local communities to address these issues. (PennState 2018, The Nature Conservancy 2017).

  Shoreline erosion can be a significant source of sediment from within the reservoir basin. This issue is being addressed during the planning and design stages. Careful consideration is being given to minimal timber clearing, recreational boating, strategically placed riprap, and off-shore breakwaters (See Figure 5).

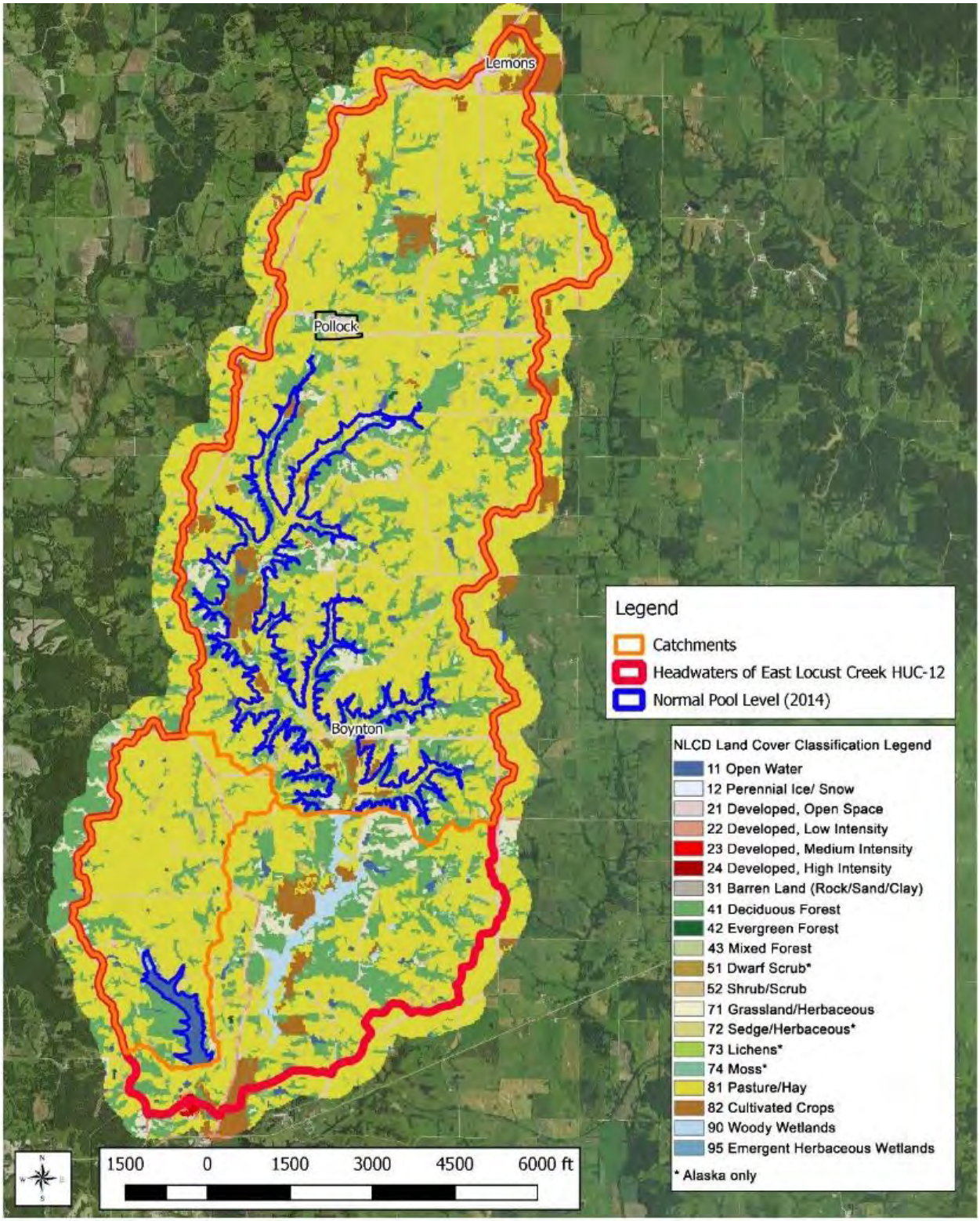

Figure 3. Potential non-point source pollutants in the Headwaters of East Locust Creek HUC 12

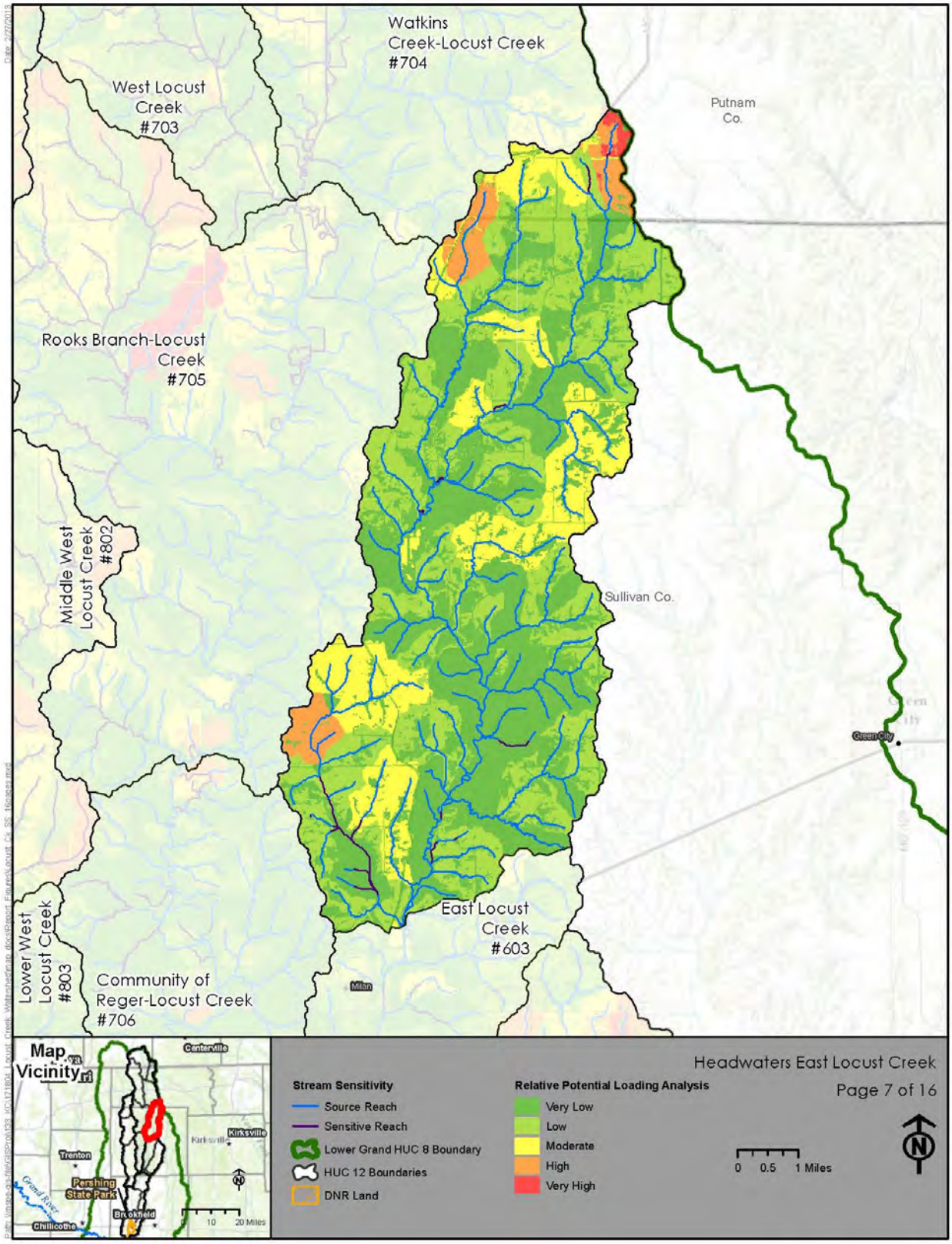

Figure 4. Sediment loading potential for the Headwaters of East Locust Creek HUC12 (HDR, 2013)

- *Escherichia coli (E coli*): High bacteria levels indicate the presence of animal (including human) excrement in a water body. High concentrations can be a health hazard. This can result in lost recreational opportunities and reduced property values. East Locust Creek is listed on the MDNR Impaired Waters List (http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm) for high levels of *E coli*. DNR sampling suggests a cumulative effect from point (waste water treatment facilities) and non-point (agricultural runoff) contributing to elevated *E. coli* levels in East Locust Creek throughout the watershed (MDNR 2007).

- Municipal waste: Household hazardous waste, like asbestos, trash, and hazardous household chemicals, are of particular concern from Boynton, Pollock and Lemons. In addition, there is an abandoned salvage yard in Pollock. An intensive cleanup effort is progressing in the town of Boynton which will be inundated by ELCR.

- Fuel storage tanks: Abandoned storage tanks are common throughout rural Missouri and are a hidden source of petroleum and other contaminants. There are currently over 30,000 underground storage tanks throughout Missouri (Bob Broze, University of Missouri, personal communication). The MDNR Source Water Assessment Report included five above ground storage tanks as potential contaminant sources above the intake located on Locust Creek.

- Cemeteries: Cemeteries have been found to be sources of leachate, arsenic, and lawn and garden maintenance chemicals. One small cemetery is located near the intake along Locust Creek. According to the Steering Committee, there are 5-8 cemeteries within the watershed of ELCR. Cemeteries are probably not a major threat to water quality in the basin; however, the category was identified in the source water contaminant report for the Commission (Appendix C).

- Railroad bed and bridges: The rail bed and associated bridges were tested for hazardous materials, including arsenic. Test results indicated they were not a threat to water quality (TetraTech 2017).

- Dissolved Oxygen: The East Fork of Locust Creek is also on the MDNR impaired waters list for low levels of dissolved oxygen (http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm). It is not anticipated that this will be a significant issue for ELCR.

As reservoir development progresses, the watershed will experience more residential and commercial development. Since this plan focuses on current contaminants, it will need to be revisited to address future source water threats, such as small scale fertilizer and pesticide uses, storm water runoff, and fuel tanks associated with marinas.

VULNERABILITY ASSESSMENT OF RAW WATER SOURCE(S)

Source water protection planning for surface water is more complex than for ground water sources (Bob Broze, University of Missouri, personal communication). Surface water supplies are unique and are often a rural community's most valuable and vulnerable resource. Surface waters are especially vulnerable due to their position on the landscape, few if any buffers from contaminants, and the desire to capitalize on ancillary benefits, such as recreation and economic development. Normally, communities would restrict access to valuable and vulnerable resources. Surface waters, however, draw people to them for recreation and development. The high expectations for surface water bodies make their management and protection especially complicated.

Climate information collected since 1895 indicates that the region is in a 30-year wet cycle and is getting wetter, especially in the winter (Guinan 2018). This is common throughout the Midwest where rainfall events are more extreme, and the landscape is shedding water faster (Tomer and Schilling 2009). Increasing rainfall during the winter months is especially troubling to water managers. The vegetation is dormant, making soils and nutrient sources, such as manure, especially vulnerable to being transported to water supplies. Sediment and nutrients are the two biggest threats to surface waters in this watershed.

This wet cycle has camouflaged a growing problem of increased water use combined with aging water supply infrastructure. Ironically, drought remains a significant threat to rural communities in the region. Local water supplies were unable to meet local needs during the recent droughts of 2000, 2012, and 2018. Climate data gathered from ancient wood from local streams indicates that there have been approximately 13 multi-decadal droughts in the last 1000 years (Stambaugh et al. 2011). Although the recent wet cycle has made some people complacent, history tells us that the region is still vulnerable to extended droughts.

The MDNR Source Water Susceptibility Report for the Commission (Appendix C) indicates that viruses or microbiological contaminants are consistently detected. It lists the Commission's source waters as highly susceptible to these types of contaminants. MDNR reports indicate that *E coli* levels exceed water quality standards for recreational use below Highway N. Initial reservoir cleanup efforts, including the town of Boynton, should help address the bacteria levels. Fortunately, the highest levels are below the future ELCR and outside of the Elmwood Lake watershed (MDNR 2006 and 2007). The Smithfield processing facility was identified as a significant source of nutrients such as nitrogen and phosphorus in the Elmwood Creek watershed (MDNR 2007). This source lies below the dam of Elmwood Lake and should not be a cause for concern.

Preconstruction water quality monitoring has begun in the ELCR watershed. The information will be used to model potential contaminant issues. For more information regarding procedures for improving the vulnerability assessment, please see the Protection Area Management Plan below.

III. PROTECTION AREA MANAGEMENT PLAN

This management plan will focus on outreach and education efforts combined with advocating for adequate funding for cost share to implement Best Management Practices (BMPs) identified by the Steering Committee and the community. BMPs to protect source water can include land use controls, regulations and permits, structural/engineered measures, emergency response planning, and public education (MDNR 2014). The BMPs below will be the foundation for source water planning and protection efforts in the near future. Source water protection efforts will be a "work in progress" as ELCR is constructed and land use changes in response to its development. Allstate Consultants will be working with the Commission to accomplish the milestones listed below. The Sullivan County Soil and Water Conservation District (SWCD) has committed to making the watershed of ELCR a priority area for their efforts, see Appendix E. Pre- and post-construction water quality monitoring will be used to evaluate the effectiveness of our source water protection efforts.

The Sullivan County SWCD and NRCS staffs are considered credible by local producers and community leaders. The Commission will work with NRCS to engage stakeholders and deploy relevant efforts to protect water quality.

PRIOR TO ELCR CONSTRUCTION

Goal: Work proactively with the producers and the community to address water quality threats in the Headwaters of East Locust Creek HUC12. Action items include the following:

- Inventory stream channels above elevation 922.3' to identify areas of excessive erosion that could contribute sediment or nutrients to ELCR.
- Work with producers, the Sullivan County SWCD, NRCS, Sullivan County Cattlemen's Association, Sullivan County Farm Bureau and others to identify BMPs that address February through June runoff events.
- Work with NRCS personnel to identify locations for dry structures and forebays to intercept sediment prior to its entering the ELCR.
- Clean up domestic waste throughout the Commission's property and the ELCR watershed.
- Model nutrient and sediment loading in the ELCR watershed to help with source water protection decision making.
- Inform the community of potential contamination from fuel storage tanks and work with local leaders to locate and properly dispose of abandoned tanks.
- Work with local agricultural producers to develop comprehensive nutrient management plans for pastures throughout the watershed.
- Move forward with the Pollock Sewer Line project and establish a sewer district.
- Partner with community leaders and the MDNR to ensure that residents of the watershed have adequate working septic systems or become tied in to the Pollock sewer system.

- Collaborate with the Sullivan County SWCD and NRCS staff to ensure funding opportunities for cost-share practices, such as fencing, establishing managed grazing systems, and buffer strips.

- Advocate with the Sullivan County Soil and Water Conservation District (SWCD) and NRCS staff to ensure funding is available for cost share practices, such as permanent vegetation establishment, sediment retention structures, dry structures, grade stabilization structures, and buffer strips.

- Inventory the network of roads and ditches to identify potential erosion and seek opportunities to better manage roadside ditches.

DURING ELCR CONSTRUCTION

Goal: Manage existing trees and install in-basin structures to minimize shoreline erosion. Action items include the following:

- Maintain a buffer of standing trees around most of the shoreline to reduce wave energy and associated shoreline erosion.

- Construct off-shore breakwaters and shoreline rip-rap in strategic locations to reduce wave energy and associated shoreline erosion. (See Figure 5.)

AFTER ELCR CONSTRUCTION

Goal: Initiate organizational structures and educational campaigns that protect the water quality and maximize benefits for the next 100 years. Action items include the following:

- Implement the Lake Authority to provide oversight for protecting water quality, see Appendix A.

- Educate homeowners about the importance of proper fertilization rates for lawns and the implications of excessive nutrient runoff for water quality.

- Inform stakeholders, such as homeowners, farmers, Missouri Department of Transportation, and other pesticide applicators, about the importance of proper pesticide application and the potential for runoff into the water supply.

- Create an extensive education campaign for community members to address concerns related to household hazardous waste. Specifically, the program will target the proper disposal substances, such as unused pharmaceuticals, pesticides, insecticides, and other potential contaminants that may be used for landscaping or lawn care. In addition, programming will include information regarding illegal discharging or dumping of automotive fluids and electronic devices or other equipment (refrigerators, washers, dryers, etc.).

- Pursue additional funding for community cleanup days in Pollock and Lemons.

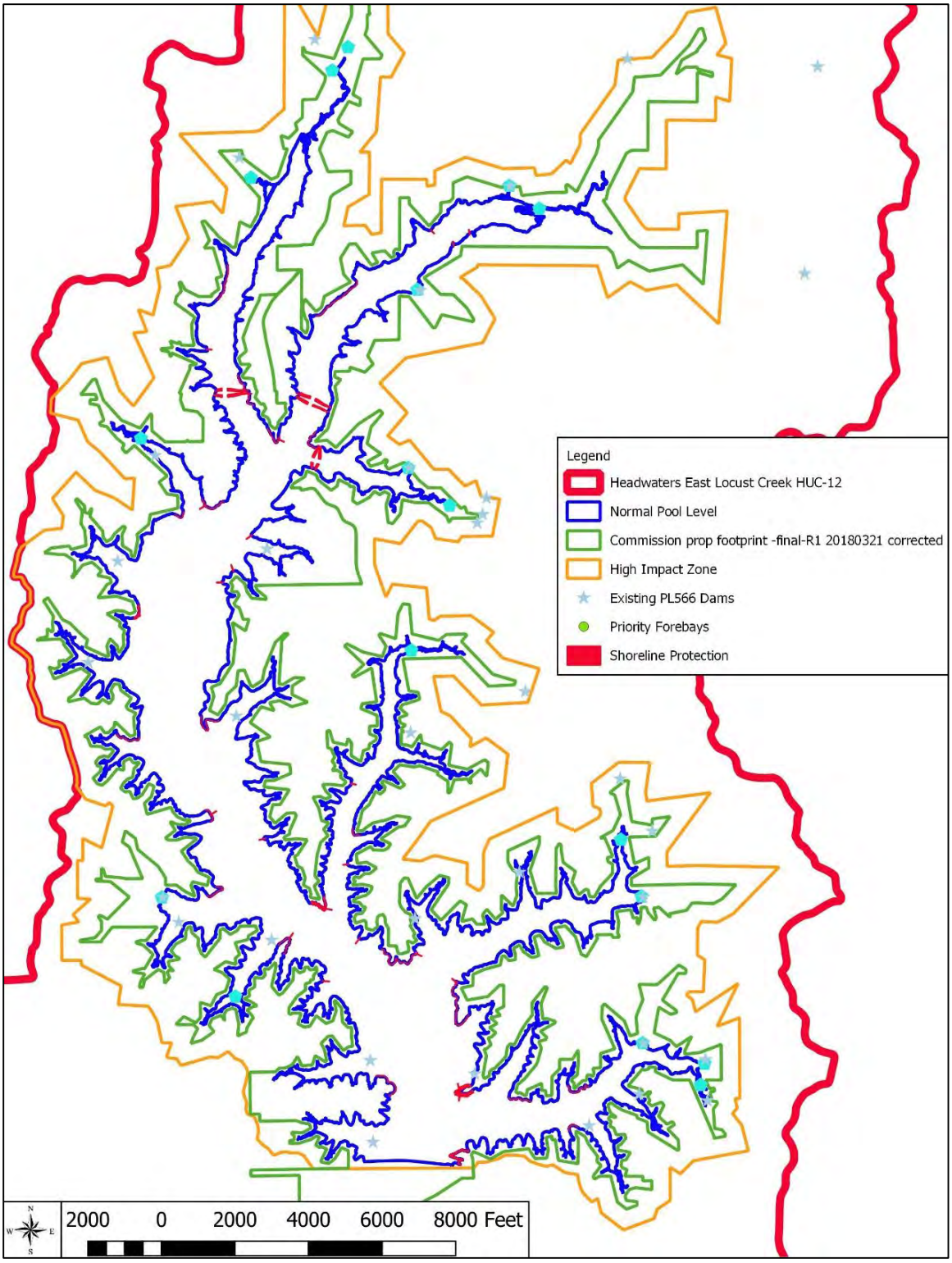

Figure 5. Preliminary Shoreline Protection & Lake Authority Emphasis Areas

The ELCR Project Team is currently working with agencies around the Midwest with experience in reservoir construction and proactive shoreline protection. Practices such as shoreline armoring, strategically placed jetties, and breakwaters will be part of the design. Figure 5 highlights potential locations for special shoreline protection efforts.

CONTINGENCY PLAN FOR WATER EMERGENCIES

Currently, the Commission has a basic emergency operations plan (Appendix F). The Steering Committee was concerned that changing this plan would encroach on the authority of the Commission. The committee suggests the following changes be considered:

- Consider developing a formal Water Shortage Response Plan that includes water use classifications and triggers for discontinuing those water uses during severe drought conditions. Drought is a significant threat to this water system. Planning prior to a drought will help minimize the number of decisions that need to be made under stressful and emotional conditions.
- Work with local emergency management staff to develop an Emergency Response Plan to be in compliance with the Federal Bioterrorism Act. This act requires all community public water systems that serve over 3,300 people develop an emergency response plan. Currently, the Commission is not in compliance with this requirement but will be developed as part of the Reservoir permitting process. For more information see http://dnr.mo.gov/env/wpp/dwsecurity/index.html .

MILESTONES & TARGET DATES FOR 2017-2019

- Met with the Commission to present them the Source Water Protection Plan for their approval at their September 2018 meeting. COMPLETE
- Update all contact information in the current emergency operations plan. COMPLETE
- Upload the Source Water Protection Plan to the Commission's website by July 1, 2017. COMPLETE
- Collaborate with the University of Missouri Extension personnel to update Sullivan County residents on ELCR progress and introduce the importance of Source Water Protection at the Sullivan County Fair, July 5-9, 2017. COMPLETE
- Organize cleanup days in Pollock and Lemons in September 2017. Work with University of Missouri Extension personnel to provide educational materials regarding the importance of proper disposal of household hazardous waste at both events. COMPLETE
- Organize cleanup day for Pollock in November 2018.
- Complete the demolition and cleanup of Boynton by October 2019. Only 2 buildings left.
- Complete a windshield tour of the East Locust Creek HUC12 to look for evidence of channel incision at road crossings and road ditches in February 2019.
- Update NRCS personnel on the details of the final plan and seek opportunities to collaborate by December 31, 2018.
- Meet with the Sullivan County SWCD at their November meeting to discuss the Source Water Protection Plan and ask them to consider these efforts for their 2019 needs assessment.
- Continue ongoing efforts to fund tying Pollock into the Milan Waste Water Treatment Facility and establishing a sewer district.
- Complete testing of the railroad bed and bridges by October 1, 2017. COMPLETE
- Work with the Commission to ensure compliance with contingency planning requirements, including the Federal Bioterrorism Act by January 1, 2020.
- Complete nutrient and sediment modelling to estimate potential load reductions for the East Locust Creek HUC12 by October 1, 2019.
- Compile all comments related to the water quality into a Water Quality Assurance Plan for ELCR by January 1, 2020.

WATERSHED MODELING

The Quality Assurance Project Plan (QAPP) for The Headwaters of East Locust Creek HUC12 is to serve as a supplemental resource to the Source Water Protection Plan (SWPP) developed for the North Central Missouri Regional Water Commission (NCMRWC). The QAPP will create a water quality modeling environment to analyze the current and proposed water supplies. Details regarding the QAPP are located in Appendix G.

Given the critical nature of the current water supply and the large investment required to construct ELCR, it is crucial that the project team be proactive in protecting the integrity of these sources. Accordingly, a SWPP was written and the QAPP is being developed as a first step towards developing a water quality modeling environment that can be used to provide information for implementation of the SWPP.

IV. SUMMARY & CONCLUSIONS

The Commission is currently providing high-quality drinking water to its customers. However, it is simply not able to produce enough water because of supply, especially during drought conditions. Drought is the significant threat to the water supply in Sullivan County and the surrounding region. The Commission is working hard with State, Federal, and local stakeholders to construct the East Locust Creek Reservoir to address their deficiency. This effort has been underway for decades. To protect this long-term effort, the Commission has worked with community leaders to think deeply about protecting water quality for future generations.

The Lake Authority legislation is an innovative approach that protects water quality in the future ELCR, while maximizing the amount of land in private ownership. The Commission will work closely with the community to find solutions that are locally appropriate and minimize the need for regulations.

The Commission's Emergency Operations Plan is currently adequate; however, during the permitting process for ELCR, an Emergency Response Plan will be developed as part of the comprehensive water quality assurance efforts.

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APPENDICES

Appendix A. Lake Authority Background & Legislation

EAST LOCUST CREEK WATER PROTECTION & SEWER DISTRICT

The primary mission of the North Central Missouri Regional Water Commission (the Commission) is to provide high-quality water to its customers, both treated and raw. The Commission has the added mission to construct the East Locust Creek Reservoir (ELCR). The latter mission requires that the Commission devise and deploy certain mechanisms that will ensure that point and nonpoint source contaminants are addressed. In order to secure a drinking water permit from the Missouri Department of Natural Resources (MDNR), it will be necessary to deploy both structural Best Management Practices and governance oversight to ensure and sustain practices that will provide the assurance of clean water flowing into ELCR. As a part of the ELCR plan and, ultimately, in pursuit of a drinking water permit from the MDNR, a Source Water Protection Plan (SWPP) will be developed and adopted. The SWPP will be a guidance document for the reduction of contaminants.

While the Commission can deploy structural Best Management Practices (BMPs) including forebays, forest and forage management, shoreline protection, wave reduction, and buffer strips, it will require the Lake Authority/future Sewer District to provide the governance and oversight necessary to protect water quality. See map on page A-3 for boundaries of the Lake Authority and sewer district.

LAKE AUTHORITY

The Commission advocated for the Lake Authority legislation that was signed into law on August 28, 2011. This legislation enabled the Commission to reduce the footprint of its property from 5,800 acres to approximately 4,550 acres by removing the need for a 300-foot buffer. In essence, in exchange for buffer acreage, the Lake Authority can exercise control over development and potential contaminating activities in the East Locust Creek Watershed from the top of the watershed to the dam. This area is a subset of the overall Headwaters of East Locust Creek (HELC) Watershed. The Lake Authority will also have oversight over the operations of the ELCR, some of which could negatively impact water quality, including recreational boating, development, docks, marina operations, and wave reduction measures.

The Commission determined their acquisition requirements, generally, based upon two criteria: 1) top of dam elevation required by the Natural Resources Conservation Service and 2) 100 feet from principal pool as recommended by MDNR. The property line was drawn to the distance from principal pool of the greater of the two criteria. In most instances, the property line exceeds 100 feet from principal pool. This is property the Lake Authority will have direct control over as it is Commission-owned property.

The Lake Authority members will be appointed by the Commission and will generally have oversight over the operations of the ELCR, but its primary mission is maintaining high-quality raw water.

HIGH IMPACT ZONE

Within the Lake Authority Area, there is a section designated as the High Impact Zone. This is a subset of the Lake Authority Area and is of particular and critical interest for the control of any activities that could contaminate or degrade the water quality of the ELCR. It is generally defined as being a line of demarcation setback 500 feet from the East Locust Creek property line, with certain exceptions, that include large tracts owned by the Commission. This area is generally owned by private individuals and will be the area prone to development. It is imperative the Lake Authority have oversight of development and activities in the High Impact Zone.

BEYOND THE HIGH IMPACT ZONE WITHIN THE LAKE AUTHORITY AREA

The remainder of the area is also of particular interest and activities will be monitored and evaluated. The Lake Authority will collaborate with communities and partners to ensure potential water quality concerns are addressed.

POLLOCK SEWER LINE – Lake Authority

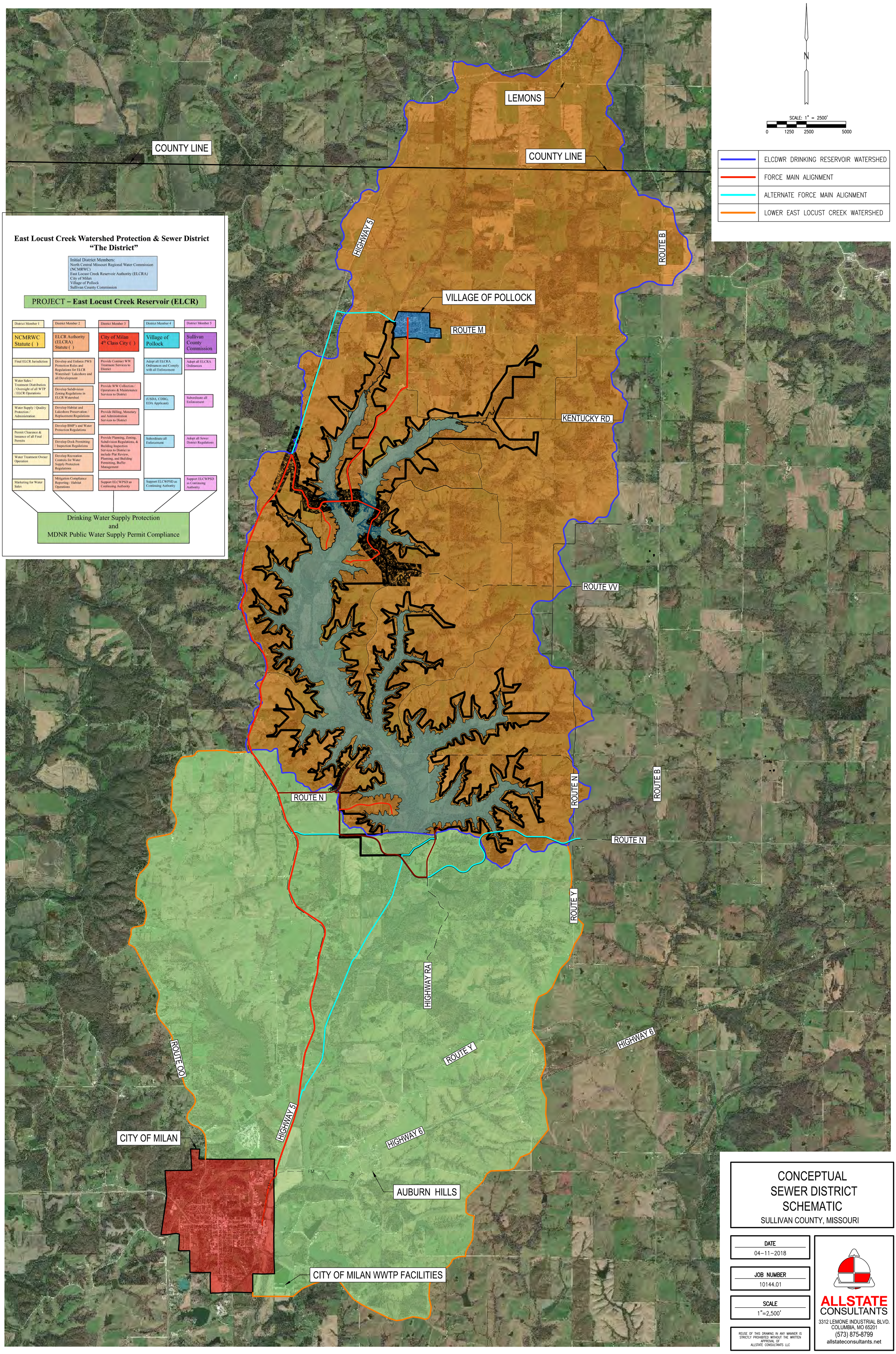
Near the Headwaters of ELCR is the Village of Pollock. Pollock does not have a centralized sewer system or adequate standards and threatens the ELCR water quality. The conceptual plan will provide sewer service to Pollock residents and then provide service to residents and future residents within or adjacent to the Lake Authority Area. The sewage will be transported to and then treated by the City of Milan. The Lake Authority will strongly encourage hook-ups from Pollock south to the dam.

POLLOCK SEWER LINE – Sewer District

Beyond the dam, it will be necessary to create and maintain a sewer district to maintain water quality beyond the watershed of ELCR.

EAST LOCUST CREEK WATERSHED PROTECTION & SEWER DISTRICT

It is necessary to create the East Locust Creek Watershed Protection and Sewer District (the District). Within the environs of the ELCR, authority will be wielded by the Lake Authority and the District. Below the dam, only The District will have authority. It will be imperative that The District and the Lake Authority cooperate and collaborate with free-flowing communications and, advisedly, shared administration.



CONCEPTUAL SEWER DISTRICT SCHEMATIC

SULLIVAN COUNTY, MISSOURI

DATE
04-11-2018

JOB NUMBER
10144.01

SCALE
1"=2,500'

REUSE OF THIS DRAWING IN ANY MANNER IS STRICTLY PROHIBITED WITHOUT THE WRITTEN APPROVAL OF ALLSTATE CONSULTANTS LLC

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COLUMBIA, MO 65201
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allstateconsultants.net

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Missouri Revised Statutes

Chapter 67
Political Subdivisions, Miscellaneous Powers
Section *67.4500*

August 28, 2011

Definitions.

67.4500. As used in sections 67.4500 to 67.4520, the following terms shall mean:

(1) "Authority", any county drinking water supply lake authority created by sections 67.4500 to 67.4520;

(2) "Conservation storage level", the target elevation established for a drinking water supply lake at the time of design and construction of such lake;

(3) "Costs", the sum total of all reasonable or necessary expenses incidental to the acquisition, construction, expansion, repair, alteration, and improvement of the project, including without limitation the following: the expense of studies and surveys; the cost of all lands, properties, rights, easements, and franchises acquired; land title and mortgage guaranty policies; architectural and engineering services; legal, organizational marketing, or other special services; provisions for working capital; reserves for principal and interest; and all other necessary and incidental expenses, including interest during construction on bonds issued to finance the project and for a period subsequent to the estimated date of completion of the project;

(4) "Project", recreation and tourist facilities and services, including, but not limited to, lakes, parks, recreation centers, restaurants, hunting and fishing reserves, historic sites and attractions, and any other facilities that the authority may desire to undertake, including the related infrastructure buildings and the usual and convenient facilities appertaining to any undertakings, and any extensions or improvements of any facilities, and the acquisition of any property necessary therefor, all as may be related to the development of a water supply source, recreational and tourist accommodations, and facilities;

(5) "Water commission", a water commission owning a reservoir formed pursuant to sections 393.700 to 393.770;

(6) "Watershed", the area that contributes or may contribute to the surface water of any lake as determined by the authority.

(L. 2011 H.B. 89)

Effective 7-11-11

CROSS REFERENCE:

Nonseverability clause, 640.099

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Missouri Revised Statutes

Chapter 67
Political Subdivisions, Miscellaneous Powers
Section *67.4505*

August 28, 2011

Authority created, powers, purpose--income and property exempt from taxation--immunity from liability.

67.4505. 1. There is hereby created within any county of the third classification with a township form of government and with more than seven thousand two hundred but fewer than seven thousand three hundred inhabitants a county drinking water supply lake authority, which shall be a body corporate and politic and a political subdivision of this state.

2. The authority may exercise the powers provided to it under section 67.4520 over the reservoir area encompassing any drinking water supply lake of one thousand five hundred acres or more, as measured at its conservation storage level, and within the lake's watershed.

3. It shall be the purpose of each authority to promote the general welfare and a safe drinking water supply through the construction, operation, and maintenance of a drinking water supply lake.

4. The income of the authority and all property at any time owned by the authority shall be exempt from all taxation or any assessments whatsoever to the state or of any political subdivision, municipality, or other governmental agency thereof.

5. No county in which an authority is organized shall be held liable in connection with the construction, operation, or maintenance of any project or program undertaken pursuant to sections 67.4500 to 67.4520, including any actions taken by the authority in connection with such project or program.

(L. 2011 H.B. 89)

Effective 7-11-11

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Missouri Revised Statutes

Chapter 67
Political Subdivisions, Miscellaneous Powers
Section *67.4510*

August 28, 2011

Members, appointment.

67.4510. A county drinking water supply lake authority shall consist of at least six but not more than thirty members, appointed as follows:

(1) Members of the water commission shall appoint all members to the authority, one-third of the initial members for a six-year term, one-third for a four-year term, and the remaining one-third for a two-year term, until a successor is appointed; provided that, if there is an odd number of members, the last person appointed shall serve a two-year term. Upon the expiration of each term, a successor shall be appointed for a six-year term;

(2) No person shall be appointed to serve on the authority unless he or she is a registered voter in the state for more than five years, a resident in the county where the water commission is located for more than five years, and over the age of twenty-five years. If any member moves outside such county, the seat shall be deemed vacant and a new member shall be appointed by the county commission to complete the unexpired term.

(L. 2011 H.B. 89)

Effective 7-11-11

CROSS REFERENCE:

Nonseverability clause, 640.099

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Missouri Revised Statutes

Chapter 67
Political Subdivisions, Miscellaneous Powers
Section *67.4515*

August 28, 2011

Initial meeting, when--officers, executive director--surety bond requirements--conflict of interest.

67.4515. 1. The water commission shall by resolution establish a date and time for the initial meeting of the authority.

2. At the initial meeting, and annually thereafter, the authority shall elect one of its members as chairman and one as vice chairman, and appoint a secretary and a treasurer who may be a member of the authority. If not a member of the authority, the secretary or treasurer shall receive compensation that shall be fixed from time to time by action of the authority. The authority may appoint an executive director who shall not be a member of the authority and who shall serve at its pleasure. If an executive director is appointed, he or she shall receive such compensation as shall be fixed from time to time by action of the authority. The authority may designate the secretary to act in lieu of the executive director. The secretary shall keep a record of the proceedings of the authority and shall be the custodian of all books, documents, and papers filed with the authority, the minute books or journal thereof, and its official seal. The secretary may cause copies to be made of all minutes and other records and documents of the authority and may give certificates under the official seal of the authority to the effect that the copies are true and correct copies, and all persons dealing with the authority may rely on such certificates. The authority, by resolution duly adopted, shall fix the powers and duties of its executive director as it may from time to time deem proper and necessary.

3. Each member of the authority shall execute a surety bond in the penal sum of fifty thousand dollars or, in lieu thereof, the chairman of the authority shall execute a blanket bond covering each member and the employees or other officers of the authority, each surety bond to be conditioned upon the faithful performance of the duties of the office or offices covered, to be executed by a surety company authorized to transact business in the state as surety, and to be approved by the attorney general and filed in the office of the secretary of state. The cost of each such bond shall be paid by the authority.

4. No authority member shall participate in any deliberations or decisions concerning issues where the authority member has a direct financial interest in contracts, property, supplies, services, facilities, or equipment purchased, sold, or leased by the authority. Authority members shall additionally be subject to the limitations regarding the conduct of public officials as provided in chapter 105.

(L. 2011 H.B. 89)

Effective 7-11-11

CROSS REFERENCE:

Nonseverability clause, 640.099

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Missouri Revised Statutes

Chapter 67
Political Subdivisions, Miscellaneous Powers
Section *67.4520*

August 28, 2011

Powers of authority--transfer of property to authority, when--zoning and planning powers.

67.4520. 1. The authority may:

(1) Acquire, own, construct, lease, and maintain recreational or water quality projects;

(2) Acquire, own, lease, sell, or otherwise dispose of interests in and to real property and improvements situated thereon and in personal property necessary to fulfill the purposes of the authority;

(3) Contract and be contracted with, and to sue and be sued;

(4) Accept gifts, grants, loans, or contributions from the federal government, the state of Missouri, political subdivisions, municipalities, foundations, other public or private agencies, individuals, partnerships, or corporations;

(5) Employ such managerial, engineering, legal, technical, clerical, accounting, advertising, stenographic, and other assistance as it may deem advisable. The authority may also contract with independent contractors for any of the foregoing assistance;

(6) Disburse funds for its lawful activities and fix salaries and wages of its employees;

(7) Fix rates, fees, and charges for the use of any projects and property owned, leased, operated, or managed by the authority;

(8) Adopt, alter, or repeal its own bylaws, rules, and regulations governing the manner in which its business may be transacted; however, said bylaws, rules, and regulations shall not exceed the powers granted to the authority by sections 67.4500 to 67.4520;

(9) Either jointly with a similar body, or separately, recommend to the proper departments of the government of the United States, or any state or subdivision thereof, or to any other body, the carrying out of any public improvement;

(10) Provide for membership in any official, industrial, commercial, or trade association, or any other organization concerned with such purposes, for receptions of officials or others as may contribute to the advancement of the authority and development therein, and for such other public relations activities as will promote the same, and such activities shall be considered a public purpose;

(11) Cooperate with municipalities and other political subdivisions as provided in chapter 70;

(12) Enter into any agreement with any other state, agency, authority, commission, municipality, person, corporation, or the United States, to effect any of the provisions contained in sections 67.4500 to 67.4520;

(13) Sell and supply water and construct, own, and operate infrastructure projects in areas within its jurisdiction,

including but not limited to roads, bridges, water and sewer systems, and other infrastructure improvements;

(14) Issue revenue bonds in the same manner as provided under section 67.789; and

(15) Adopt tax increment financing within its boundaries in the same manner as provided under section 67.790.

2. The state or any political subdivision or municipal corporation thereof may in its discretion, with or without consideration, transfer or cause to be transferred to the authority or may place in its possession or control, by deed, lease, or other contract or agreement, either for a limited period or in fee, any property wherever situated.

3. The state or any political subdivision may appropriate, allocate, and expend such funds of the state or political subdivision for the benefit of the authority as are reasonable and necessary to carry out the provisions of sections 67.4500 to 67.4520.

4. The authority shall have the authority to exercise all zoning and planning powers that are granted to cities, towns, and villages under chapter 89, except that the authority shall not exercise such powers inside the corporate limits of any city, town, or village which has adopted a city plan under the laws of this state before August 28, 2011.

(L. 2011 H.B. 89)

Effective 7-11-11

CROSS REFERENCE:

Nonseverability clause, 640.099

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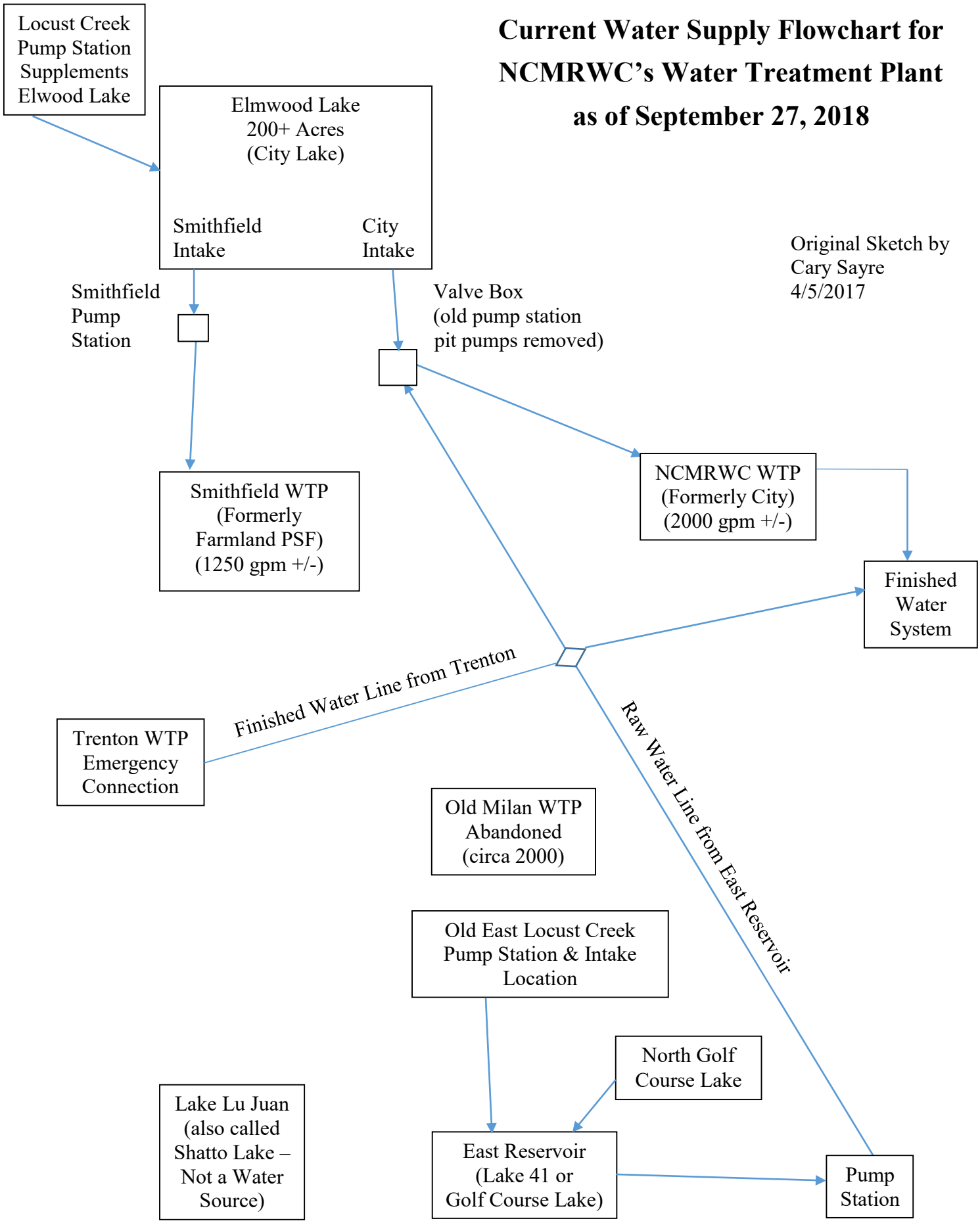
Appendix B. Water System Details

Current Water Supply Flowchart for NCMRWC's Water Treatment Plant as of September 27, 2018



Sullivan County

Sullivan County is located within the north central portion of the Study Area in Missouri (see Figure 1-53). There are seven public water systems within Sullivan County: Sullivan Co. PWSD 1, North Central MO Regional Water Commission (NCMRWC), and the Cities of Green City, Green Castle, Humphreys, Milan, and Newtown. There is one private non-transient non-community (NTNC) water system within Sullivan County operated by Smithfield Farmland Corporation. Of the seven public water systems, only one is a surface water supplier (NCMRWC). The remaining six purchase finished surface water from within Sullivan County either directly from NCMRWC or via a consecutive connection. NCMRWC does have an emergency connection with the City of Trenton in Grundy County.

Figure 1-54 illustrates the supplier and customers in Sullivan County. Table 1-19 presents the general water system information for each system within Sullivan including the total number of connections, total population served, average daily flow, design capacity (or contracted capacity), total emergency capacity, water source, and source capacity. According to the MDNR DWW, the eight public water systems within Sullivan serve a total population of 8,739.

Of the seven public water systems, only one is a surface water supplier (NCMRWC). The remaining six purchase finished surface water from within Sullivan County either directly from NCMRWC or via a consecutive connection. NCMRWC does have an emergency connection with the City of Trenton in Grundy County.

Current Groundwater Suppliers

Sullivan County does not have any groundwater sources or systems that purchase groundwater.

Current Surface Water Suppliers

In Sullivan County, the NCMRWC utilizes Elmwood Lake, Golf Course Lake, and Locust Creek for surface water supply. NCMRWC also has an emergency connection with Trenton Municipal Utilities.

The NCMRWC cannot meet current demand without pumping supplemental flow from Locust Creek into the Elmwood Reservoir. Smithfield Farmland Corp also draws from the Elmwood Reservoir to provide water to a poultry-processing plant and water for the Premium Standard Farms meat processing plant. The combined use from NCMRWC and Smithfield result in a total water demand of 1.65 MGD. According to the 2011 WSS, the optimum yield of the Elmwood and Golf Course Lakes is 0.937 MGD. Figure 1-55 depicts the total annual demand versus the optimum yield for the Elmwood and Golf Course Lakes and the optimum yield achieved by pumping Locust Creek. According to the 2015 NCMRWC Water System Source Improvement report, the Elmwood Lake demands stressed Locust Creek and Old City Lake to record low levels in spring 2013.

As part of this 2016 Study, the optimum yield determined in the 2011 WSS has been overlain with the more recent annual demands compiled as part of the Missouri's Major Water Users Database. However, the demands projected were not analyzed using RESOP, it is merely an aide to the reader to better understand the availability of the source.

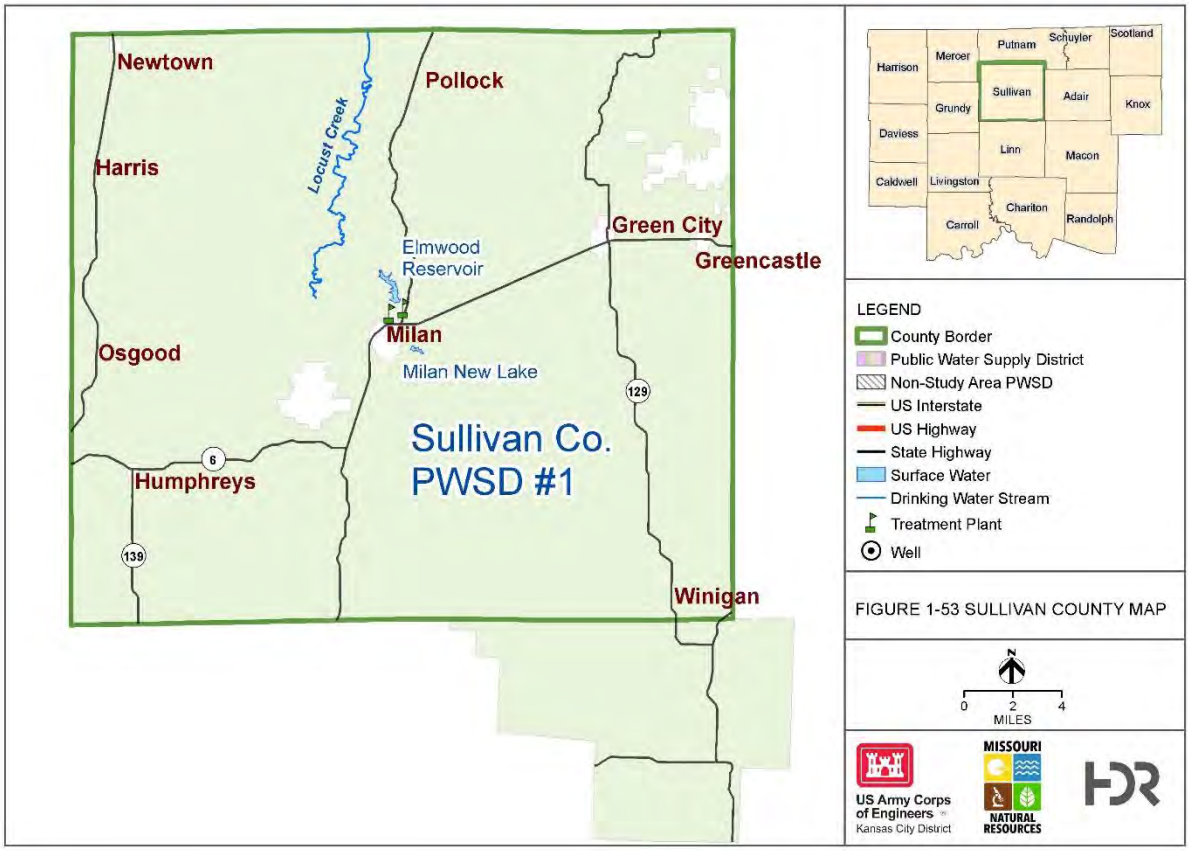


FIGURE 1-53 SULLIVAN COUNTY MAP

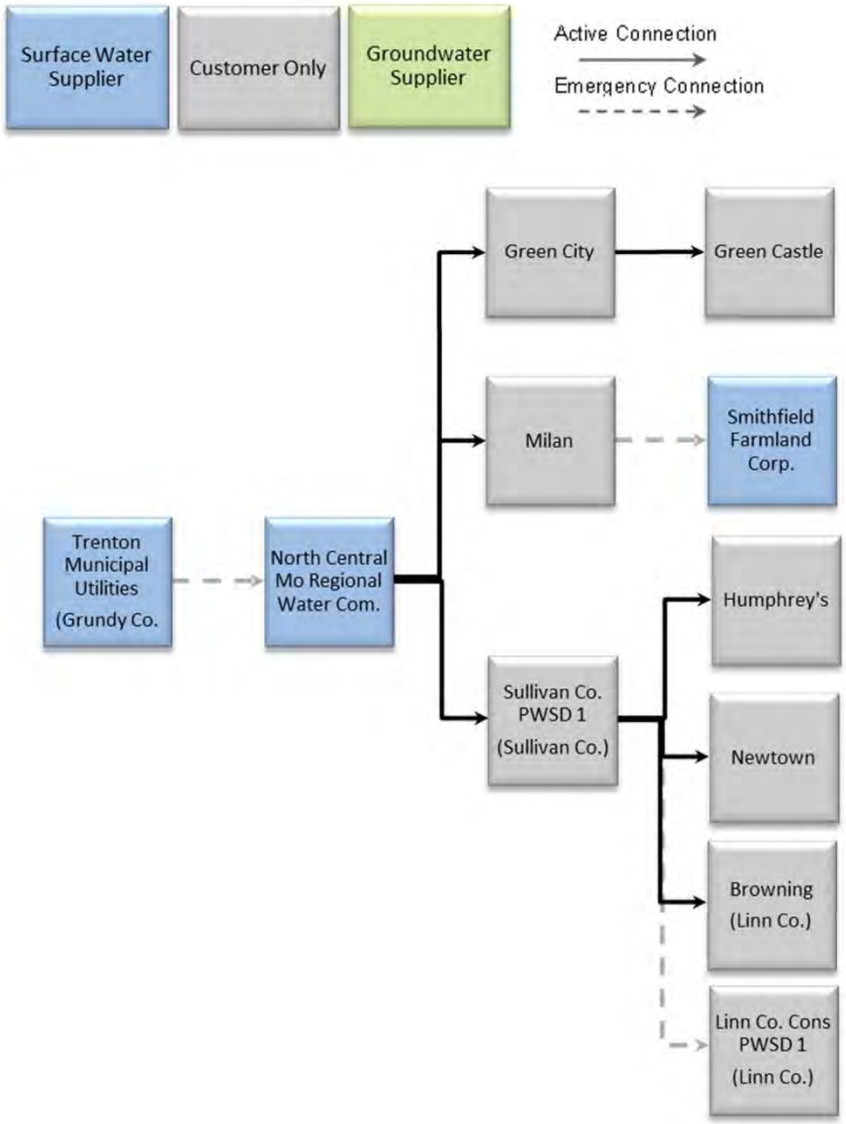


Figure 1-54 Sullivan County Water Suppliers and Customers

Table 1-19 Sullivan County – Water System Information

System/ID #	Connections [1]	Population[1]	ADF (MGD)[1]	Design Capacity/Contract (MGD)[1]	Total Emergency Capacity (MGD)[1]	Source[1],[3],[4]	Source Name [3]	Source Capacity (MGD)[3],[4]
GREEN CASTLE MO2010328	100	275	0.03	NR	0.03	SW Purchase		Purchase
GREEN CITY MO2010329	326	671	0.06	0.43	0.23	SW Purchase		Purchase
HUMPHREYS MO2010389	43	98	0.01	NR	0.01	SW Purchase		Purchase
MILAN MO2010523	809	1,960	0.16	0.20	0.78	SW Purchase		Purchase
NEWTOWN MO2010574	87	183	0.02	NR	0.02	SW Purchase		Purchase
NORTH CENTRAL MO REGIONAL WATER COM MO2021537	3	25	0.65	2.80	1.20	2 Lakes, 1 Creek	Elmwood Lake Golf Course Lake Locust Creek	1.09
SMITHFIELD FARMLAND CORP MO2181076	9	1,200 (NTNC)	0.32	0.40	NR	1 Lake	Elmwood Lake	NR
SULLIVAN CO PWSD 1 MO2024594	1,738	4,327	0.74	0.70	0.09	SW Purchase		Purchase
Totals	**3,115**	**7,539**	**1.99**	**4.53**	**2.35**			

NR = Not Reported NTNC = Non-Transient Non-Community
[1]MDNR Drinking Water Watch
[2]NCMRWC 2015 Preliminary Engineering Report and Feasibility Analyses for Water System Source Improvements
[3]MDNR 2011 RESOP Analysis
[4]MDNR 2007 Groundwater System Evaluation

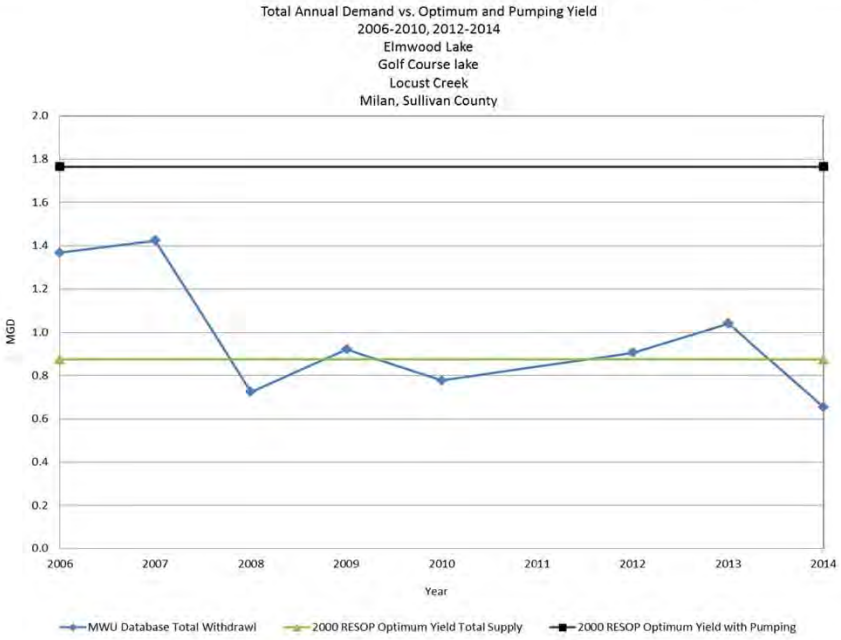


Figure 1-55 Demand Compared to 2000 Calculated Optimum Yield from Elmwood Lake, Golf Course Lake, and Locust Creek

Note: The demands projected above were not analyzed using RESOP. It is merely an aide to better understand the availability of the source.

Appendix C. MDNR Source Water Assessment Report, March 2016

North Central MO Regional Water Commission

PWSS No. 2021537, Elmwood Reservoir Intake

Sullivan County, Map 1 of 3

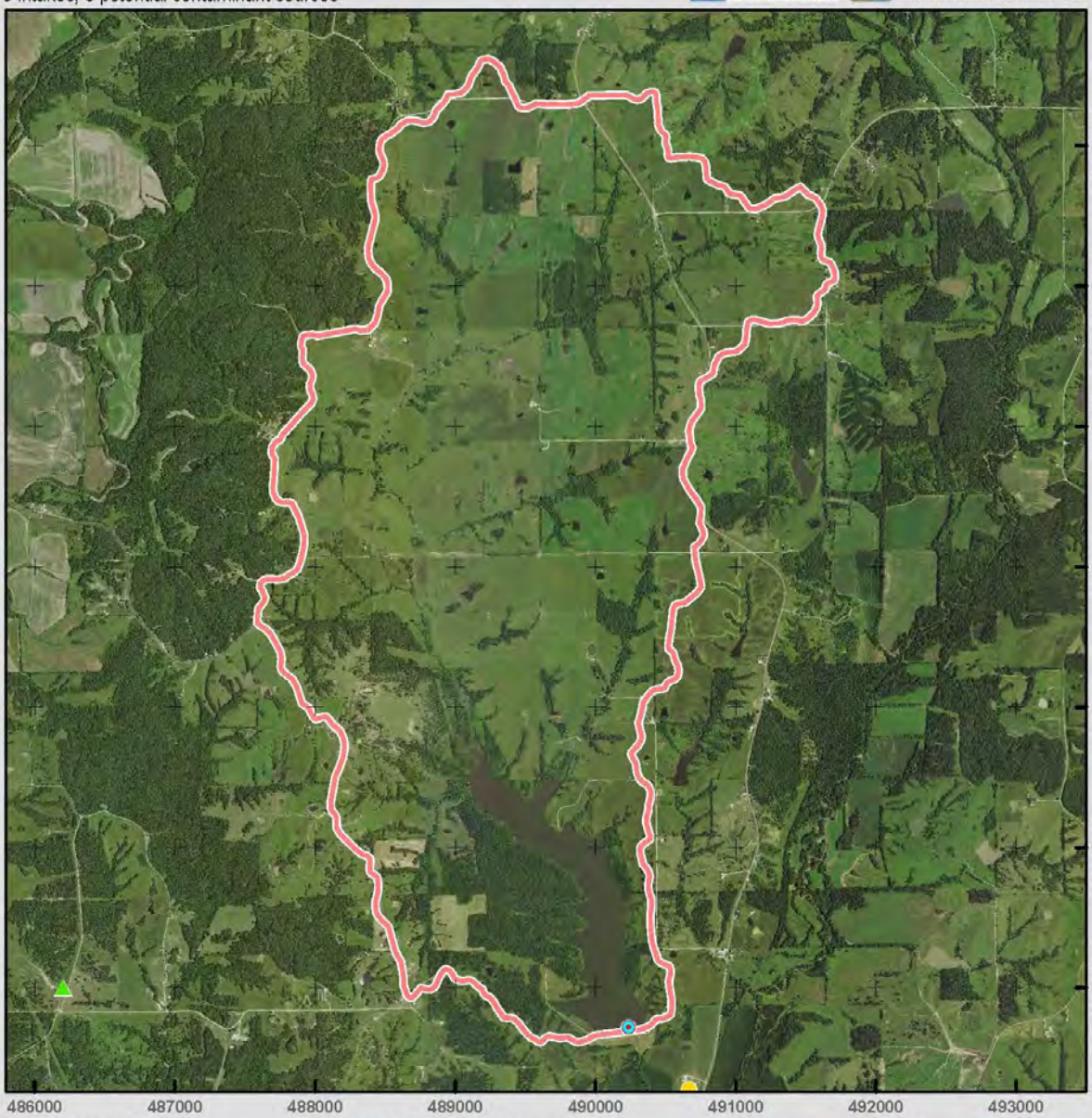
3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by:

CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

Miles

0 0.55 1.1

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

Aerial photos from 2014 USDA NAIP

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North Central MO Regional Water Commission

PWSS No. 2021537, New Milan Lake Intake

Sullivan County, Map 2 of 3

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by: Center for Applied Research and Environmental Systems, University of Missouri; Missouri Department of Natural Resources

Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

Miles

0 0.2 0.4

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

Aerial photos from 2014 USDA NAIP

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North Central MO Regional Water Commission

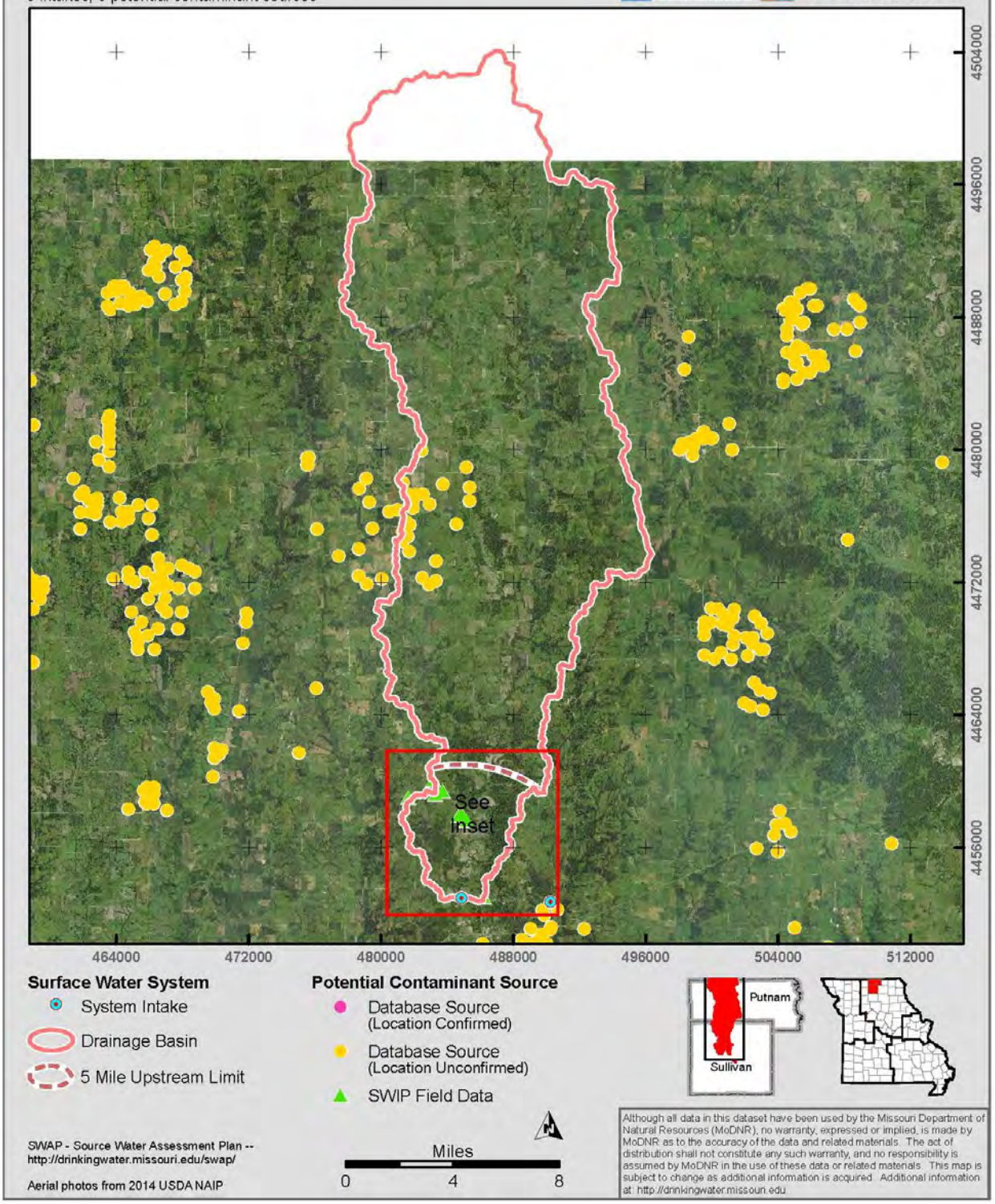
PWSS No. 2021537, Locust Creek Intake

Sullivan County, Map 3 of 3

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by:



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

Miles

0 4 8

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

Aerial photos from 2014 USDA NAIP

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North Central MO Regional Water Commission

PWSS No. 2021537, Locust Creek Intake

Sullivan County, Map 3 of 3 - INSET

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by: Center for Applied Research and Environmental Systems, University of Missouri; Missouri Department of Natural Resources

Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

Miles

0 0.7 1.4

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/

Aerial photos from 2014 USDA NAIP

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North Central MO Regional Water Commission

PWSS No. 2021537, Elmwood Reservoir Intake

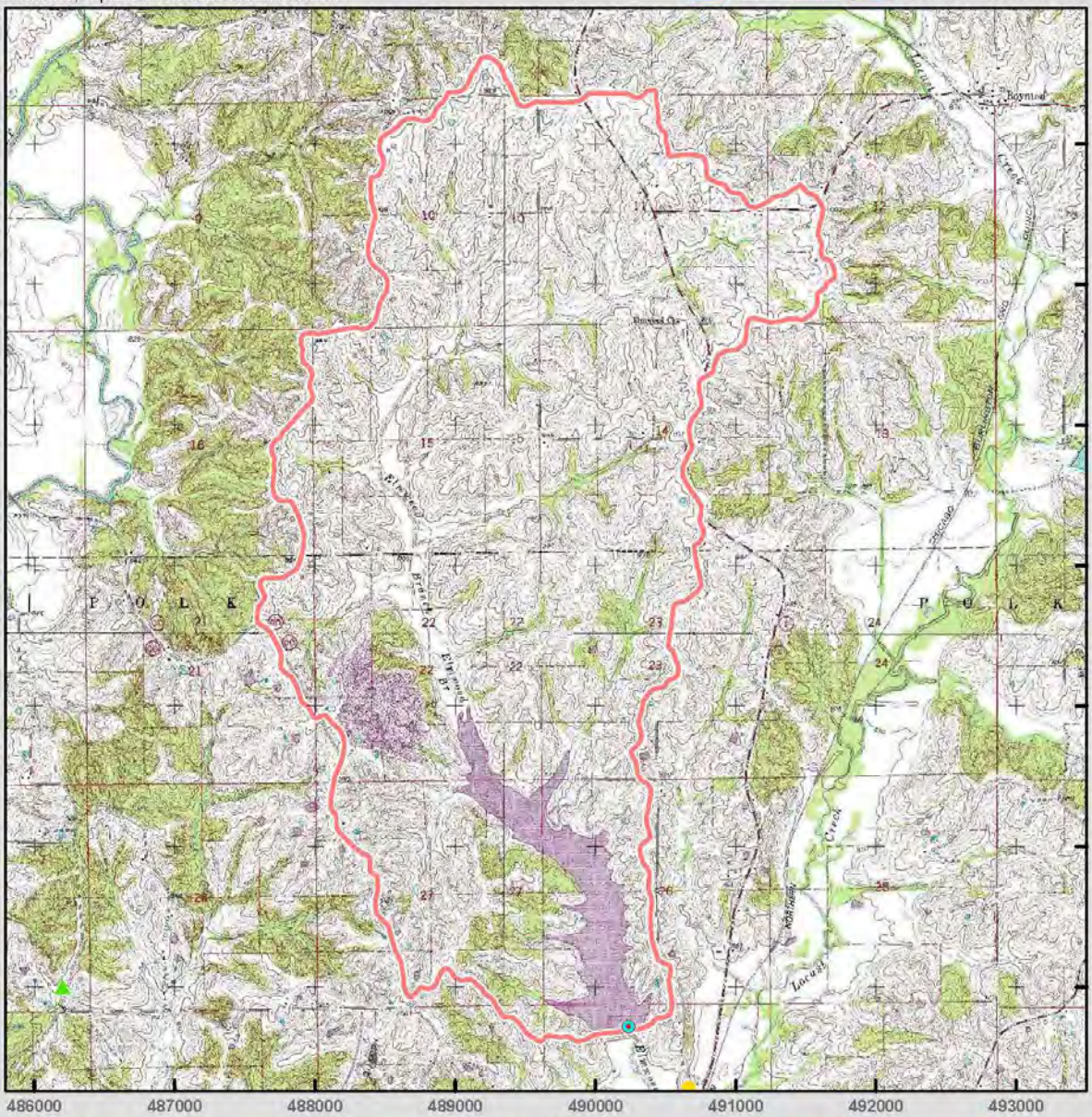
Sullivan County, Map 1 of 3

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by:

Missouri Department of Natural Resources



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

Miles

0 0.55 1.1

SWAP - Source Water Assessment Plan --
http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

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North Central MO Regional Water Commission

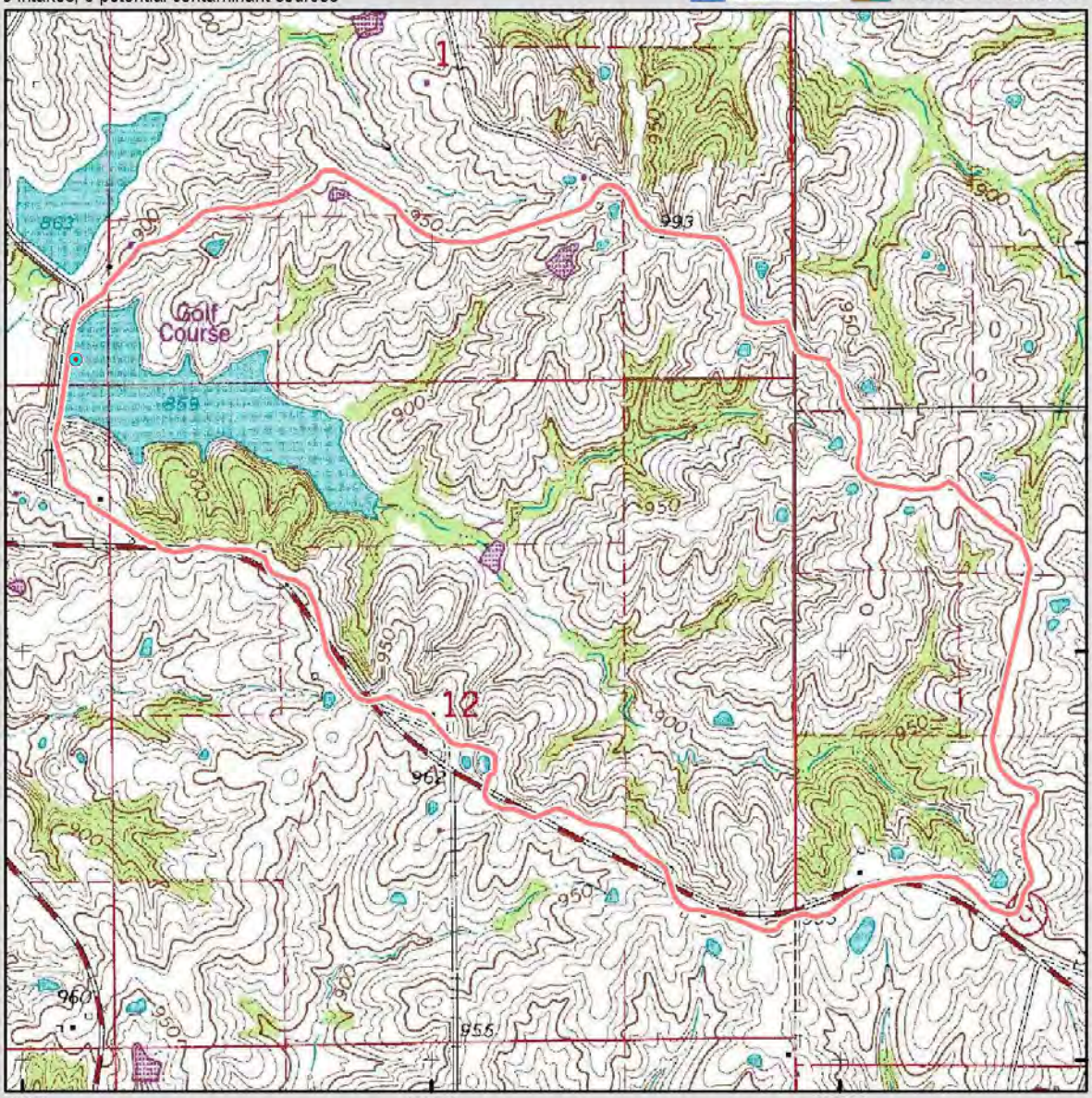
PWSS No. 2021537, New Milan Lake Intake

Sullivan County, Map 2 of 3

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by: Center for Applied Research and Environmental Systems, University of Missouri; Missouri Department of Natural Resources



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Miles
0 0.2 0.4

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North Central MO Regional Water Commission

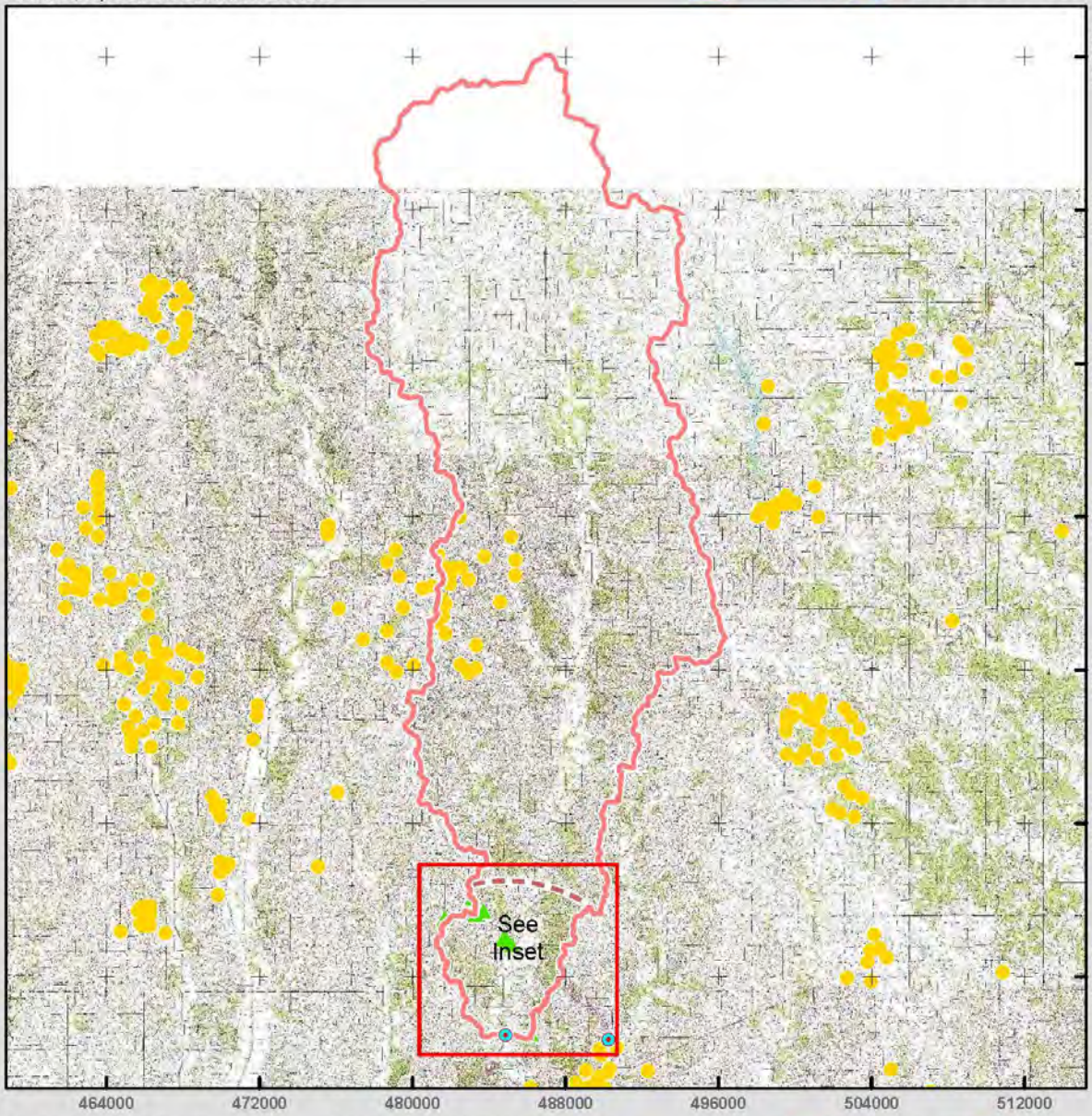
PWSS No. 2021537, Locust Creek Intake

Sullivan County, Map 3 of 3

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by: Center for Applied Research and Environmental Systems, University of Missouri; Missouri Department of Natural Resources



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Miles 0 4 8

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North Central MO Regional Water Commission

PWSS No. 2021537, Locust Creek Intake

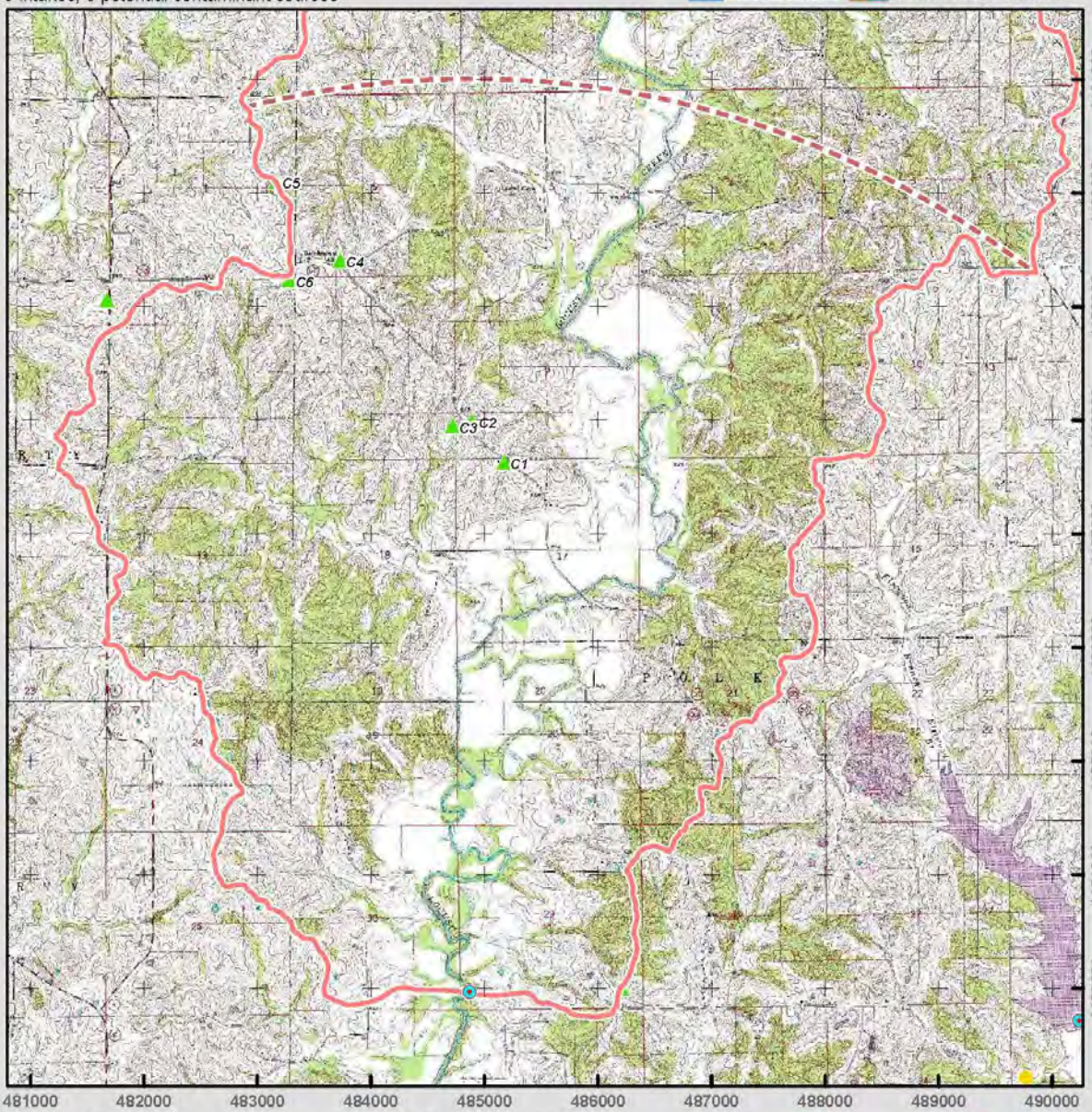
Sullivan County, Map 3 of 3 - INSET

3 intakes, 6 potential contaminant sources

Map Update: Mar 05, 2015

Prepared by:

Missouri Department of Natural Resources



Surface Water System

- System Intake
- Drainage Basin
- 5 Mile Upstream Limit

Potential Contaminant Source

- Database Source (Location Confirmed)
- Database Source (Location Unconfirmed)
- SWIP Field Data

SWAP - Source Water Assessment Plan -- http://drinkingwater.missouri.edu/swap/
For basemap symbols, see the U.S. Geological Survey (USGS) publication: Topographic Map Symbols.

Miles
0 0.7 1.4

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North Central MO Regional Water Commission

PWSS No. 2021537

Sullivan County

3 intakes

Sheet Update: Mar 05, 2015

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Intake ID	20216	20217	30117
Extended PWS #	2021537203	2021537202	2021537201
Local Intake Name	Elmwood Reservoir Intake	New Milan Lake Intake	Locust Creek Intake
Intake Type	Impoundment Intake	Impoundment Intake	River Intake
Contributing Acres	4,122.26	664.84	139,285.02
Latitude	-93.11477	-93.10421	-93.1778785665
Longitude	40.22486	40.19778	40.2270358509
Location Method	DRG/Map	DOQQ	GPS
Method Accuracy (ft)	200	33	82
USGS 7.5 Quadrangle	Milan East	Milan East	Milan West
County	Sullivan	Sullivan	Sullivan
MoDNR Region	Northeast	Northeast	Northeast

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North Central MO Regional Water Commission

PWSS No. 2021537

Northeast County

6 potential contaminant sources

Sheet Update: Mar 05, 2015

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Map C.No.	CARES ID	Site Name	Type	Location Code	Accuracy Code	Method Code	Database Code
C1	386133		Tank (above-ground fuel)	TK	33 ft	I2	CARES
C2	386134		Tank (above-ground fuel)	TK	33 ft	I2	CARES
C3	386135		Tank (above-ground fuel)	TK	33 ft	I2	CARES
C4	386136	Bairdstone Cemetery	Cemetery	CF	33 ft	I2	CARES
C5	386137		Tank (above-ground fuel)	TK	33 ft	I2	CARES
C6	386138		Tank (above-ground fuel)	TK	33 ft	I2	CARES

Method Codes

Code	Address Matching (Geocoding)
A2	Block/Group
A3	Street Centerline
A4	Nearest Street Intersection
A5	Primary Street Name
A6	Digitization
AO	Other Address Matching
Z1	ZIP Code Centroid
	Census - 1990
C1	Block Centroid
C2	Block/Group Centroid
C3	Tract Centroid

Code	Global Positioning System
G1	Static Mode
G2	Kinematic Mode
G3	Differential Post Processing
G4	Precise Positioning Service
G5	Signal Averaging
G6	Real Time Differential Processing
	Interpolation
I1	Topo Map
I2	Aerial Photography (DOQQ)
I3	Satellite Imagery

Code	Other
P1	Land Survey
S2	Quarter Description
UN	Unknown

Location Codes

BL	Building
CF	Center of Facility
IN	Intersection
LS	Lagoon or Pond
MG	Main Access Point (Gate)
MA	Main Office
OT	Other
PL	Pile
RD	Road
TK	Tank, Standpipe, or Tower
WL	Well
UN	Unknown

Accuracy Codes

Code	Metric
m	Meters
km	Kilometers
	English
ft	Feet
yd	Yards
mi	Miles
UN	Unknown
NF	Site not found at database position
NV	Site position not verified

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North Central MO Regional Water Commission

PWSS No. 2021537

Contaminant Summary Sheet

6 potential contaminant sources

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Sheet Update: Mar 05, 2015

6 Potential Contaminant Sources in the Listed Databases:

AFS (EPA AIRS Facility Sites)	Perchlo (MoDNR Perchlorate Sites in Missouri)
APCP (MoDNR Air Pollution Control Program Sites)	Pest Ap (MDA Licensed Pesticide Applicators)
APF (MoDNR Active Permitted Landfills & Transfer Stations)	RCRIS (EPA Resource Conservation and Recovery Information System)
CERCLIS (EPA CERCLIS)	Silos (USGS Minuteman II Missile Silos)
Chemcov (VA Selected Chemical Sites)	SMARS (MoDNR Superfund Management and Registry System)
Dealcov (MDA Pesticide Dealer Locations)	Tanks (MoDNR Petroleum Tank Database)
Dioxin (MoDNR Confirmed Dioxin List)	Tier 2 (MERC Tier II Reports)
Grain B (USDA Former Grain Bin Sites)	Tire D (MoDNR Resolved and Unresolved Waste Tire Dumps)
HW Gen (MoDNR Hazardous Waste Generators)	TRI (EPA Toxic Release Inventory)
HW Tran (MoDNR Hazardous Waste Transporters)	VCP (MoDNR Voluntary Cleanup Program Sites)
LUST (MoDNR Leaking Underground Storage Tanks)	WQIS (MoDNR Water Quality Information System)
MoDOT (MoDOT Highway Maintenance Facilities)	
PADS (EPA PCB Activity Data Base System)	6 SWIP Field Inventory (see below)

6 Potential Contaminant Sources in the SWIP Field Inventory:

0	Airport or abandoned airfield	0	Machine or metalworking shop
0	Animal feedlot	0	Manufacturing (general)
0	Apartments and condominiums	0	Material stockpile (industrial)
0	Asphalt plant	0	Medical institution
0	Auto repair shop	0	Metal production facility
0	Automotive dealership	0	Mining operation
0	Barber and beauty shop	0	Other
0	Boat yard and marina	0	Paint store
0	CAFO	0	Park land
0	Campground	0	Parking lot
0	Car wash	0	Petroleum production or storage
0	Cement Plant	0	Pharmacies
1	Cemetery	0	Photography shop or processing lab
0	Communication equipment mfg	0	Pit toilet
0	Country club	0	Plastic material and synthetic mfg
0	Dry cleaner	0	Print shop
0	Dumping and/or burning site	0	Railroad yard
0	Electric equipment mfg or storage	0	Recycling/reduction facility
0	Electric substation	0	Research lab
0	Farm machinery storage	0	Restaurant
0	Feed/Fertilizer/Co-op	0	Sawdust pile
0	Fire station	0	School
0	Funeral service and crematory	0	Sports and hobby shop
0	Furniture manufacturer	0	Swimming pool
0	Furniture repair or finishing shop	0	Tailing pond
0	Garden and/or nursery	5	Tank (above-ground fuel)
0	Garden, nursery, and/or florist	0	Tank (other)
0	Gasoline service station	0	Tank (pesticide)
0	Golf courses	0	Tank (underground fuel)
0	Government office	0	Trucking terminal
0	Grain bin	0	Veterinary service
0	Hardware and lumber store	0	Wastewater treatment facility
0	Hazardous waste (Federal facility)	0	Well (abandoned)
0	Highway maintenance facility	0	Well (domestic)
0	Jewelry or metal plating shop	0	Well (irrigation)
0	Junk yard or salvage yard	0	Well (livestock)
0	Lagoon (commercial)	0	Well (monitoring)
0	Lagoon (industrial)	0	Well (public water supply)
0	Lagoon (municipal)	0	Well (unknown)
0	Lagoon (residential)		
0	Landfill (municipal)		
0	Laundromat		
0	Livestock auction		

Although all data in this dataset have been used by the Missouri Department of Natural Resources (MoDNR), no warranty, expressed or implied, is made by MoDNR as to the accuracy of the data and related materials. The act of distribution shall not constitute any such warranty, and no responsibility is assumed by MoDNR in the use of these data or related materials. This sheet is subject to change as additional information is acquired. Additional information at: http://drinkingwater.missouri.edu.

North Central MO Regional Water Commission

PWSS No. 2021537

Susceptibility Determination Sheet

3 intakes

Prepared by: CENTER FOR APPLIED RESEARCH AND ENVIRONMENTAL SYSTEMS UNIVERSITY OF MISSOURI

Missouri Department of Natural Resources

Sheet Update: Mar 05, 2015

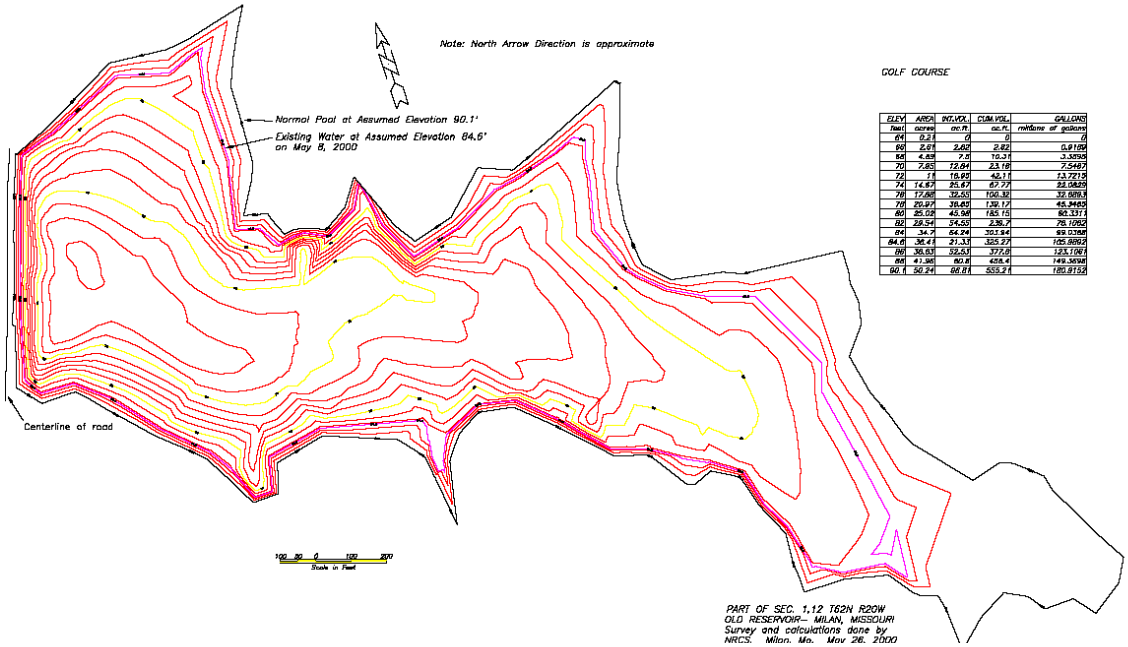
The Missouri Department of Natural Resources (MoDNR) has assembled this information to assess the susceptibility of drinking water sources to contamination. There are many unforseen and unpredictable factors that may cause a source to be contaminated. MoDNR routinely monitors all public supplies to ensure public health is protected. Public water systems and local communities are encouraged to take all measures possible to reduce the susceptibility of their drinking water source to chemical contamination. For more information, call 1-800-361-4827.	Not Susceptible	Moderately Susceptible	Highly Susceptible	Incomplete Data
A system is highly susceptible based on detection histories if:				
Volatile Organic Chemicals (VOCs) have been consistently detected the source water,				X
Synthetic Organic Chemicals (SOCs) have been consistently detected the source water,				X
Inorganic Chemicals (IOCs) have been detected in a well above naturally occurring levels,				X
Nitrates have been consistently detected at or above one-half the MCL, or				X
Viruses or microbiological contaminants are consistently detected in the source water.			X (1)	
A system is moderately susceptible to contaminants if:				
Any contaminants listed in Appendix F-a are found in the source water area,		X (2)		
Land use in the source water area is a likely non-point source of contamination,				X
The water body receives recharge from a contaminated groundwater source, or				X
There is a high density of transportation corridors in the source water area.				X
A system is highly susceptible to contamination if:				
Any contaminant sites identified in the source water area are known to have released contaminants into the environment and may reach the water body, or				X
A large portion of the land use in the source water area is a likely non-point source of contamination, or				X
The source water is affected by contaminated groundwater.				X

(1) This system uses a water source that shows signs of contamination. The Department of Natural Resources will monitor the degree of contamination. The water system should treat the water accordingly to remove contamination before it enters the distribution system. The water system and watershed protection team should also make an effort to eliminate contaminants entering the source water.

(2) An intake (or intakes) serving this system has been determined to be susceptible due to the presence of potential contaminant sources. The water system and the watershed protection team should take extra care to ensure that all potential contaminants in the source water area are handled properly to avoid contamination of the drinking water supply. Periodic monitoring will be required to track contamination of the source water. If possible, contaminant sources should be removed from the source water area.

Although all data in this document have been used by the Missouri Department of Natural Resources (MoDNR), no warranty, expressed or implied, is made by MoDNR as to the accuracy of the data and related materials. The act of distribution shall not constitute any such warranty, and no responsibility is assumed by MoDNR in the use of these data or related materials. This document is subject to change as additional information is acquired. Additional information at: http://drinkingwater.missouri.edu

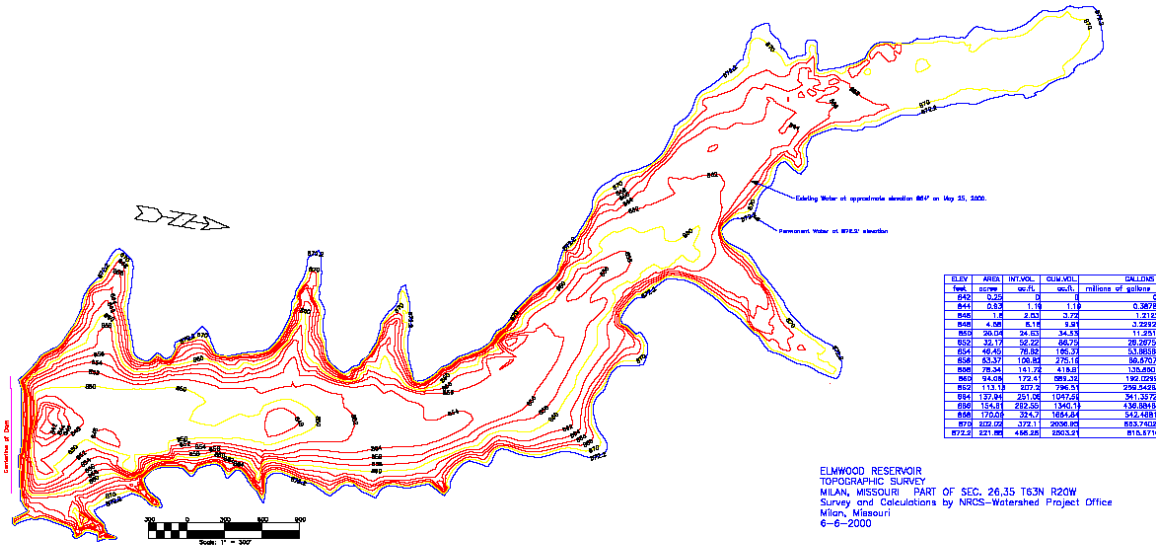
Appendix D. Bathymetric & Volume Information for Elmwood Lake and Old East Reservoir in Sullivan County



GOLF COURSE

ELEV	AREA	INT.VOL.	CUM.VOL.	GALLONS
feet	acres	cu.ft.	cu.ft.	millions of gallons
64	0.21	0	0	0
66	2.61	2.82	2.82	0.91108
68	4.88	7.5	10.31	3.33155
70	7.65	12.84	23.15	7.5447
72	11	18.65	42.11	13.7215
74	14.67	25.67	67.77	22.0825
76	17.86	32.53	100.32	32.6918
78	20.97	38.83	139.17	45.3485
80	25.02	45.98	185.15	60.3371
82	28.54	54.53	239.7	78.1052
84	34.7	64.24	303.94	99.0388
84.6	36.41	21.33	325.27	105.9893
86	38.63	52.53	377.8	123.1061
88	41.96	80.8	458.4	149.3698
90.1	50.24	96.81	555.21	180.9153

Figure 22.4.b Bathymetric map and area/volume table of Golf Course Reservoir, Milan, Missouri. **ri**



ELEV	AREA	INT.VOL.	CUM.VOL.	GALLONS
feet	acres	ac.ft.	ac.ft.	millions of gallons
842	0.25	0	0	0
844	0.63	1.19	1.19	0.3878
846	1.6	2.53	3.72	1.213
848	4.58	6.18	9.9	3.2292
850	30.04	34.63	34.53	11.251
852	33.17	52.22	86.75	28.2675
854	46.45	78.62	165.37	53.9059
856	63.37	109.82	275.18	89.6703
858	78.34	141.72	416.91	135.880
860	94.08	172.41	589.32	192.0291
862	113.13	207.2	796.53	259.5426
864	137.94	251.06	1047.59	341.3572
866	154.81	292.55	1340.14	436.9818
868	170.06	324.7	1664.84	542.4891
870	372.05	372.1	2036.95	663.7402
872.3	221.86	466.26	2503.21	815.671

Figure 22.4.a Bathymetric map and area/volume table of Elmwood Reservoir, Milan, Missouri.

Appendix E. Sullivan County Soil &
Water Conservation District Letter of Support

Sullivan County Soil and Water Conservation District
23487 Eclipse Drive
Milan, Mo. 63556
660-265-3440 Ext. 3

August 23, 2017

Mr. Brad Scott, General Manager
North Central Missouri Regional Water Commission
201 N. Market Street
Milan, MO 63556

Dear Mr. Scott:

The Sullivan County Soil and Water Conservation District Board strongly supports the completion of the East Locust Creek Reservoir Project. Currently, Sullivan County does not have a reliable source of drinking water. This project will address a critical need for both Sullivan County citizens and agricultural producers. At our August 4th meeting, the Board agreed to assist with your source water protection efforts by making the watershed of the lake a priority for District funds.

We look forward to collaborating on this critically important project.

Jimmy Hoselton
Chairman
Sullivan County Soil and Water Conservation District

Appendix F. The Commission's Emergency Operations Plan

MIKE WARD – OPERATION MANAGER – A- #940	660-292-0744
LAWRENCE ALLEN – CHIEF OPERATOR – A – 12136	660-946-4328 660-973-62…
J.C MACALISTER – D – 9143	660-265-3774 660-988-5559
ELLEN HODGE – OFFICE MANAGER	660-265-4448 660-342-2547
BRAD SCOTT – MANAGER	816-590-0264
AUTHORITY CONTACTS	
MODNR – NORTHEAST	660-385-8000
EPA REGION 7	913-551-7030
EMERGENCY RESPONSE	573-634-2436
MODNR CENTRAL OFACE	573-751-5331 OR 573-751-4674
FBI	816-512-8200
STATE EMERGENCY MANAGEMENT	573-751-9100
STATE LAB	573-751-7929
SULLIVAN CO. LEPC	911
RURAL ELECTRIC COOP	660-265-4404

SUPPLY REPAIR CONTACTS	
REGER ELECTRIC – MILAN	660-445-2130
THN ELECTRIC	660-665-4598
SIDENER	816-377-0044 800-528-2887
HACH (CHEMICAL)	800-227-4224
BRENNTAG MID-SOUTH INC. (CHEMICAL)	800-821-7400
AQUAPURE (CHEMICAL)	216-709-0092
DAN STEVENS (TRACHOE SERVICES)	660-635-1631
SYSTEMS	913-422-9260
G.S. ROBBINS	314-302-0090
HENKE APPLICATIONS	660-748-5859
HAYNES EQUIPMENT	913-782-4962
U.S. FILTER-WATRELINE PARTS	314-442-4450

RESPONSE TO FACILITY FAILURE

IF THE NCMRWC WATER PLANT FAILS FOR WHATEVER REASON THERE IS CONTINGENCY PLAN TO PROVIDE WATER TO THE NCMRWC MEMBERS AND THEIR CUSTOMERS.

1. 8” FINISHED WATER MAIN FROM TRENTON, MO, WILL SUPPLY 400,000 GPD TO SULLIVAN RURAL AT ENTRY POINT AND WILL SUPPLY WATER TO REMAINING NCMRWC MEMBERS UNDER POSSIBLE RESTRICTIONS ON WATER USE.
2. 8” FINISHED WATER MAIN FROM FARMLAND FOODS WHICH WILL PROVIDE A MINIMUM OF 200,000 GPD TO THE MILAN AND GREEN CITY GREEN CASTLE AREA.
3. FINISHED WATER MAY TRANSPORTED FROM WATER SALESMAN AT WATER PLANT VIA MILAN RURAL FIRE TRUCKS. MILAN RURAL HAS 31,200 GALLON TANKS AND 21,000 GALLON TANKS. TRUCKS SHOULD BE DISINFECTED WITH TWO GALLONS OF BLEACH PER 2,000 GALLONS OF WATER FOR SIX HOURS AND THEN DRAINED AND FLUSHED AND REFILLED.

CHEMICAL HAZARD OR FIRE
THE MILAN RURAL FIRE DEPT. IS THE FIRST RESPONDER TO EITHER A CHEMICAL HAZARD OR FIRE.

THE NCMRWC HAS TWO REFERENCE MANUALS FOR EMERGENCY RESPONSE
1. MODNR
2. SULLIVAN COUNTY LEPC

BOTH MANUALS MAY BE USED FOR REFERENCE DEPENDING ON SITUATION.

COOPERATIVE ACTIONS
THE NCMRWC WILL BE IN DIRECT COOPERATION WITH THEIR REGULATORY AUTHORITY, THE MISSOURI DEPARTMENT OF NATURAL RESOURCES FOR DIRECTION AND GUIDENCE SO THAT ANY EMERGENCY MAY BE RESOLVED IN A TIMELY MANNER.

ELECTRICAL FAILURE
THE NCMRWC CONTACT FOR ELECTRIC OUTAGE IS THE RUAL ELECTRIC COOPERATIVE AND THEY SHALL ACT AS REPAIR AND REPLACE FOR ANY PRIMARY POWER OUTAGE PROBLEMS.

SNOW REMOVAL
IN CASE OF A BLIZZARD, THE NCMRWC MAY CONTRACT THE CITY OF MILAN ROAD DISTRICT FOR HEAVY SNOW REMOVAL.

List of Engineers

Larkin and Associates
9233 Ward Parkway Suite 300
Kansas City, Mo. 64114

Rhodes Engineering
401 West Helm
Brookfield, Mo. 64628

ET Archer
3234 E. 11th Suite 2305
Kansas City, Mo. 64106

Mark Young, PE (MBE)
Bucher Willis & Ratliff Corporation
7920 Ward Parkway
Kansas City, Mo. 64114-2021

Cary Sayre, PE
Allstate Consultants
119 S. Main Street
Marceline, Mo. 64658

EPM Inc. (MBE)
13A SW 3rd St.
Lee's Summit, Mo. 64063

Dubois Consultants Inc. (MBE)
5737 Swope Parkway
Kansas City, Mo. 64130

Akin Gordon & Cowger Engineers Inc. (WBE)
P.O. Box 754
Liberty, Mo. 64068

Shafer Kline & Warren Inc.
921 Jackson St.
Chillicothe, Mo. 64601

Crowley, Wade, Milstead, Inc.
3200 South M-291
Independence, Mo. 64057

Snyder & Associates
802 Francis
St. Joseph, Mo. 64501

Benton & Associates, Inc.
713 N. High St.
Kirksville, Mo. 63501
adorrell@bentonassociates.com

Great River Engineering, Inc.
P.O. Box 29
Bowling Green, Mo. 63334

Bartlett & West Inc.
1719 Southridge Dr., Suite I00
Jefferson City, Mo. 65109
phone: 573-634-3181

Olsson Associates
1251 NW Briarcliff Parkway
Kansas City, Mo. 64116
phone: 816-361-1177
fax: 816-361-1888
www.oaconsulting.com

Arcturis (WBE)
1910 Pine Street
St. Lows, Mo. 63103
ARCTURIS.COM

Trabue, Hansen & Hinshaw Inc.
1901 Pennsylvania Drive
Columbia, Mo. 65202
phone: 573-814-1568
twooten@thhinc.com

Poeping, Stone, Bach, and Ass.
Attn: Michael Purol, PE
80 Broadway, Suite 224
U.S. Federal Building
P.O. Box 190
Hannibal, Mo. 63401
phone: 573-406-0541
fax: 573-406-0390
michaelp@psba.com

Gredell Engineering Resources
1505 East High Street
Jefferson City, Mo. 65101
phone: 573-659-9078
fax: 573-659-9079

Appendix G: Quality Assurance Project Plan

Quality Assurance Project Plan

for

Headwaters of East Locust Creek

Prepared for

The North Central Missouri Regional Water Commission

201 North Market Street

Milan, MO 63556

Prepared by

Allstate Consultants

3312 LeMone Industrial Blvd.

Columbia, MO 65201

Approval Signatures (required prior to project start):

_____ Date: _____
Project Manager Print Name

_____ Date: _____
QA Officer Print Name

_____ Date: _____
Project Official Print Name

_____ Date: _____
Project Official Print Name

Table of Contents

Provide a table of contents for the document, including sections, figures, tables, references, and appendices. Apply a document control format on each page following the Title and Approval Sheet when required by the Project Manager and QA Manager.

Section **Page**

1.0 PROJECT MANAGEMENT 3
1.1 Distribution List 3
1.2 Project/Task Organization 3
1.3 Problem Definition/Background 3
1.4 Project/Task Description and Schedule 8
1.5 Quality Objectives and Criteria for Model Inputs/Outputs 10
1.6 Documents and Records 11
2.0 DATA GENERATION AND ACQUISITION 11
2.1 Calibration 11
2.2 Data Acquisition Requirements (Non-Direct Measurements) 12
3.0 ASSESSMENT AND OVERSIGHT 13
3.1 Assessment and Response Actions 13

1.0 PROJECT MANAGEMENT

1.1 Distribution List

Project Manager
Bradley M. Scott
NCMRWC General Manager
201 North Market St.
Milan, MO 63556
(660) 265-4448

Engineer
John Holmes, PE, CFM, LEED-AP
Allstate Consultants LLC
3312 LeMone Industrial Blvd.
Columbia, MO 65201
(573) 875-8799

1.2 Project/Task Organization

The Quality Assurance Project Plan (QAPP) for The Headwaters of East Locust Creek HUC 12 is to serve as a supplemental resource to the Source Water Protection Plan developed for the North Central Missouri Regional Water Commission (NCMRWC). The QAPP will create a water quality modeling environment to analyze the current and proposed water supplies. The NCMRWC has directed Allstate Consultants LLC to develop the QAPP and the associated model of the HUC 12. Specifically, John Holmes (P.E., C.F.M., LEED-AP) and Brent Elliott will develop the watershed model and Bradley Scott (NCMRWC General Manager) will act as the Quality Assurance (QA) Manager. The project team will continue to grow as the development of the model progresses.

1.3 Problem Definition/Background

The Headwaters of East Locust Creek HUC 12 is home to the existing Elmwood Reservoir and the proposed East Locust Creek Reservoir (ELCR), both of which have the primary purpose of providing public drinking water. Elmwood Reservoir is the current primary source of water for the North Central Missouri Regional Water Commission (NCMRWC) which has been tasked with developing ELCR and leading in regionalization of water supply in the 10-county region surrounding Sullivan County, Missouri, the home of both reservoirs. NCMRWC currently supplies water for Sullivan County and a small part of Linn County to the south but does not have adequate water sources to be able to produce water during a drought similar to the drought of the 1950s (design drought). Elmwood Reservoir is supplemented with pumping from additional sources, but this pumping would not be sufficient to prevent running out of water in

the design drought.

The ELCR is being designed to allow the 10-county region to have adequate water during the design drought. Construction of ELCR is anticipated to cost nearly $100 million and commence in 2019 or 2020. Reservoir construction will take 2 years and filling could take an additional 2 to 5 years. Consequently, Elmwood Reservoir will likely remain the primary drinking water source for NCMRWC until at least 2023 and possibly until 2026.

Given the critical nature of the current water supply and the large investment required to construct ELCR, it is crucial that the project team be proactive in protecting the integrity of these sources. Accordingly, a Source Water Protection Plan (SWPP) was envisioned and this QAPP is being written to guide development of a water quality modeling environment to provide information for implementation of the SWPP. The goal of this QAPP is to assist the project team in developing a modeling environment that will efficiently provide useful information in the short and long term. The modeling environment will need to address at least three phases.

- Elmwood Reservoir and its auxiliary sources, current conditions
- ELCR watershed and reservoir bed, pre-construction
- ELCR watershed management and reservoir operations, post construction

A significant driver in the need for a modeling environment is new nutrient criteria proposed by the Missouri Department of Natural Resources (MDNR) and under review by EPA. If accepted by EPA, the criteria will be applicable to both reservoirs. The criteria specifies screening thresholds for nitrogen, phosphorous, and chlorophyll. Under these proposed criteria, the reservoirs will be classified as impaired and placed on the 303(d) list in one of two ways.

A. The geometric mean of samples taken between May and September in a calendar year exceeds the Chlorophyll-a Response Impairment Threshold Value (30 ug/L) more than once in three years' time.

B. The geometric mean of samples taken between May and September in a calendar year exceeds screening threshold value for Chlorophyll-a (18 ug/L), Total Nitrogen (843 ug/L) or Total Phosphorous (49 ug/L) in the same year that one of five response assessment endpoints are identified in the reservoir. The five response assessment endpoints are:
    1. Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms,
    2. Epilimnetic excursions from dissolved oxygen or pH criteria,
    3. Cyanobacteria counts in excess of 100,000 cells/mL,
    4. Observed shifts in aquatic diversity attributed to eutrophication, and,
    5. Excessive levels of mineral turbidity that consistently limit algal productivity during the period of May 1 – September 30.

MDNR will derive the schedule for monitoring based on their understanding of which bodies of water are likely to be impaired; but, for the purposes of this document, it should be assumed that MDNR monitoring will occur annually.

Selection of a modeling environment involves weighing the costs and benefits of a range of model capabilities and finding a model that fits the budget while providing as many of the desired capabilities as possible. The capabilities needed depend on the modeling project goals. Some of the questions that could be partially answered by the model are listed below.

- Current Conditions
    - How much additional nutrient loading could Elmwood Reservoir handle if it becomes necessary to supplement water supply from higher concentration sources?
    - How long will the current water sources adequately supply water if a drought continues?
    - If the proposed new state nutrient criteria are implemented, will Elmwood Reservoir be listed? What avoidance alternatives are available?
- ELCR watershed and reservoir bed pre-construction
    - Will the proposed clearing be sufficient to avoid excessive nutrient loading at startup?
    - What will be the post-project concentration of any constituents that exist in the reservoir bed prior to inundation?
    - What will be the best elevation to locate the ecological flows intake to ensure optimal water conditions for downstream?
    - Which constituent issues are of most concern?
    - What sources contribute the most pollutants?
    - How proactive do we need to be about nutrients, sediment, etc.?
    - Will the model be flexible enough to provide additional answers as new questions arise?
- ELCR watershed management, including reservoir operations and buffer management
    - Under what set of climatic conditions do we need to pay special attention to nutrient loading problems?
    - Can the model predict algal blooms and guide reaction?
    - Can the model be adjusted to help in rapid evaluation of developing issues?
    - Policy decisions
        - What will be the constituent impacts of agricultural use changes in the watershed?
        - What will be the constituent impacts of future development?
        - What watershed BMP policies would be most cost effective?

    - What agricultural practice policies would be most cost effective?
    - What activities should the project team incentivize in watershed?
    - What is the value of increasing buffer widths?
    - How will climate change impact the reservoirs?
    - How will potential regulatory changes affect the reservoirs?
  - Can impairment listing be avoided at a reasonable cost?
  - If ELCR is considered for addition to the impaired waters list, can we provide information to refute the listing?
  - Financials
    - Can we document the need for funding for source water protection?
    - What are the cost benefit tradeoffs of proposed projects?
    - What will be the added treatment cost due to a proposed change?
    - Would a BMP cost be recouped in reduced water treatment cost?
    - Compare policy decisions to water treatment costs?

The following capabilities are being considered in this evaluation.

Capabilities	Variables	Options
Model watershed loading rates of various constituents[a].	On what spatial scale?	The source water protection plan is intended to cover the HUC 12, so a spatial scale that supports a HUC 12 level analysis would be optimal.
	On what temporal scale?	No need for a sub-daily time step has been identified. An annual time step would be too coarse to address many of the project purposes. A daily time step would be optimal, but a monthly time step may be adequate for most purposes.

Capabilities	Variables	Options
	How broad an array of constituents?	Core constituents that are certainly needed from the watershed model are: ● Total Nitrogen ● Nitrate/Nitrite ● NH3 ● Total Phosphorous ● Sediment ● BOD ● Runoff Volumes However, all other things being equal, whichever model has the broadest range of capabilities is best for addressing future concerns.
	What BMP/Practices should it simulate?	The watersheds are currently heavily agricultural in nature so the ability to model agricultural practices is highly valuable. The watershed will likely experience some retail and residential development due to construction of ELCR so the ability to model limited "urban" BMPs is also of value.
Model the fate and interactions of these constituents in the reservoirs	Built into watershed model, linked to watershed model, or completely independent?	Given the need to model the watershed at a relatively small scale and a relatively small time step plus the need to utilize a two dimensional reservoir model for East Locust Creek, it is most likely that a linked model is the best option. However, a single model that met all these criteria would be optimal.
	On what spatial scale?	Given the certainty that ELCR will be a stratified reservoir and that we wish to use the ELCR model for a variety of purposes, it would be appropriate to use a two-dimensional model with the second dimension being used to model the stratification. Alternatively, it may be possible to get by with a one-dimensional model for Elmwood Reservoir because it is not expected to need as wide an array of modeling capabilities.

Capabilities	Variables	Options
	On what temporal scale?	Because a major concern will be predicting and reacting to algal blooms, a daily model is probably required for ELCR. The Elmwood Reservoir model may be adequate on a monthly temporal scale. An annual model would not be sufficient for either.
	How broad an array of constituents?	The reservoir models will need to evaluate the same core constituents as the watershed model, plus chlorophyll. However, all other things being equal, whichever model has the broadest range of capabilities is best for addressing future concerns.
a. For the purposes of this document, "constituents" is intended as a general term representing the range of pollutants, contaminants, conditions, parameters, etc., including but not limited to nutrients, algae, oxygen, oxygen demand, sediment, temperature, etc.		

As of this writing, the watershed model selection has been narrowed down to one of the following three choices.

- BASINS
- HSPF
- SWAT

All three of these choices provide the capabilities described in the table above and all three have interface options that allow for fairly rapid collection and processing of basic model data. We are leaning towards SWAT because it has the best options for modeling agricultural practices but are not yet committed to that choice.

It is our plan to use the WASP model for the reservoir water quality modeling because it can be linked to multiple watershed models and because it has all of the capabilities described above.

1.4 Project/Task Description and Schedule

The project is envisioned as a phased and practical approach to develop a robust model over the long term. In the interim, confidence in model results for various project sub-areas and constituents will gradually grow at varying rates. For example, the Elmwood Reservoir portion of the model will have data for calibration readily available early in the project and will represent an active drinking water system necessitating a high level of confidence before model results are used to make operational decisions. The ELCR portion, on the other hand, will need to produce hypotheses to help make design decisions before full scale calibration is even possible. In the short term it is hoped that the model, while possibly still uncalibrated, will be capable of providing useful but tentative direction to the project team in making decisions regarding the preparation of the reservoir bed. As time passes, it may become possible to calibrate watershed inputs prior to the filling of ELCR and improve confidence to some degree, even before the

receiving water response can be calibrated. By the time the reservoir is filled and starting to provide drinking water, it is hoped that the model will be ready to be calibrated and the project team will have developed insights into where the critical calibration points are.

Time Frame	Item	Assigned To
Ongoing	Nutrient sampling of existing drinking water sources	John Holmes, Christina Judas
Ongoing	Design of ELCR	Project Team
Fall 2018	Watershed and receiving water model selection	John Holmes, Brent Elliot
Fall 2018	Uncalibrated watershed model development	John Holmes, Brent Elliot
Fall 2018	Elmwood Reservoir water quality model development and calibration	John Holmes, Brent Elliot
Winter 2018	Apply Elmwood Reservoir model to management of Elmwood Reservoir	John Holmes, Brent Elliot
Winter 2018	"Calibration" of entire watershed model based on Elmwood Reservoir results	John Holmes, Brent Elliot
Spring 2019	ELCR water quality model - uncalibrated	John Holmes, Brent Elliot
Spring 2019	Apply uncalibrated ELCR water quality model predictions to final design of ELCR	John Holmes, Brent Elliot
Spring 2019	Develop plan for early verification and adaptation of ELCR design assumptions that are based on the model	John Holmes, Brent Elliot
Spring 2019	Water quality sampling of major watershed inputs into proposed ELCR	Greg Pitchford, Heather Krempa
Summer 2019	Verification of watershed model calibration for ELCR major inputs	John Holmes, Brent Elliot
Fall 2019	Design of ELCR complete	Project Team
Spring 2020	Adjust sampling plan based on 2019 results and continue water quality sampling of major watershed inputs into proposed ELCR	Greg Pitchford, Heather Krempa, John Holmes, Brent Elliot
Spring 2020-Fall 2021	Construction of ELCR	Project Team
Fall 2021-Fall 2026	Reservoir filling	Rainfall
2025-2026	Calibrate ELCR water quality model	TBD

1.5 Quality Objectives and Criteria for Model Inputs/Outputs

As described above, model output quality expectations will vary by location and constituent and through time as more calibration data becomes available. As the model is applied to a specific purpose, it will be necessary to write a Model Application Report (MAR) describing the purpose and criteria to be applied.

Examples of acceptance criteria and the types of data issues addressed are described below.

Data reasonableness: Data from various sources, including data collected prior to initiation of this plan will occur when necessary to provide needed input to the models and in some cases, calibration data. The reasonableness of these data will need to be evaluated and documented. For example, was the data set collected prior to major changes in the watershed?

Data completeness: Data that comes with quality control documentation will be weighted more heavily than other data, all other things being equal. The source of all data used in the models should be documented and the completeness of the set should be evaluated prior to its use. Additional sampling data collected will need to provide the information necessary to determine whether the reservoirs are meeting the proposed nutrient criteria and to meet the appropriate quality standards for that purpose.

Data representativeness: Data representativeness should also be addressed in the model documentation, such as specifying time and location for sample collection and comparability in sampling and sample analysis methods for input data. Other methods for assessing data representativeness relative to current conditions (e.g., photograph verification, visual assessment, considering data from bathymetric and ground truth land use surveys) can be detailed as needed.

Acceptability of model calibration and testing inputs and outputs: We are defining model calibration in this setting as how well the model is able to reproduce observed flow rates and concentrations of nutrient, dissolved oxygen, and chlorophyll-a (e.g., trends and peak values), as measured from field surveys.

Generally speaking, the long term goal will be that at least 90% of the input nutrient concentration measurements at a given sampling station should be within two standard errors of the mean measurement at that station.

Other goodness-of-fit evaluations may also be considered when determining model evaluation associated with these criteria. For example, data may need to be transformed (e.g., logarithmic) to better achieve these criteria and other model assumptions, or further investigations into specific data values may be necessary.

While it is preferable to develop quality criteria that tend to be quantitative in nature, certain stages of the model application process may benefit from assessments that are more general and qualitative. For example, when evaluating the outcome of model calibration, qualitative

assessments may be done by evaluating how well the outputs of the fitted model are able to match the overall trend in prediction over time or over the entire watershed area. This evaluation could be documented in a MAR by using graphs. An evaluation of how well these model outputs reflect peaks and valleys in the predicted water quality values at specified time points or at certain points in the watershed can also be compared to what has been observed and collected in surveys.

1.6 Documents and Records

Documentation will be important for defending the model predictions used for all purposes ranging from design decisions to providing supporting information for addressing impairments. The type of information that will be part of the record should be itemized so that modelers are aware before the project begins of the records that should be kept. Examples of appropriate documentation include: calibration and sensitivity analyses results, records of written rationale for selection of models or modules, record of code verification (e.g., hand-calculated checks, comparison to other models), sources of existing data used, and any adjustments to model parameter values that result from model calibration. All records, including modeler's notebooks and electronic files, should be maintained by the project manager in a central project archive.

2.0 DATA GENERATION AND ACQUISITION

2.1 Calibration

Water quality data on such measures as chlorophyll-*a*, phosphorus, nitrate, and dissolved oxygen that were collected from earlier surveys, in addition to flow measurements obtained from the United States Geological Survey gage on East Locust Creek (06901205), will be supplemented by additional sampling and used in calibrating the model depending on the particular application.

The calibration will judge the extent to which the model is able to predict current and future water quality measures that agree with what was actually observed in the surveys. For instance, the extent to which the model accurately captures observed trends in the water quality data at the various sampling points in the reservoirs, after taking into account the underlying variability in these monitored data, will be determined and appropriately documented. The performance criteria upon which the calibration will be deemed acceptable will be noted in a MAR developed for each individual application of the model.

Within the model calibration exercise, model rate coefficients will be adjusted as necessary to meet the calibration criteria and to reflect current scientific knowledge and various process rates that fall within a reasonable range of values found in the scientific literature. A list of internal variables used to calibrate the model outputs should be included in the MAR, along with any adjustments made to the model. The rationale for any needed model adjustments based on the results of the calibration process will be documented in the MAR.

2.2 Data Acquisition Requirements (Non-Direct Measurements)

As indicated previously, different types of data already existing in various databases may be used for model calibration and as input to the model. The MAR will include a section discussing the different sources of these data, the intended uses of these data on the project, the specific criteria for accepting an existing data source for use on the project, and any limitations that the use of these data may have on this project.

The primary types of existing data to be used in the modeling effort are any existing nutrient point source loads. Non-point source loads for the watershed will be predicted based on the latest NLCD land use classifications. Data from any permitted point sources in the watershed are taken from whatever discharge monitoring reports exist in the state's point source database. When average flow conditions are assumed, non-point source loadings are calculated as a sum (across the different types of land uses) of land use areas multiplied by their respective land use loading coefficients. Land use loading coefficients will be based on best available data and may be modified within reasonable ranges for calibration. Non-point sources represent such contributors as atmospheric deposition, as well as loads from septic tanks, urban development, agriculture, and forest land.

Where the modeling effort will consider different scenarios that represent either baseline or future conditions and low versus average flow characteristics, these scenarios will simulate seasonality effects as appropriate. Therefore, different sets of existing data (i.e., point source loads and non-point source loads) will be needed as model inputs for each scenario. These data sources should be listed in the MAR for each scenario, along with any limitations that these data may have in terms of predicting the scenarios.

Where water quality and physical field data were collected by others in earlier surveys according to documented field and laboratory protocols and at documented monitoring stations it may be used for model inputs and calibration. In order to ensure this data is appropriate for use in this model, survey records will be checked to assure conformance with procedures established for their initial collection and to assure that the resulting data meet the project requirements Data should be reviewed to be sure that their values fall within previously-observed and reasonable ranges (e.g., base flow nutrients and groundwater). Any limitations on the existing data that may impact a model's predictive ability for this project should be discussed in the MAR. For example, water quality surveys for which data were used in model calibration were collected over 15 years ago, and therefore, any changes to the waterway and its environment since then needs to be taken into consideration.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessment and Response Actions

Different types of assessments and model performance evaluations may be performed as appropriate in any given model application. The assessments and evaluations should be documented in the MAR.

Examples include:
• Testing the Model - The ability of the selected model and modules to correctly represent modeled conditions will be assessed focusing on project purposes. A sensitivity analysis will be performed to determine the effect of flow rates, focusing on non-point flows and corresponding loads. The goal of this analysis is to test the sensitivity of the model during high flows to assure its responses are reasonable. If needed, further verification will be done by comparing model prediction results with survey data for base conditions.

• Performing Multiple Runs of the Model to Simulate Drought Impacts - To assess the extent to which drought impacts the model outputs and, ultimately, to incorporate impacts into a drought response plan, the model will be fitted under different scenarios for nutrient loading and stream and reservoir flow conditions. Some assessment is necessary to verify that the different scenarios that are selected represent the critical conditions for which the drought may impact the ability to meet water quality standards.

• Evaluating Existing Data - Modeling staff will evaluate data to be used in calibration and as model input according to criteria discussed in the MAR and will follow-up with the various data sources on any concerns that may arise.

Appendix H. Definitions & Acronyms

DEFINITIONS (selected terms)

Aquifer – A formation or series of formations that are sufficiently permeable to conduct groundwater and to provide economically significant quantities of water to wells or springs.

Community Water System - A system for the provision to the public of piped water for human consumption, if the system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals on a year-round basis.

Contaminant - Any physical, chemical, biological, or radiological substances in water including, but not limited to, those substances for which maximum contaminant levels (MCLs) are established by the Missouri Department of Natural Resources.

Groundwater – Water derived from one or more aquifers through wells or springs.

Groundwater Under the Direct Influence of Surface Water (GWUDISW) - Any water beneath the surface of the ground with significant and relatively rapid shifts in water characteristics, such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the Missouri Department of Natural Resources. The determination of direct influence may be used on site-specific measurements of water quality or documentation of well construction characteristics, or both, and geology with field evaluation. The presence of macroorganisms, algae, or large-diameter pathogens in raw well water will also constitute as groundwater under the direct influence of surface water.

Hydrologic Unit Code (HUC) - is a sequence of numbers or letters that identify a hydrological feature like a river, river reach, lake, or area like a drainage basin (also called watershed) or catchment.

Maximum Contaminant Level - The maximum permissible level, as established in 10 Code of State Regulations 60-4, of a contaminant in any water that is delivered to any user of a public water system.

Maximum Contaminant Level Goal - A level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur and which allows an adequate margin of safety. These levels are not enforceable by the State of Missouri or the United States Environmental Protection Agency.

Missouri Safe Drinking Water Law - The Revised Statutes of Missouri, sections 640.100 through 640.140.

Noncommunity Water System - A public water system that is not a community water system. There are two types of noncommunity public water systems (transient and non-transient). A transient noncommunity public water system will have at least fifteen (15) service connections or regularly serve an average of twenty-five (25) or more persons for at least sixty (60) days of the year. A nontransient noncommunity public water system will serve at least twenty-five (25) persons (e.g., the same persons) for over six (6) months of a year.

Potential Contaminant Source – Specific point or non-point sources from which contamination of drinking water may originate.

Public Water System – A system for the provision to the public of piped water for human consumption, if the system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days out of the year. A public water system is either a 'community' or 'noncommunity' water system.

Risk Ranking – A prioritized ranking of known and potential contaminants to water supply sources based on the assessed relative threat that each potential or known contaminant possesses with respect to the water source.

Secondary Contaminant Levels - Those contaminant levels established by the Missouri Department of Natural Resources for contaminants that may affect the taste, odor, color, staining and scale-forming tendencies of water.

Service Connection - Any water line or pipe connected to a water distribution main or pipe for the purpose of conveying water to a point of use.

Sole Source Aquifer – A drinking water supply in an area with few or no alternative sources to the ground water resource, and where if contamination occurred, using an alternative source would be extremely expensive. If such an aquifer supplies a public water system on which at least 50% of the population depends, it may be designated as a sole source aquifer.

Source Water Protection Area – The area around a raw water source that is significant with respect to recharge of the water source reservoir (e.g., aquifers, rivers, or lakes). For groundwater wells, this area represents the regions that are immediately adjacent to the wellhead and extend a discreet distance away from the wellhead (e.g., the recharge area for the well). For surface water supply sources, this area represents the watershed or drainage basin that feeds directly into the source reservoir or stream. Every water supply intake device will have unique parameters that affect the size of the source water protection area. The Missouri Department of Natural Resources developed preliminary source water protection areas for all public water system raw water intake devices through the Vulnerability Assessment project. Additional modeling or monitoring is the most effective method for improving the accuracy of delineated source water protection areas.

Surface Water – All water which is open to the atmosphere and subject to surface runoff. This includes all tributary streams and drainage basins, natural lakes, and artificial reservoirs above the point of the water supply intake.

Susceptibility Determination – The level of risk of a drinking water source to contamination from known or potential contaminants (regulated or unregulated). During the Vulnerability Assessment project, preliminary susceptibility determinations were performed for all public water supply sources in the state by the Missouri Department of Natural Resources.

Treated Water - Water which is handled or processed in any manner to change the physical, chemical, biological, or radiological content and includes water exposed to the atmosphere by aeration.

Underground Injection Control Program – A program to prevent injection activities from endangering underground sources of drinking water.

Vulnerability Assessment (source water) – An analysis of the susceptibility of a drinking water source to contamination from synthetic organic chemicals. The Missouri Department of Natural Resources has performed preliminary vulnerability assessments for all public water systems in Missouri.

Watershed – A land region draining into a single river or other body of water. A group of watersheds that drain into a major water body is often referred to as a drainage basin.

Watershed Approach - A watershed approach is a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically-defined geographic areas, taking into consideration both groundwater and surface water flow characteristics.

Water Supply Source - All sources of water including wells, infiltration galleries, springs, reservoirs, lakes, streams, or rivers from which water is derived for public water systems, including the structures, conduits, pumps, and appurtenances used to withdraw water from the source or to store or transport water to the water treatment facility or water distribution system.

Wellhead Protection Area – The surface and subsurface area surrounding a well or well field, supplying a public water system, through which contaminants are reasonably likely to travel to contaminate a source.

ACRONYMS

AFO - Animal Feeding Operation

AgNPS - Agricultural Non-Point Source (pollutant)

APCP - Air Pollution Control Program (Division of Environmental Quality, MDNR)

ASDWA - Association of State Drinking Water Administrators

AST - Above ground Storage Tank

AWWA - American Water Works Association

BMP - Best Management Practice

CAFO - Concentrated Animal Feeding Operation

CCR - Consumer Confidence Report

CFR - Code of Federal Regulations

CRP - Conservation Reserve Program

CSR - Code of State Regulations

DEQ - Division of Environmental Quality (MDNR)

DGLS - Division of Geology and Land Survey (Division of Environmental Quality, MDNR)

DHSS - Missouri Department of Health and Senior Services

EER - Emergency Environmental Response (Field Services Division, Environmental Services Program, MDNR)

EOP - Emergency Operations Plan

ERP - Emergency Response Plan

ESP - Environmental Services Program (Field Services Division, MDNR)

FSD - Field Services Division (Missouri Department of Natural Resources)

GIS - Geographic Information System

GW - Groundwater

GWUDISW - Groundwater Under the Direct Influence of Surface Water

HUC - Hydrologic Unit Code

HWP - Hazardous Waste Program (Division of Environmental Quality, MDNR)

ID - Identification

KCRO - Kansas City Regional Office (MDNR)

LRP - Land Reclamation Program (Division of Environmental Quality, MDNR)

LUST - Leaking Underground Storage Tank

MCL - Maximum Contaminant Level

MCLG - Maximum Contaminant Level Goal

MDA - Missouri Department of Agriculture

MDC - Missouri Department of Conservation

MGD - Million Gallons per Day

MRWA - Missouri Rural Water Association

MoCREP - Missouri Conservation Reserve Enhancement Program

MoDNR - Missouri Department of Natural Resources

MTBE - Methyl Tertiary Butyl Ether

NERO - Northeast Regional Office (MDNR)

NRCS - Natural Resources Conservation Service

NPL - National Priorities List

NPS - Non-Point Source (pollution)

NRWA - National Rural Water Association

PCB - Polychlorinated Biphenyl

PDWB - Public Drinking Water Branch (formerly PDWP; Division of Environmental Quality, Water Protection Program, MDNR)

PDWP - Public Drinking Water Program (reorganized as PDWB in 2004)

PWS - Public Water System

SDWA - Safe Drinking Water Act

SDWIS - Safe Drinking Water Inventory System

SALT - Special Area Land Treatment

SERO - Southeast Regional Office (MDNR)

SLRO - St. Louis Regional Office (MDNR)

SOC - Synthetic Organic Chemicals

SRF - State Revolving Fund

SW - Surface Water

SWAP - Source Water Assessment Plan (Missouri State source water protection plan)

SWCP - Soil and Water Conservation Program (Division of Environmental Quality, MDNR)

SWIP - Source Water Inventory Project

SWMP - Solid Waste Management Program (Division of Environmental Quality, MDNR)

SWP - Source Water Protection

SWPA - Source Water Protection Area

SWPP - Source Water Protection Plan

SWRO - Southwest Regional Office (MDNR)

TOT - Time-of-Travel

UMEX - University of Missouri Extension

USDA - United States Department of Agriculture

USEPA - United States Environmental Protection Agency

USGS - United States Geological Survey

UST - Underground Storage Tank

VA - Vulnerability Assessment

VOC - Volatile Organic Chemicals

WBID - Water Body Identification Code

WHP - Wellhead Protection

WHPA - Wellhead Protection Area

WHPP - Wellhead Protection Program (Missouri State wellhead protection plan)

WPCB - Water Pollution Control Branch (Division of Environmental Quality, Water Protection Program, MDNR)

WPP - Water Protection Program (Division of Environmental Quality, MDNR)

WQCC - Water Quality Coordinating Committee

WRC - Water Resources Center (Office of the Director, MDNR)

Appendix I

Mitigation Conceptual Planning Assumptions

Engineering Our Community

ALLSTATE CONSULTANTS

Important Notice to All Readers:

This document contains a mitigation plan for East Locust Creek Reservoir. All the information contained in this document is proprietary. The information is not to be shared without consent of the North Central Missouri Regional Water Commission or Allstate Consultants LLC.

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Summary of Compensatory Mitigation Planning for the East Locust Creek Reservoir Sullivan County Missouri

(Dated: February 6, 2020)

PRELIMINARY

Owner: North Central Missouri Regional Water Commission
Sponsor: USDA-NRCS

DRAFT

NORTH CENTRAL MISSOURI
Regional Water Commission

PREPARED BY:

ALLSTATE CONSULTANTS

CHAD W. SAYRE, PE E-27878

CONFIDENTIAL

Introduction and Need:

The mitigation obligations for the East Locust Creek Reservoir (ELCR) are steep and will require a novel approach to ensure that mitigation obligations are met without laying a heavy financial burden on one of the poorest regions of Missouri. The project will need to mitigate for the loss of approximately 49 miles of streams, mostly perennial and intermittent. The project will result in the loss of approximately 350 acres of wetlands and 900 acres of woodlands inhabited by Indiana bats (*Myotis sodalis*). Traditional project-oriented mitigation assumes a "like for like" or "in-kind" offset that conserves biodiversity of a similar kind to that affected by the development, while overlooking opportunities for trading up (Kiesecker, *et. al.*, 2010). The ELCR will be impacting habitats that are ubiquitous (farmed wetlands, highly altered stream channels, and unmanaged woodlands) while offering the chance to mitigate impacts in the Lower Grand Conservation Opportunity Area. This area contains unique habitats supporting a variety of species of conservation concern at the state and continental level.

Conservation Opportunity Areas:

The East Locust Creek Reservoir will lie in the upper reaches of the Lower Grand HUC 8 (8-digit hydrologic unit code) watershed. The lower portions of the watershed encompass an area known as the Lower Grand Conservation Opportunity Area (COA) that has been highlighted in Missouri's State Wildlife Action Plan (MSWAP). The Lower Grand COA is part of a network of opportunity areas representing approximately 13% of Missouri that were selected using professional knowledge and GIS prioritization (MDC 2015). COA's were identified in collaboration with team and partner input and "represents the greatest opportunities for sustainable conservation of fish, forest, and wildlife resources for all habitat systems in Missouri." (MDC 2015). This area was identified as early as 2005 by numerous conservation partners. ELCR mitigation planning efforts have drawn deeply from the MSWAP. The MSWAP is part of a nationwide planning process.

> "The plans promote strategic planning and prioritization in the management of fish and wildlife diversity, so that limited resources are leveraged to the maximum possible benefit for wildlife diversity conservation. The program also supports working across agency and state boundaries toward common goals for resource management. Key to the success of the program is that it also allows the flexibility for states to build their plans in a manner that best integrates with and leverages their existing programs and partnerships." (MDC 2015)

Primary Resources Used:

Other planning documents used include Great Rivers Associates (2011), HDR (2013), Heitmeyer, *et. al.*, (2011), Pitchford and Kerns (1994), Todd, *et. al.*, (1994), U.S. Fish and Wildlife Service (2011), and UMRGLR JV (2007). A more exhaustive list of references is provided at the conclusion of this report.

Inter-Governmental and Private Cooperation:

To date, limited financial resources have been a primary limiting factor to accomplish conservation planning objectives (MDC 2015). The ELCR project not only brings the opportunity and finances to provide for human needs, but also to accomplish vital planning objectives in a priority landscape. Current efforts include a multi-agency ecosystem restoration feasibility study led by the Kansas City District of the U.S. Army Corps of Engineers Planning

Section (USACE 2019). This is a unique opportunity to leverage federal, state, and private monies to accomplish multiple resource objectives in an economically disadvantaged part of Missouri, where communities have experienced many of the burdens of environmental regulation, but few of the benefits. But for this project, several planning objectives may not be accomplished.

ELCR Contributions to Conservation Planning Efforts:

The ELCR team recognizes that the project will have adverse impacts for which compensatory mitigation will need to be addressed. However, conservation agencies need to recognize that the reservoir, itself, will accomplish several objectives highlighted in plans completed by agencies, such as the Corps of Engineers, U.S. Fish and Wildlife Service, Missouri Department of Conservation, and Missouri Department of Natural Resources. The recently completed Grand River Feasibility Study (USACE 2019) recognizes the need for more flood control and expansion of the PL-566 program to reduce natural resource damages to sensitive fish and wildlife habitat caused by increasing precipitation due to climate change. The Lower Grand River HGM report published by Heitmeyer et al (2011) also calls for reduced sediment and flooding in the upper portions of the Lower Grand HUC8 watershed to protect sensitive habitats found in the lower portions of the watershed. The MSWAP (MDC 2015) expresses concerns regarding the increasing trends toward more "problematic winter flooding". From a habitat perspective, the ELCR will provide extensive open water habitat which has been identified in the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan as the "cover type in greatest need for restoration and enhancement to achieve carrying capacity goals" (UMRGLRJV 2007). For more details regarding each plan, see Appendix A. Oversight agencies should recognize that this project is not only providing critical drinking water infrastructure, but addressing conservation planning objectives in the 13% of Missouri that has been targeted for intense conservation activities (MDC 2015).

The Path forward:

Due to the scale and uncertainties that come with all mitigation projects, the ELCR project team has committed to a multi-faceted approach that includes several initiatives to accomplish species, wetland, and stream mitigation requirements. Once the mitigation obligation is met for a category, the team will not pursue further initiatives, but rather, will focus on the remaining mitigation categories.

Bat Mitigation

Recent conversations with USFWS personnel have been encouraging. It appears the USFWS requires a mitigation ratio of 1:1. The Biological Assessment is nearly complete.

Bat Mitigation Initiative #1 – NCMRWC Property

This approach focuses on timber management and limited tree planting with associated site protection instruments and financial assurances on available NCMRWC property. Conversations are underway with the Missouri Department of Conservation to be the long-term steward of this effort as part of their Community Assistance Program agreement.

Bat Mitigation Initiative #2 – Smithfield Foods Property

Should a higher mitigation ratio be required, the project team is scheduled to meet with Smithfield Foods management in February 2020 regarding mitigation on some of their production farms. There are 2,564 acres of suitable bat habitat on their Green Hills and Valley View Farms. Conservation easements or other forms of site protection instruments will be pursued to protect and manage these acres for Indiana bats.

Wetland Mitigation

Wetland mitigation options include replacement of a 181-acre Wetland Reserve Program (WRP) easement, as well as traditional wetland mitigation obligations.

Wetland Mitigation Initiative #1 – Central States Land and Auction Company

The ELCR Team has completed the WRP easement evaluation and will be taking a recommendation to the February 2020 meeting of the NCMRWC. Replacing a federal easement is an arduous process that can significantly delay the project. The Central States Land and Auction Company has submitted a proposal that should meet the requirements for the easement, and negotiations on this proposal are underway.

Completion of this project will help fulfill objectives in the Lower Grand HGM report (Heitmeyer et al 2011), Our Missouri Waters Healthy Watershed Plan (MDNR 2016), Missouri State Wildlife Action Plan (MDC 2015), and the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007). For more detailed information regarding the objectives in each plan see Appendix A.

Wetland Mitigation Initiative #2 – NCMRWC Property and ELCR Watershed

Steve Hefner with NRCS has identified several potential wetland sites on NCMRWC property, as well as throughout the entire watershed. These sites will not only provide mitigation opportunities, but source water protection as well. They should be a high priority for mitigation.

Wetland Mitigation Initiative #3 – NCMRWC and Other Local Properties

Numerous mitigation opportunities are located along the East Fork of Locust Creek from the ELCR dam to the Milan WWTP. Potential wetland sites, including those on the NCMRWC-owned "Stutler Tract" have been identified, and initial conversations have begun with other landowners. One tract owned by the Bright family has the potential for adding tertiary treatment to effluent from the Milan WWTP.

Completion of these projects will help fulfill objectives in the Grand River Feasibility Study (USACE 2019), Lower Grand HGM report (Heitmeyer et al 2011), Our Missouri Waters Healthy Watershed Plan (MDNR 2016), Missouri State Wildlife Action Plan (MDC 2015), and the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007). For more detailed information regarding the objectives in each plan see Appendix A.

Wetland Mitigation Initiative #4 – Swan Lake National Wildlife Refuge

The NCMRWC may want to consider claiming the remainder of wetland mitigation credits be granted from projects at the Swan Lake National Wildlife Refuge described below. Completion of this project will help fulfill one-third (1/3) of the public land objectives in the Grand River

Feasibility Study (USACE 2019), while also completing objectives highlighted in the Lower Grand HGM report (Heitmeyer et al 2011), Missouri State Wildlife Action Plan (MDC 2015), and the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007). For more detailed information regarding the objectives in each plan see Appendix A. Completion of this project also brings added value by addressing problematic flooding in the vicinity of the Garden of Eden Levee District.

Stream Mitigation

By all accounts, mitigating for adverse impacts to 49 miles of stream will be the most challenging mitigation objective. Initial calculations based upon the Missouri Stream Mitigation Method (MSMM) indicate that this requires 1.2 million credits worth of mitigation projects. Recent policy changes by the EPA may allow for a significant reduction in the stream mitigation obligations for the project. This plan assumes the full mitigation obligation under the 2015 Waters of the US policy. However, regulators need to be made aware of this concession throughout the negotiation process. The Lower Grand River COA requires both adding resilience to stream systems while addressing sediment inputs from upper portions of the watershed. This mitigation approach will focus on improving riparian habitat, restoring linear and lateral habitat connectivity, and reducing sedimentation in the lower portions of the Lower Grand HUC8 watershed. All mitigation efforts will tie into mitigation efforts identified in conservation planning documents.

Stream Mitigation Initiative #1 – Riparian Plantings

Streamside (riparian) plantings of trees or other native vegetation is the most common form of stream mitigation. Targeted reaches for riparian restoration and enhancement include East Locust Creek from the dam to the Milan WWTP, stream channels in the ELCR watershed, and Smithfield Foods production farms. The proposed permittee responsible riparian projects would convert farmland or grassland along streams to forested riparian buffers. The initial mix of swamp white oak (*Quercus bicolor*), pin oak, bur oak, shellbark hickory, silver maple (*Acer saccharinum*), American sycamore (*Platanusoccidentalis*), and eastern black walnut (*Juglans nigra*) would be planted on a 12’x12’ spacing (stocking density of 302 trees per acre) (Philip Sneed, Blackwell Creek Forestry, personal communication). All operations for riparian buffer projects would be conducted in the sequence presented in Table 1 below.

TABLE 1 – Sequence of events for riparian buffer projects:

Practice	Year 1	Year 2	Year 3	Year 4	Year 5
Planting Plan Development	X				
Mobilization	X	X	X	X	X
Site Preparation					
Mow	X				
Herbicide Application	X				
Herbicide (Buccaneer Plus)	X				
Tree Planting					
Bare root seedlings	X				
Mechanical Planting	X				
Monitoring and Maintenance					
Weed Control w/ Fusilade	X				
Herbicide (Fusilade)	X				
Weed Control w/ Oust		X	X	X	X
Herbicide (Oust)		X	X	X	X
Mowing	X	X	X	X	X
Bare root seedlings		X	X	X	X
Hand Planting		X	X	X	X
Easement					
Survey and Boundary Posting	X				
Legal Fees	X				
Monitoring and Report Writing	X	X	X	X	X

The mitigation target for this effort is 200,000 to 500,000 stream credits. Completion of these projects will help fulfill objectives in the Grand River Feasibility Study (USACE 2019), Lower Grand HGM report (Heitmeyer et al 2011), Our Missouri Waters Healthy Watershed Plan (MDNR 2016), Missouri State Wildlife Action Plan (MDC 2015), and the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007). For more detailed information regarding the objectives in each plan see Appendix A.

Stream Mitigation Initiative #2 – Aquatic Organism Passage (AOP) Barriers

Nationwide efforts have been implemented to remove AOP barriers on United States Forest Service (USFS) and United States Fish and Wildlife Service (USFWS) properties for twenty years or more. These barriers are typically outdated low water crossings that no longer provide safe passage across a stream. Additionally, the Missouri Department of Conservation (MDC) has participated with other funding partners to assist counties with replacing poorly functioning low water crossings. Likewise, MDC has begun replacing AOP barriers on state land in the past five to seven years, regardless of the presence of rare, threatened, and endangered (RTE) species.

These solutions provide added value to the ELCR mitigation efforts by bringing badly needed infrastructure improvements to rural counties. AOP barrier replacements address all five functional categories (hydrology, hydraulics, geomorphology, physiochemical, and biology) within the Stream Functions Pyramid Framework (SFPF). Federal and state programs provide precedents for barrier removal as a method for generating compensatory mitigation credits. Likewise, the MSMM lists low water crossing removal replaced with a span bridge as "excellent net benefit" for stream channel restoration and aquatic organism migration. Site protection instruments will include an inter-governmental agreement between the NCMRWC and the County Commission where the project is located. This process is consistent with Corps guidance documents (USACE 2016b). Financial assurance documents will include performance bonds or other approved financial assurance instruments in compliance with Corps guidance documents (USACE 2016a).

The mitigation target for this effort is 400,000 to 600,000 stream credits. Completion of these projects will help fulfill objectives in the Grand River Feasibility Study (USACE 2019), Lower Grand HGM report (Heitmeyer et al 2011), Our Missouri Waters Healthy Watershed Plan (MDNR 2016), and Missouri State Wildlife Action Plan (MDC 2015). For more detailed information regarding the objectives in each plan see Appendix A.

Stream Mitigation Initiative #3 – Swan Lake National Wildlife Refuge

Various planning efforts, including the Corps Feasibility Study (USACE 2019), have identified approximately 6,000 acres of floodplain habitat projects that need to be completed at the Swan Lake National Wildlife Refuge. Public lands comprise the "core" of prized habitat and lands in the Lower Grand COA (Heitmeyer 2011). This occasion is a formidable opportunity to break out of the constraints of "like-for-like" mitigation and "trade-up" from a habitat perspective. This project would address floodplain expansion issues identified with the Garden of Eden levee, replace lost wet prairie habitat, and fulfill one-third (1/3) of the public land objectives identified in the USACE feasibility study. Additionally, no farmland would be taken out of production. The mitigation efforts could address planning objectives that would not likely be accomplished but for the ELCR project. Concerns have been raised about the legality of conservation easements on Federal lands. Corps guidance documents provide a suite of options other than easements for mitigation projects on federal lands (USACE 2016b). Under a management agreement, USFWS could manage the properties as part of their routine refuge management. The mitigation target for this effort is 400,000 to 1,500,000 stream credits and perhaps the remainder of the wetland credits. Other opportunities exist on public lands within the COA and may eventually become part of the mitigation plan.

Completion of this project will help fulfill one-third (1/3) of the public land objectives in the Grand River Feasibility Study (USACE 2019), while also completing objectives highlighted in the Lower Grand HGM report (Heitmeyer et al 2011), Missouri State Wildlife Action Plan (MDC 2015), and the Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007). For more detailed information regarding the objectives in each plan see Appendix A. Completion of this project also brings added value by addressing problematic flooding in the vicinity of the Garden of Eden Levee District.

Stream Mitigation Initiative #4 – Private Mitigation Providers

The ELCR Project Team recognizes the mitigation expertise that resides in the private sector. Several mitigation providers have reached out to the team to express interest in aiding with this

endeavor. The team is working with NRCS procurement specialists to develop a Request for Information (RFI) to initiate dialogue with private mitigation providers without disqualifying them from bidding on mitigation services. The RFI will be distributed in February with a three-month deadline for project development. Interviews with the ELCR Project Team will be scheduled in early May. Private mitigation providers will be encouraged to consider conservation priorities for the Lower Grand COA. These priorities will be supported by the ranking process. The mitigation target for this effort is 200,000 stream credits.

Final Considerations

Long-term Monitoring, Maintenance and Financial Assurances:

The funding cost share for the actual long-term maintenance implementation needs to be determined. The long-term maintenance consists of the long-term (currently estimated at five years) worth of monitoring, maintenance, and replacement of the mitigation projects. The PL-566 program does not allow NRCS to engage in long-term obligations for mitigation. In order to garner the value for all funding partners of required mitigation, the NCMRWC plans to convert the estimated future mitigation costs to a single present value element similar to a mitigation credit to eliminate the long-term funding obligation. By doing so, this would allow NRCS to participate at a 50% cost share (for that portion of the mitigation project) and eliminate long-term funding obligations.

The NCMRWC will pursue options to self-provide or outsource through a private or governmental partner, the long-term mitigation obligations. It is possible that this is a service the MDNR or other state agency could provide and further possible that they would do so, or at least partially, as an in-kind contribution to the project.

Mitigation Timing:

Due to the desire for an expedient mitigation path that achieves 1:1 mitigation credit and respects the mitigation hierarchy, the East Locust Creek Reservoir Project Team recommends an adaptive management / timed mitigation approach that takes advantage of project lag and reservoir filling time to accomplish mitigation over a series of years, yet prior to impacts to waters of the United States. This adaptive management / timed approach allows all mitigation to take place prior to impacts to jurisdictional waters, without further delay and increased costs to the public. It would allow mitigation to take place over a period of approximately seven years.

ELCR PERMITTEE RESPONSIBLE MITIGATION PLAN

Bat Mitigation 900 Acres

- NCMRWC Land Acquisitions for ELCR Footprint & Dam (4,500 acres)
- NCMRWC Acquisition - Mitigation Tract #1 (121 acres)
- NCMRWC Acquisition - Mitigation Tract #2 (61 acres)
- Targeted Tract #1 HUC8 (6,452 acres)
- Targeted Tract #2 HUC8 – Sullivan (305 acres)
- Targeted Tract #3 HUC8 – Sullivan (508 acres)
- Targeted Tract #4 HUC8 – Chariton (836 acres)

WRP Easement 181 Acres

- Targeted Tract #8 HUC8 – Linn (203 acres)
- Targeted Tract #2 HUC8 – Sullivan (305 acres)
- Private Providers Engagements Unique Places?

Wetland Mitigation 160 Acres

- NCMRWC Land Acquisitions for ELCR North Wetland Complex (TBD acres)
- NCMRWC Acquisition - Mitigation Tract #1 (121 acres) (30 acres Wetland)
- Targeted Tract #7 HUC8 – Sullivan (204 acres)
- Targeted Tract #2 HUC8 – Sullivan (305 acres)

Stream Mitigation 1.2 Million

- Private Providers Engagements 200,000 Credits
- Swan Lake NWR – Mass Project Converted to Stream (< 6,000 ac.) 400k to 1.5M Credits
- Aquatic Organism Passage (AOP) Barrier Removals – HUC8 400k to 600k Credits
- Riparian Plantings with Perpetual Easement 200k to 500k Credits
  - Targeted Tract #1 HUC8 (6,452 acres)
  - Targeted Tract #3 HUC8 – Sullivan (508 acres)
  - Targeted Tract #5 HUC8 – Linn (969 acres)
  - Targeted Tract #6 HUC8 – Sullivan (372 acres)

TABLE 2 – Timeline for Submission of ELCR Mitigation Plan:

Mitigation Plan Details	Feb	Mar	Apr	May	Jun
Riparian Plantings					
Identify sites	**X**				
Negotiate with landowners		**X**	**X**		
Credit calculations and planting plans			**X**		
AOP Evaluation					
Evaluation Report			**X**		
Negotiate with Counties			**X**		
Swan Lake NWR					
Complete Conceptual Plan	**X**				
Negotiations with USFWS	**X**	**X**	**X**	**X**	
Private Mitigation Providers					
RFI/RFP	**X**				
Interviews				**X**	
Selection				**X**	
Write Plan		**X**	**X**	**X**	
Submit to Corps					**X**

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Appendices

Appendix A

Mitigation and Conservation Planning Objectives

Grand River Feasibility Study: Draft Indegrated Feasibility Resport and Environmental Assessment (USACE 2019)

Section	Page Number	Comment
Executive Summary	ES-1	Flood frequency and intensity have increased in recent years
Executive Summary	ES-1	Paragraph decribing the importance of Lower Grand COA
Executive Summary	ES-3	Goal #2 Realize additional benefits to improving recreation and reducing flooding in the region
Executive Summary	ES-6	Perferred alternative for yellow creek is to work on Swan Lake National Wildlife Refuge
Executive Summary	ES-11	Yellow Creek Study area - The Corps does not consider this a complete USACE plan
Executive Summary	ES-13	Bank Stabilizations measures above Pershing State Park implemented in these preferred watersheds. Watkins Creek - Locust Creek, **ELC**, West LC, LC
1.4	5	Paragraph describing the importance of the Lower Grand COA.
1.5	10	The importance of COA.
2.1.1	16	The importance of wet prairie habitat in the region
2.2	22	The portion of Locust Creek at Pershing State Park and Fountain Grove is listed as outstanding importance for a variety of reasons.
2.4	35	Yellow Creek conservation area was purchased in 1988 to protect important habitats.
2.7	39	Several streams in the Lower Grand river watershed are impaired or have TMDL's
2.8.5	41	Mitigation efforts in the Lower Grand COA will be important to many species of conservation concern
2.15	50-51	More evidence that ELCR customer base are economically disadvantaged.
2.17.1	52-54	Three notible floods in 84 years from 1909-1993. Over five notible floods in 26 years from 1993-2019
2.17.2	54	Summary of large levee systems along the Lower Grand
3.5.2	66	Lower portions of the wet prairie at Pershing State Park are not anticipated to experience high levels of deposition.
3.7.1	70	Swan lake national wildlife refuge will continue to manage the property to the best of their abilities with budgetary constraints
3.7.1	70	Wet prairie and emergent wetlands can be improved at Swan Lake NWR.
3.7.1	71	Mangement plan will improve bottomland hardwood forest.
4.3.2	73	Goal #2 includes critical infrastructure, agriculutre, water quality, recreation and flood risk reduction
4.3.3	74	Desire to increase quality and quantity of wet prairie at Pershing State Park

4.3.3	74	Goals for Yellow Creek include improve wet prairie and emergent wetlands and bottomland forest.
4.6.1	77	Bank stabilization techniques that are recommended
4.6.10	79	The study recommends reservoirs and small dams as a sediment reduction technique
4.7	79	Documentation that the Yellow Creek Avullsion may occur
4.7.2	86	Yellow Creek alternative 11 at Swan Lake NWR considered a best buy
4.8.2	87	Definition of a best buy is the most efficient plan
4.8.2	90	Locust Creek best buy alternative associated with Pershing State Park
4.8.3.1	94	Corps would like to see a new channel constructed that connects Higgins Ditch to Locust Creek
4.10.1	101	Synergy between multiple agencies, the pubic, and Federal entities will be required to address sedimentation issues
4.10.3	102	Yellow Creek plan YC11 is the only effective plan in achieving the Yellow Creek objectives
4.10.4	103	Paragraph 2 talks about the importance of this region
4.10.4	103	Pershing State Park, Fountain Grove and Swan Lake are all listed as important significant areas
4.10.4	104	The 3 project areas can be completed independently
5.4.1	107	No action will result in continued loss in important habitats
5.9.2	110	Yellow Creek alternative will have no impact to prime farmland
5.19.2	121	ELCR mentioned
6.1.1	132	Importance of watershed bank stabilization above Pershing State Park including preferred watersheds
6.6	140	Note federal cost share in table 6-2 is 65%/
7.1.1	142	BMP's in the watershed include water impoundment reservoir
7.2.3	145	It appears the Corps Planning Section is in favor of more PL566 projects in the waterhsed

Our Missouri Waters Healthy Watershed Plan (Lower Grand River) (MDNR 2016)

Section	Page Number	Objective
Key Points	3	Hundreds of hours of work by participants, presenters, and planners
Objectives and Opportunities	4	Reduce Strambank Erosion
Objectives and Opportunities	4	Reduce logjams and adverse effects
Objectives and Opportunities	4	Reduce flooding and associated streambank damage
Objectives and Opportunities	4	Improve wq and stream habitat
Objectives and Opportunities	4	Reduce sediment and nutrients transport from watershed
Objectives and Opportunities	4	Reduce bacteria levels in impaired streams

Missouri State Wildlife Action Plan (MDC 2015)

Section	Page Number	Objective
Forward	i	Work with partners to identify and prioritize conservation opportunaties
Preface	1	Limited resources continue to ba a limiting factor
Preface	1	Maximize limited resources by working across agency and state boundaries
Preface	1	Habitat rather than species based approach
Preface	1	Priority watershed based approach
Preface	4	Habitat-based conservation
Preface	8	Build connectivity within COA's
Preface	9	Lower Grand River Floodplain crucial for migratory and resident wildlife
Preface	10	COA's identified by professionals and represent greatest opp for conservation
Preface	11	Lower Grand COA part of 13% of state identified for priority efforts
Preface	15	Projections show an increase in problematic winter flooding
Preface	20	Success depenant on working with partners at national, state, and local levels to ensure collaboration
Preface	21	maximize efficient and effective use of limited public resources
Preface	21	Importance of cooperative ageements and MOU's
Maps	31`	Lower Grand COA Grassland/Prairie/Wetland overlap
Grassland/Prairie/Savannah	52	Wet praires are critically emperiled community type (<0.04% remaining)
Species of Greatest Conservation Need	17	Flat Floater Mussel
Species of Greatest Conservation Need	23	Monarch Butterfly
Species of Greatest Conservation Need	28	Trout-perch
Species of Greatest Conservation Need	32	Small-mouthed salamander
Species of Greatest Conservation Need	32	Northern crawfish frog
Species of Greatest Conservation Need	35	Prairie massasauga
Species of Greatest Conservation Need	35	Graham's crayfish snake

An Evaluation of Ecosystem Restoration and Management Options for Floodplains in the Lower Grand River Region (Heitmeyer et al. 2011)

Section	Page Number	Objective
Executive Summary	vii	Gargen of Eden Levee especially degrading to floodplain habitat in LGR
Executive Summary	viii	Reduce soil erosion and sidiment loading
Executinve Summary	viii	Restore stream corridors and drainage systems
Executinve Summary	viii	Expand floodways and drainage corridors
Executive Summary	viii	Modify agricultural programs on public lands
Restoration and Management Options	47	Public lands have provided the "core"of land and resources to sustain LGR…but management has been constrained
Restoration and Management Options	50	change water and sediment inputs from upper watershed to reduce flooding and sediment deposition

Upper Mississippi River and Great Lakes Region Joint Venture Implementation Plan (UMRGLRJV 2007)

Section	Page Number	Objective
Eastern Tallgrass Prairie	23	High priority upland birds: Henslow's Sparrow, Cerulean Warbler, Red-Headed Woodpecker
Bird Habitat Cover Types	29	Wet meadow
Bird Habitat Cover Types	29	Shallow semi-permanent marsh
Bird Habitat Cover Types	29	Extensive open water
Bird Habitat Cover Types	29	Grassland
Integrated Bird Conservation	32	Open lands has the greatest need for restoration and enhancement (MO a priority)
Integrated Bird Conservation	36	Extensive open water is the cover type in greatest need for restoration and enhancement to achieve carrying capacity goals
Integrated Bird Conservation	36	Wet mudflats/moist soil plants greatest area need for maintenance and protection
Appendix A-1	57	Marsh-wetland conservation objectives for MO
Appendix D-1	69	Extensive open water objective for MO=2,354 acres
Appendix E-1	73	Wet mudflat objective for MO=840 acres

Appendix B

The Next Generation of Mitigation

The Next Generation of Mitigation: Linking Current and Future Mitigation Programs with State Wildlife Action Plans and Other State and Regional Plans

August 4, 2009

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Developed with funding provided by the
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Table of Contents

Executive Summary **4**
Background **4**
Findings and Recommendations for Action **5**

Chapter 1. Introduction **9**
a. Purpose of whitepaper **9**
b. Increasing infrastructure investments will threaten our natural environment and the human and wildlife benefits of natura habitat if effective mitigation practices are not adopted and implemented **9**
c. The importance of the mitigation concept **10**
d. The role of compensatory mitigation in supporting conservation **10**
e. Definition **11**

Chapter 2. A New Approach to Making Mitigation an Effective Tool for the Conservation of Natural Systems **13**
a. The need for a more comprehensive approach to conservation and mitigation **13**
b. The information basis for a "next generation" of mitigation **13**
i. State Wildlife Action Plans **13**
ii. Other federally recognized and regional conservation plans **14**
iii. The next generation of mitigation: a comprehensive approach **17**

Chapter 3. Foundations of Existing Mitigation Programs **19**
a. Legal framework of existing mitigation programs **19**
b. Scope of current programs: funding and acreage affected **24**
c. Performance of existing mitigation programs **25**
i. The deterrent factor **25**
ii. The role of avoidance and minimization **25**
iii. The role of compensatory mitigation **26**
1. Replacement of functions and services and the need for effective ecological performance standards **27**
2. The need for adequate monitoring **28**
3. The need for rigorous oversight and enforcement **29**
iv. The need for connectedness to a conservation vision **30**

Chapter 4. A Framework for Advancing The Next Generation of Mitigation **32**
a. Essential components of the next generation of mitigation **32**

i. Policy goal 32
ii. Landscape-level planning for conservation and ecosystem services 32
iii. Regulatory drivers 34
iv. Mitigation protocol 34
v. Implementation regulations and guidance 34
b. Existing or expanded provisions for next generation mitigation 35
i. Clean Water Act §404 mitigation 35
ii. Federal Endangered Species Act 36
iii. The operation of the National Environmental Policy Act on federal lands and elsewhere 38
iv. Specific activities and circumstances under existing la 39
1. Energy development 39
2. Transportation and infrastructure 40
3. Response to sea level rise 42
4. Department of Defense/Homeland Security applications 43
5. Civil Works compensatory requirements 44
6. Federal Energy Regulatory Commission licensing 45
7. Natural resource damages 46
c. Potential new authorities 46
i. On-shore energy development 46
ii. Offshore energy/marine spatial planning 47
iii. Transportation legislation 47
iv. Habitat regulatory authority 47

Chapter 5. Incorporating Ecosystem Services 49

Chapter 6. A Vision for the Next Generation of Mitigation in the U.S. 51
a. Overall conclusions 51
b. Benefits and risks of a more comprehensive approach t mitigation 53

Chapter 7. Next Steps: A Plan of Action 55

Chapter 8. Conclusion 56

ENDNOTES 57

Executive Summary

The next generation of mitigation is explicitly designed to ensure that emerging resource conflicts arising from ene gy and other infrastructure development have more beneficial conservation outcomes. This white paper has been prepared by the Environmental Law Institute (ELI) and The Nature Conservancy (TNC). It is designed to defin and describe the next generation of mitigation, which entails:

- A more comprehensive approach to application of the mitigation protocol (avoid, minimize, compensate) in existing and potential regulatory processes;
- Use of State Wildlife Action Plans and other plans to create an effective decision-making framework for the application of the mitigation protocol; and
- Allocation of compensatory funds derived from mitigation in a manner that supports lasting and large scale ecological results.

While new habitat protection legislation could improve mitigation, we believe much progress can be made by adjusting existing laws and regulations and using tools already available, if those tools are applied as proposed. The suggested changes can also bring greater efficiencies to the mitigation process, a resul especially important at a time of limited financial resources. Guided by these practices mitigation can benefit both conservatio and economic goals by: reducing siting conflicts; increasing mitigation s consistency, transparency, and cost-effectiveness; reducing uncertainty and risks; and ensuring the delivery and durability of higher value conservation results. This is particularly true if consistent approaches can be taken across multiple jurisdictions.

Background

In the coming years, the U.S. will experience significant loss of natural habitats due t population growth, infrastructure development, energy development, and climate change. In the energy sector, for example, in order to meet low carbon electricity and biofuel production requirements as much as one-fift of the land area of the U.S. may be needed for energy production and transmission facilities. New or expanded transmission corridors will affect habitats extending beyond the footprint of the right-of-way. In the Mountain West, over 100,000 additional oil and gas wells with a footprint of roughly 2 million acres are anticipated over the next 20 years. Other infrastructure investments are also increasing with the recent passage of economic stimulus legislation that provides $150 billion for infrastructure including $50 billion for transportation projects. Climate change and sea level rise will demand new measures to deal with coastal hazards and altered rainfall patterns. These trends will have significan impacts on natural systems including habitat fragmentation and loss of ecosystem function. The effective use of regulatory programs coupled with careful mitigation could reduce and offset this damage, but past experience suggests the need for improvements to our approach to mitigation if this objective is to be achieved.

There are existing tools and precedents allowing us to achieve improved outcomes for the nation's at-risk habitats. In the U.S., we now have decades of conservation planning

experience, more comprehensive ecological data than ever available before, advanced modeling and planning tools, and a wealth of effective on-the-ground conservation efforts. And recent policies, such as the 2008 rule requiring a "watershed approach" to compensatory mitigation for losses of aquatic resources, support a more comprehensive framework for mitigation decision-making.[1]

Findings and Recommendations for Action

A more comprehensive approach to mitigation is needed to sustain systems of interconnected, resilient, natural habitats. Such systems provide habitat for plant and animal species and support the resources and processes that underpin human well-being, such as water quality and quantity, pollination of crops, natural hazard mitigation, and recreational opportunities. Ensuring these benefits fo future generations will require improvements in landscape and watershed planning, rigorous use of available ecological information, and greater consistency and coordination in applying mitigation strategies.

We find significant opportunities for improvi the current mitigation framework to make it more effective in meeting the nation's conservation and development priorities. In general, we believe mitigation can move beyond what is often a piecemeal response, to a more integrated, consistent, and pro-active approach guided by landscape and watershed planning. Such an approach will deliver more effective conservation outcomes for wildlife, natural landscapes, and the ecosystem services on which communities depend. It will also help business by improving the basis for project planning, increasing mitigation efficienc , and reducing uncertainty and risks.

Fundamental changes needed:

(1) **Ensure consistent and rigorous application of the mitigation protocol** (avoid, minimize, compensate) for addressing impacts to wildlife habitat under existing, expanded, and future regulatory programs. We stress throughout this paper the primary importance of the avoidance and minimization elements of the protocol.

(2) **Use State Wildlife Action Plans, other federally recognized conservation plans (such as Coastal Zone Management Plans, Forestry Plans, and Endangered Species Recovery Plans), and regional plans as the framework for a more comprehensive approach to making the "avoid, minimize, compensate" decisions required by the protocol.** Use of this planning context will lead to decisions that provide stronger and more resilient protection for whole watersheds and other natural systems for their multiple benefits

(3) **Give priority in the investment of compensatory funds to projects and activities identified by State Wildlife Action Plans and other plans and that are sufficient in scale and strategic i their location to support the long term health of whole ecosystems.** Further benefits can be achieved by anticipatin compensation needs and accomplishing "advance mitigation" when the opportunities for larger ecosystem benefit still exist.

Supporting recommendations:

- Federal and state agencies should play a stronger role in supporting ecologically significant and rigorou mitigation.
    - The President's Council on Environmental Quality (CEQ) should lead an effort to achieve consistent application of the mitigation protocol across federal agencies and programs.
    - The CEQ and federal agencies should strongly encourage federal agency use of State Wildlife Action Plans, other federally recognized conservation plans, and detailed regional plans, to create a biologically-based framework for decision-making informed by environmental review under the National Environmental Policy Act.
    - State agencies responsible for permitting and decision-making should apply the mitigation protocol and make use of State Wildlife Action Plans, other federally recognized conservation plans, and detailed regional planning in their own decisions and approvals affecting habitat.
- State Wildlife Action Plans should be continuously improved to ensure that they support mitigation opportunities and decision-making. Specificall , they should identify sites or areas appropriate for restoration through compensatory mitigation. Some State Wildlife Action Plans use detailed mapping to convey the intent of habitat conservation in their states, but others lack the kinds of detailed information necessary to make specific resourc planning and permitting decisions on the ground. State Wildlife Action Plans can more effectively guide the avoidance of key wildlife habitat, cumulative impact analysis, and the expenditure of compensatory mitigation funds if they set priorities for *protection* of high quality habitat and for *restoration* of important degraded habitat, related natural systems, and connectivity.
- A federal agency or institution should be tasked with assessing the outcomes of existing mitigation actions on landscape and watershed conservation under all federal statutes and should make periodic recommendations on how to improve mitigation across federal agencies. Among the specifi issues that should be evaluated are:
    - The appropriate role of §404 of the Clean Water Act in efforts to deal with the permitting of wetland alterations associated with shoreline protection from sea level rise.
    - Use of the mitigation protocol in the location and expansion of military facilities.
    - Use of the next generation of mitigation in the planning and location of transportation facilities.
    - The consistent use and effectiveness of current avoidance and minimization measures employed across all

mitigation programs.
    - The availability and quality of the tracking programs (impacts, compensation, monitoring) utilized across all mitigation programs.
    - The effectiveness of current cumulative impact analysis conducted across all mitigation programs applied by multiple political jurisdictions within single watersheds and other landscape units.
- Federal energy and infrastructure legislation should expressly include requirements to use the mitigation protocol as it is described here in the planning and design of large scale energy facilities on federal lands and waters, in the design and siting of new transmission corridors that involve federal agencies such as the Federal Energy Regulatory Commission (FERC), and in the siting of major energy generating facilities finance through federal programs and loan guarantees. The mitigation protocol should also be incorporated into legislation guiding offshore energy siting for conventional and alternative energy sources.
- Despite the substantial scale and scope of the nation's current mitigation programs, which primarily protect many wetlands, streams, and the habitat of threatened and endangered species, other high value, natural landscapes remain unprotected. Conservation agencies and organizations should explore opportunities to adopt mitigation requirements for impacts to these key areas.

<u>Proposed Near-Term Actions:</u>

- The President's Council on Environmental Quality should convene a multi-agency workshop on the use of the mitigation protocol and on how mitigation could be used more effectively by federal decision-makers to achieve landscape scale/watershed scale conservation, considering both climate change and the likely impacts of new infrastructure and conservation investments.
- The U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency should undertake an evaluation of the effectiveness of the agencies' approach to avoidance and minimization and cumulative impact analysis. The agencies should consider developing guidance and tools to support the ability of field sta f to undertake this analysis.
- The U.S. Fish and Wildlife Service should meet with the Association of Fish and Wildlife Agencies and with other stakeholders to evaluate how State Wildlife Action Plans could be adapted and coordinated with other natural resource plans to better serve as the framework for the effective use of the mitigation protocol in multiple programs.
- U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration should commit resources to developing effective policies and tools to guide mitigation under the Endangered Species Act,[2] such as: a system to track required mitigation measures, and monitoring; guidance and tools to support

cumulative impact analysis; policy that clarifies the role of habitat mitigatio under §7; and research on the ecological effectiveness of the habitat mitigation measures undertaken under the Act.

- Amendments should be considered to the now pending energy legislation to expressly require use of the mitigation protocol for planning energy projects on federal lands and in federal waters, where the approval of transmission corridors directly involve Federal agencies such as FERC, or that affect federally protected resources as a way of both protecting the environment and improving the regulatory process.
- Building on the limited experience with consultation under SAFETEA-LU, the next transportation authorization bill should expressly refer to the State Wildlife Action Plans and other regional plans, where appropriate, in the sections that deal with project-level evaluation, and should expressly require that the mitigation protocol be employed to support the priorities in these plans.

Chapter One

Introduction

a. Purpose of whitepaper

This whitepaper evaluates the potential of a well-designed approach to mitigation to address the impacts to natural habitats from anticipated infrastructure and other development activities. This paper is not intended as an overall analysis and critique of the performance of §404 of the Clean Water Act, nor does it seek to compare or critique specific compensatory mitigatio mechanisms (i.e., wetland mitigation banking, conservation banking, etc.). Specificall , it examines opportunities to apply the mitigation protocol ("avoid, minimize, compensate") more consistently and rigorously to existing, expanded, and any new authorities that regulate activities that affect habitat and species; and opportunities to make mitigation decisions within the context of a more comprehensive vision for conservation. The paper explains how the State Wildlife Action Plans and other federally recognized and regional conservation plans can be used as the framework for this more comprehensive approach to mitigation – the next generation of mitigation. Adopting the next generation of mitigation concepts will help reduce impacts to ecosystems and watersheds from infrastructure construction, energy development, and urbanization; direct these impacts to the least environmentally harmful places; guide cumulative impact analysis; and ensure that funds for offsetting unavoidable impacts will be used more effectively to restore and protect a network of natural areas in the U.S. If implemented and managed properly across whole ecosystems, watersheds, and ecoregions the mitigation of public and private development offers an opportunity to create a more sustainable economy and a healthier environment for human and natural communities.

b. Increasing infrastructure investments will threaten our natural environment and the human and wildlife benefits of natural habitat if effective mitigation practices are not adopted and implemented

Despite the current economic downturn, there is likely to be extensive investment in infrastructure in the United States over the next ten years and beyond. Analyses undertaken to support the recently passed economic stimulus legislation reveal many roads, bridges, dams, flood control structures, rail transit systems and water and sewer systems that must be built, rebuilt, or replaced.[3] Climate change and sea level rise demand new measures to deal with coastal hazards and altered rainfall patterns. The need to reduce carbon emissions and to achieve energy independence will result in extensive new development of lower carbon energy generation and transmission facilities and further exploitation of conventional energy sources, particularly natural gas reserves. The latest version of transportation legislation soon to be taken up by Congress will increase investment in roads and mass transit. While the housing market is now stalled, our population is still projected to grow, requiring more development within and adjacent to metropolitan centers. Continuing global threats are leading to continuing military investment. As a result of the Base Realignment and Closure (BRAC) process, the global restationing of forces from overseas bases, and planned increases in the size of the Army and the Marine Corps, military units are being relocated and new units are

being created. These actions require new construction and increases in military activity at "gaining bases." For example, relocation of forces now stationed on Okinawa and elsewhere to Guam in Micronesia will require extensive construction on Guam and additional training and other military activities in the broader Micronesia region, with the associated additional pressure on marine coastal, wetlands (including coral reefs), and terrestrial resources.

All of these trends suggest extensive public and private infrastructure investments over the next ten years. If past development patterns and practices are any indication of our future direction, this will result in widespread fragmentation of and damage to the natural systems that provide essential human benefit and habitat for plant and animal species. Planning for the location and scope of impacts upon the landscape, and coordinating mitigation strategies to maximize conservation benefits at the landscape and watershed scales will be needed to avoid these outcomes.

c. The importance of the mitigation concept

Recent experience with the administration of our more mature, substantive mitigation programs (§404 of the Clean Water Act (CWA) and the Endangered Species Act (ESA)) has shown that, managed effectively, the mitigation protocol can reduce the environmental impacts of construction projects and produce significan resources for restoration and conservation of the natural environment (see Chapter 4, "Implementation regulations and guidance to support the mitigation protocol.")
Since the mitigation protocol can be made part of project planning, design, and financin process, it is an effective way to influenc the environmental impacts of infrastructure investments and produce significant resource to offset unavoidable damages. Moreover, if mitigation is planned using landscape-level ecological information, it can accomplish meaningful results in coordination with other (mitigation and non-mitigation) conservation actions on the same landscape.

Land and water conservation financed b requiring development projects to avoid environmental damage and offset impacts is likely to receive easier legislative support than the allocation of significant tax revenue for habitat protection and restoration through the appropriation of government funds for conservation purposes. Compensatory mitigation funds often come from long-term public or private financing, are seen as a cos of doing business, and their payment is seen as a way of facilitating the development or infrastructure objective.

d. The role of compensatory mitigation in supporting conservation

Private and public expenditures for compensatory mitigation under the existing major federal programs total approximately $3.8 billion annually,[4] and the Clean Water Act §404 program supports the conservation and restoration of approximately 50,000 acres of aquatic resources a year (see Chapter 3, "Scope of current programs"). Despite the expenditure of compensation funds under the mitigation protocol, many projects have fallen short of their potential for achieving habitat protection and restoration (see Chapter 3, "Performance of existing compensatory mitigation programs"). If mitigation is managed in a more comprehensive way, it can have a more widespread and positive impact on America's

environmental future, as well as on the services provided to people by these ecosystems.

The nation's major mitigation programs are now structured to protect many wetlands, streams, and the habitat of threatened and endangered species. However, uplands (even high quality, intact, and mature areas that harbor multiple at-risk species) outside of existing federal ownership, receive no federal protection, and are rarely the target of mitigation expenditures under state or federal programs. Legal protection and requirements for compensation for species and habitats not yet listed as threatened or endangered are also lacking. Thus, despite the adoption of the new §404 compensatory mitigation regulations and the substantial scale of mitigation overall, the scope of the nation's current mitigation framework is still too narrow. There is real potential, however, to build on this experience as we look at planning and mitigation for future activities that will affect habitats across the nation.

e. Definitions

Several terms will be used in the course of this paper and are defined here

Compensatory mitigation: The restoration, creation, enhancement, or preservation of natural resources to compensate for impacts pursuant to a regulatory program that: (1) prospectively issues permits or licenses or approvals for activities that affect fish an wildlife habitat or other natural resources; or (2) assesses after-the-fact damages for injury to, destruction of, or loss of habitat or natural resources.[5]

Compensatory mitigation mechanisms: Obligations to provide compensatory mitigation may be satisfied by: purchasin credits from a conservation or mitigation "bank" that is established in advance, making a payment to an "in-lieu fee" program that supports a planned conservation action, or by the regulated entity or actor directly undertaking the compensation actions.

Federally recognized and regional conservation plans: In addition to the State Wildlife Action Plans, a wide range of other federally recognized, state-based plans offer important conservation information that can be useful in guiding mitigation decisions. These include, for example, coastal zone management plans, state forestry plans, and endangered species recovery plans. These plans offer value because they are prepared in all or many states; they are constructed according to standards set forth in federal law and therefore offer some consistency; many are referenced in existing federal laws and regulations; and many have been developed through a transparent process with the participation of the public. Other regional, state, and local conservation plans may be appropriate for consideration, including detailed planning that may accompany large scale energy or other infrastructure investments.

Mitigation: Avoiding the impacts of an action; minimizing such impacts by limiting the degree or magnitude of the action or its implementation; rectifying the impact by repairing, rehabilitating or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; and compensating for the impact by

replacing or providing substitute resources or environments.[6]

Mitigation protocol: The mitigation protocol means an approach to the foreseeable impacts of projects that requires first making ever effort to avoid damages to environmental resources, then minimizing that damage that cannot be avoided, and only then offsetting the damage that cannot be avoided or minimized.

Next generation mitigation: A more effective, comprehensive approach to existing, expanded, and future mitigation programs, that rigorously and consistently applies the mitigation protocol *and* is guided by landscape- and watershed-based planning informed by the State Wildlife Action Plans and other federally recognized and regional natural resource plans.

State Wildlife Action Plan: A comprehensive wildlife conservation strategy prepared by each state and territory pursuant to the Conservation and Reinvestment Act of 2000.[7]

Chapter Two

A New Approach to Making Mitigation an Effective Tool for the Conservation of Natural Systems

a. The need for a more comprehensive approach to conservation and mitigation

The mitigation program that operates under §404 of the CWA provides an example for the need for a more comprehensive approach to conservation and restoration of habitats and resource lands and waters. Particularly in light of the likely impacts of climate change, we have come to value more fully the services provided by healthy wetlands—storing water in times of flood and metering it out in times o drought, improving water quality, sequestering carbon, and sustaining wildlife. At the same time we now understand that restoring or creating pieces of unconnected aquatic habitats to compensate for losses does not actually sustain these important values over space or time.[8] A more comprehensive approach – the next generation of mitigation – is needed to maximize the ability of the mitigation protocol to advance the conservation of natural systems. Such an approach is, in fact, reflected in the new Compensatory Mitigatio Rule promulgated by the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) in 2008, requiring use of a "watershed approach."[9] Similarly, the idea of Habitat Conservation Plans (HCPs) adopted pursuant to the ESA involves planning across entire property ownerships or groups of ownerships to save key habitat for specific listed species while allowing th development of other less critical areas. A more comprehensive approach to mitigation will support the conservation of ecological systems and not just satisfy regulatory requirements through piecemeal actions.

b. The information basis for a "next generation" of mitigation

Over the years, federal legislation has required and encouraged a variety of state-based plans to guide the use of federal grant funds for natural resource purposes. These plans – as well as regional, state, and local conservation plans – can provide the framework for the next generation of mitigation. The most far-reaching of these plans, State Wildlife Action Plans, have been developed in each of the 50 states and six territories. The plans can offer a framework for a comprehensive consideration of mitigation.

i. State Wildlife Action Plans

Congress created the State Wildlife Grants Program in 2000.[10] In order to be eligible for these new funds, the states were each required to prepare a State Wildlife Action Plan (the original term was "comprehensive wildlife conservation strategy"), a comprehensive plan addressing eight required elements by October 2005. Those elements are:

1. *Information on the distribution and abundance of species of wildlife;*
2. *Descriptions of extent and condition of habitats and community types essential to conservation of species;*
3. *Descriptions of problems which may adversely affect species or their habitats, and priority research and survey efforts to assist in conservation and research;*
4. *Descriptions of conservation*

actions proposed to conserve the identified species and habitats an priorities for implementation;

5. *Proposed plans for monitoring species identified in (1) and thei habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting conservation actions to respond to new information or changing conditions;*
6. *Descriptions of procedures to review the plan at intervals not to exceed ten years;*
7. *Plans for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes; and*
8. *Broad public participation in developing and implementing these plans.*[11]

State Wildlife Action Plans are strategic blueprints that can guide wildlife and habitat conservation on public and private lands and waters. Every state has now completed a firs generation State Wildlife Action Plan and some are engaged in revisions that add more comprehensive habitat maps and include specific responses to the projected impact of climate change. Approximately 31 State Wildlife Action Plans include spatially explicit maps delineating the location of terrestrial, and in some cases aquatic, conservation opportunity areas.[12]

State Wildlife Action Plans can be used as guides for the next generation of mitigation. Because of their focus on habitat, and their provision for public involvement and regular updating with new information, the Plans offer an important framework for guiding mitigation decision-making. The most comprehensive of the habitat maps can serve as a guide to the areas that should be avoided in infrastructure construction projects. However, if the State Wildlife Action Plans are to be more influentia in guiding the expenditure of compensatory mitigation funds, they must be updated to include information and maps identifying restoration priorities. In most cases, in order to guide mitigation and other decisions, the plans must be accompanied by more detailed and finer scale information on critical habitat species distributions, and habitat connectivity, particularly in areas of likely energy and other infrastructure investment.

ii. Other federally recognized and regional conservation plans

In addition to the State Wildlife Action Plans, other federally recognized, state-based plans offer important conservation information that can be useful in guiding mitigation decisions. Among these are coastal zone management plans and special area management plans, state forestry plans, endangered species recovery plans, waterfowl and fish management plans and state conservation and open space plans. Other regional, state, and local conservation plans may be appropriate for consideration as well.

- Coastal Zone Management Plans: Under the Coastal Zone Management Act of 1972 coastal states develop Coastal Zone Management Plans that must identify critical coastal resources and suggest ways of protecting

those resources. The Coastal Zone Enhancement Program of 1990, part of CZMA, now requires coastal states to conduct an assessment of their coastal management activities in nine areas.[13] These assessments must be carried out every five years [14] Many of the coastal states have also adopted Special Area Management Plans to address particular conservation needs within their coastal zones.[15]

- State Forestry Plans: The 2008 Farm Bill added a new section to the Cooperative Forestry Assistance Act of 1978, requiring state foresters to develop a statewide assessment of forest resource conditions and a long-term statewide forest resource strategy. In doing so, the state foresters are required to coordinate with their state wildlife agencies "with respect to strategies contained in the State wildlife action plans" and must "incorporate any forest management plan of the state including…State wildlife action plans."[16] The State Forestry Plans are used for a variety of conservation purposes, including coordination with the previously existing Forest Legacy Program. Under Forest Legacy, for states to be eligible for funding for the purchase of conservation easements on forest lands, they must develop and receive US Forest Service approval of an assessment of need, which identifies maps, and describes forest lands that are deemed important and in need of protection from conversion to non-forest uses. [17] The US Forest Service "shall give priority to lands which can be effectively protected and managed, and which have important scenic or recreational values; riparian areas; fish and wildlife values, includin threatened and endangered species; or other ecological values."[18]
- Endangered Species Recovery Plans: One of the central goals of the federal Endangered Species Act is the recovery of threatened and endangered species and the ecosystems on which they depend.[19] Once a species is listed by the U.S. Fish and Wildlife Service or National Oceanic and Atmospheric Administration, the agencies must "develop and implement a recovery plan" that includes 1) "a description of such site-specific managemen actions" that will support "conservation and survival of the species"; and 2) "objective, measurable criteria" that will support species recovery.[20] Recovery plans go out to public comment and after they are finalized the plans guide habitat protection and restoration.[21] Recovery plans are also centrally available on a U.S. Fish and Wildlife Service web site.[22]
- Waterfowl Management Plans: Authorized by the North American Wetlands Conservation Act of 1986,[23] the North American Waterfowl Management Plan relies upon partnerships to implement migratory bird conservation. The partnerships are called "joint ventures," which include a broad cross section of government at all levels, conservation organizations, and citizens. Joint ventures develop implementation plans, guided by biologically based planning, focused on areas of concern identified in the Plan There are currently 13 joint ventures in the United States.[24]

- Fish Habitat Plans: Modeled on the North American Waterfowl Management Plan, a coalition of agencies has launched a new initiative aimed at conserving fish habitat. I passed under the National Fish Habitat Conservation Act (first introduced i September 2008 and reintroduced in May, 2009),[25] the National Fish Habitat Action Plan[26] would rely on the federal agencies working cooperatively with plan partners to identify causative factors for declining fish population in aquatic systems; use an integrated landscape approach that includes the upstream/downstream linkages of large-scale habitat condition factors; assess and classify the nation's fis habitats; and support program partners.
- State Conservation and Open Space Plans: Many states undertake their own conservation priority setting planning actions, such as New York State's Open Space Plan and the Florida Forever planning process. Some of these plans combine funding strategies with conservation priorities.[27]
- Regional Conservation Plans: Several regional conservation planning efforts can help to inform mitigation decision-making. For example, in 2007, the Western Governor's Association launched its Wildlife Corridors Initiative, "a multi-state and collaborative effort to improve the knowledge and management of migratory corridors and crucial habitat."[28] The Association established a Western Wildlife Habitat Council to "identify key wildlife corridors and crucial wildlife habitats in the West and coordinate implementation of needed

The Nature Conservancy's Ecoregional Planning

To guide its conservation activities, the Nature Conservancy employs ecoregional planning – a comprehensive process for identifying a set of places or areas that, together, represent the majority of species, natural communities, and ecological systems found within a particular eco-region. Ecoregions are large and identifiable (i.e., map-able) landscapes that differ qualitatively from one another in terms of ecology and biological phenomena and are defined by climate, geology, topography and associations of plants and animals. An ecoregional portfolio (i.e., priority sites), the end product of ecoregional planning, is a selected set of areas that represents the full distribution and diversity of these systems. The selection of portfolio sites is guided to a large degree by biological targets. These can be important plants or animals, or biological communities that when conserved result in the preservation of all representative biodiversity. For each of these targets viability goals are established and it is these goals that drive the selection of areas that are needed to meet these goals. Ecoregional portfolios effectively address the fundamental goals of biodiversity conservation:

- Represent all distinct natural communities within conservation landscapes and protected areas networks;
- Maintain ecological and evolutionary processes that create and sustain biodiversity;
- Maintain viable populations of species;
- Conserve blocks of natural habitat that are large enough to be resilient to large-scale stochastic and deterministic disturbances as well as to long-term changes.

policy options and tools for preserving those landscapes."[29] The Nature Conservancy uses ecoregional plans to guide its conservation acquisitions and priorities. (See Box "Ecoregional Planning.")

iii. The next generation of mitigation: a comprehensive approach

The next generation of mitigation, as described in this paper, depends upon having the biological information and public priority setting needed to make wise landscape-level decisions about mitigation. The State Wildlife Action Plans may be the most advanced tool for accomplishing this goal. A number of other planning authorities can also inform this decision-making. (See Chapter 4, "Landscape-level planning for conservation and ecosystem services," for a discussion of these authorities.) Ultimately the programs and plans could be used together to yield a vision for conservation that can be used for multiple purposes.

Our proposed approach is to use the State Wildlife Action Plans and other federally recognized and regional conservation plans to guide the mitigation protocol in relation to existing, expanded, and any future authorities that regulate impacts to habitat and species.

The Watershed Approach articulated in the 2008 Compensatory Mitigation Rule provides an excellent example that demonstrates how this integration might occur in future decision-making (see Chapter 3, Box "The Watershed Approach"). The Watershed Approach is an "analytical process" for making compensatory mitigation decisions that relies upon a landscape perspective.[30] It acknowledges that there may be many circumstances under which an existing watershed plan is not available to guide compensatory mitigation, and in these instances, it lays out an approach for using existing plans and information available from other sources to guide the decision-making.[31]

Similarly, we propose that in instances when the State Wildlife Action Plan is sufficientl detailed to guide mitigation decision-making, it should be used. But when detail is lacking or other federally recognized or regional plans provide important information on key habitat and species distribution, these plans should be consulted as well. There may be instances, such as current proposals to increase solar energy production in the Mojave Desert, where additional and more detailed planning (i.e., at a finer resolution), tied to th framework of statewide planning, is needed to inform the location of and mitigation for facility construction in a way that protects and enhances the critical natural resources of the Desert.

The overall objective proposed here is to use appropriate species and habitat plans to avoid and minimize impacts on the most sensitive environmental resources, to guide cumulative impact analysis, and to channel compensatory mitigation funding to the restoration and protection of larger natural systems that will be resilient to the environmental threats we face today. These healthy natural systems will yield numerous ecosystem benefits to the public Achieving this vision will require adjustments to some existing legislation, regulations, and guidance.

The Disney Wilderness Preserve

The Nature Conservancy's Disney Wilderness Preserve project provides an example of effective mitigation carried out under the §404 Program and represents the kind of results we would hope to achieve more widely from our proposals. In 1994, when the Walt Disney Company was contemplating construction of the Animal Kingdom at Walt Disney World in Central Florida and the development of the residential community named Celebration, it was clear that the projects would damage significant areas of wetlands in the Reed Creek Watershed at the headwaters of the Everglades ecosystem. Regulatory agencies and the Disney Corporation determined that, while some wetlands damage could be avoided and that some wetlands could be protected on-site, to offset the damage that could not be avoided it was best to select a large mitigation site in the Reedy Creek watershed that was remote from the Disney properties. A 10,000-acre cattle ranch with extensive degraded wetlands was purchased downstream on Reedy Creek at a strategic location adjacent to the Kissimmee chain of lakes. (This area had been identified as important by early planning fo Preservation 2000 – a precursor to the Florida State Wildlife Action Plan.) In exchange for build-out permits, Disney agreed to minimize wetlands loss at their development sites and to provide funding to The Nature Conservancy to buy the ranch, restore its wetlands, and manage the property into the future. Ultimately, other developers contributed to the project to meet their own compensatory mitigation needs, allowing TNC to purchase and restore additional adjoining land.

The compensation project is now complete. The wetlands and adjacent uplands have been successfully restored and the Disney Wilderness Preserve property has become the anchor for the conservation of more than 25,000 acres of land protecting the Everglades headwaters. The Disney Preserve provides both exceptional wildlife habitat and important ecosystem services. It stores extensive amounts of water in times of heavy rainfall, removes excess nutrients from Reedy Creek, metes out water in times of drought, and supports extensive wildlife, including several listed species. Because it has become part of a larger system of protected lands, it has every prospect of enduring in the years to come.

Chapter Three

Foundations of Existing Mitigation Programs

a. Legal framework of existing mitigation programs

Mitigation under U.S. law means avoiding, reducing, and offsetting the foreseeable impacts of authorized activities on the environment. Mitigation as currently understood and practiced derives much of its content from definitions in regulations adopte by the Council on Environmental Quality in 1978 to guide federal agencies' implementation of the National Environmental Policy Act (NEPA).[32]

National Environmental Policy Act and Mitigation: Under NEPA, federal agencies are required to consider the impacts on the environment of their proposed actions. NEPA requires agencies undertaking major federal actions that significantly a fect the human environment (including issuance of permits and licenses) to prepare an Environmental Impact Statement (EIS), which includes analysis of alternatives, identification o impacts, and identification of potentia measures to mitigate identified impacts. NE A regulations define "mitigation" to include

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.
(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(e) Compensating for the impact by replacing or providing substitute resources or environments.[33]

During its 40-year history, NEPA has not been interpreted by the courts to require by itself the adoption and implementation of mitigation measures in connection with federal actions. Rather, NEPA requires that the responsible agency use the NEPA process to *identify* relevant mitigation measures that can address the impacts of the proposed action and its alternatives.[34] The mitigation identified in th NEPA process may subsequently serve as the basis for mitigation requirements laid out in a record of decision, a mitigated "finding of n significant impact," permit, license, contract or other legally binding document; however, the basis for the mitigation requirement is the underlying law being administered by the agency, as informed by NEPA.

For example, private or public users may be required to mitigate impacts on public lands through the Secretary of Interior's duty under the Federal Lands Policy Management Act to prevent "unnecessary or undue degradation"[35] or the Secretary of Agriculture's duty under the Forest Service Organic Act to regulate "occupancy and use [of the national forests] and to preserve the forests thereon from destruction."[36] Mitigation may also be required by the terms of various permitting programs and regulations, such as §404 of the CWA. The NEPA process helps to identify the kinds of mitigation that may be available.

Mitigation plays a more specific role i NEPA under a particular provision of the regulations that allows a federal agency to

forego preparation of a full EIS where an environmental assessment (EA) results in a Finding of No Significant Impact (FONSI) [37] An agency may commit to mitigation as the basis for a "mitigated FONSI" as a way of avoiding the need to prepare the more detailed EIS.[38]

Part of NEPA requires federal agencies to "interpret and administer" their laws and policies in accordance with the "policies" set forth in NEPA, and further provides that these policies are "supplementary to those set forth in existing authorizations of Federal agencies."[39] Federal agencies could use these provisions to support more holistic or aggressive mitigation requirements and conditions.[40]

Several states have their own "state NEPAs." Among these, several, including California and Washington, require adoption of mitigation measures. In these states, the environmental impact review process itself can trigger mitigation obligations to compensate for private and state activities subject to such review.[41] (See Box "Compensation for Impacts to California's Oak Woodlands.")

Clean Water Act Section 404 Program and Mitigation: The most robust and fully developed mitigation regime is that operating under the CWA's §404 program, which regulates dredge and fill activitie in the waters of the United States.[43] In the 1972 law, Congress assigned the day-to-day authority for issuing permits to the Corps, but assigned responsibility for developing the environmental criteria for permitting (the §404(b)(1) Guidelines) to the EPA. In 1980, the §404(b)(1) Guidelines were adopted as final regulations [44] In 1986, the Corps adopted

Compensation for Impacts to California's Oak Woodlands

California's Environmental Quality Act requires state and local agencies to identify the significant environmental impacts of thei actions and to avoid or compensate for them. In 2001, a provision was adopted requiring mitigation for projects that result in the "conversion of oak woodlands that will have a significant e fect on the environment."[42] The new program allows for several mitigation alternatives, including preserving existing oak woodlands through easements, planting an equivalent number of trees, or contributing funds to the Oak Woodlands Conservation Fund administered by the California Wildlife Conservation Board. Contributed funds may be used for a variety of purposes, including the purchase of conservation easements, land improvement grants and cost-share incentive payments, public education and outreach by local government entities, and for assistance to local governments to encourage the incorporation of oak conservation elements into local general plans.

California's Oak Woodlands Conservation Program is an example of a state using its existing authorities – here the state NEPA and ESA – to expand the mitigation protocol to a valuable and dwindling habitat type.

See: California Wildlife Conservation Board. "Oak Woodlands Conservation Program." http://www.wcb.ca.gov/Pages/oak_woodlands_program.asp. (Last visited April 14, 2009.)

a comprehensive mitigation policy that applied to permit actions under §404 and §§9 and 10 of the Rivers and Harbors Act of 1899.[45] Compensatory mitigation guidelines issued by the Department of the Army and EPA in 1990 set out the process for carrying out mitigation under the program.[46] These guidelines referenced the NEPA mitigation definitions described above, but condensed them into three steps and prescribed that the steps be pursued in sequence ("sequencing"). The sequence is: (1) avoidance, (2) minimization, and (3) compensation for impacts that cannot be avoided or minimized.[47]

Avoidance is the first step in the mitigatio sequence. During this step, the Corps determines whether or not the proposed project is the least environmentally damaging practicable alternative (LEDPA). The LEDPA is identified by an evaluation of the direct secondary, and cumulative impacts on the aquatic ecosystem of each alternative under consideration. [48]

In 2008, after many years of practice, studies, outreach, and public comment, the Corps and EPA adopted new compensatory mitigation regulations that supplement, and in some cases replace, the regulations and guidance the agencies had been using for decades. In keeping with past practice, the Compensatory Mitigation Rule states that compensatory mitigation requirements may be achieved through the restoration, enhancement, establishment, and "in certain circumstances" preservation of similar aquatic resources. It specifies, howeve , that restoration should generally be the first option considere [49] and that preservation may only be used when fiv specific criteria are met [50]

The Compensatory Mitigation Rule explicitly preserves the mitigation sequence.[51] The Rule creates higher standards for measuring compensatory mitigation performance against ecological performance standards and requires mitigation site selection to be carried out using a "watershed approach" (see Box "The Watershed Approach," below). The watershed approach outlined in the rule states that the Corps must undertake an assessment of information on the "cumulative impacts of past development activities…"[52] when making decisions about siting compensation projects. The Rule also includes requirements for financial assurances, permanent protection and other measures intended to ensure the long-term conservation and management of compensatory mitigation sites.

This regulatory compensatory mitigation regime is now on a firmer footing than mos other compensatory mitigation regimes. The 2008 Rule is already influencing othe existing compensatory mitigation programs, such as compensatory mitigation carried out under the Water Resources Development Act (see Chapter 4, "Civil Works compensatory requirements"). It does, however, have some characteristics that might limit its useful application in other mitigation contexts. The §404 program is distinctly focused on aquatic resources and watersheds; while it allows for the use of preservation of high quality resources as a means for providing compensatory mitigation, it discourages the use of preservation as a sole mitigation mechanism. The 2008 rule does not support double-dipping or credit "stacking" wherein the same conservation action might address multiple disparate impacts of different activities.[53]

Chart 1: Estimated Annual Compensatory Mitigation Costs Expended or Committed Under Major Federal Regulatory Programs

Regulatory Program Estimate (in millions)	*Cost*
Clean Water Act Section 404	$2,947.3
Endangered Species Act Section 10	$370.3
Federal Natural Resource Damage Programs	$87.7
Federal Power Act	$210.3
Northwest Power Act	$207.1
Total:	$3,822.7

Reference: Environmental Law Institute. October 2007. *Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities.* Washington, DC: Environmental Law Institute.

ESA, Habitat Conservation, and Mitigation
The federal Endangered Species Act includes two separate provisions that may require mitigation to compensate for allowed impacts to a listed species or its habitat: §7 consultations and §10 incidental take permits.

ESA §7: ESA §7 guides federal activities. Section 7 requires federal agencies to "insure that any action authorized, funded, or carried out" by the agency is not likely to jeopardize the continued existence of listed species or result in the destruction of critical habitat.[54] Under the provision, federal agencies must consult with either the U.S. Fish and Wildlife Service (FWS) or the National Oceanic and Atmospheric Administration (NOAA) (the "Services"), depending on the species involved. FWS staff estimates that the agency conducts over 2,000 formal consultations per year.[55] NOAA conducts close to 400 consultations a year.

Following this consultation, the Services must provide the federal agency with a written statement – known as a "biological opinion"– that outlines how the proposed activities affect the species or its critical habitat.[56] During the formal consultation process, the Service is required to not only evaluate the effects of the action on the listed species or habitat, but must also consider cumulative effects.[57] When formulating its biological opinion, the Services are directed to determine whether the action "taken together with cumulative effects, is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. [58]

In rare instances the Services find that th activity would jeopardize the species or adversely modify critical habitat (a "jeopardy opinion"). In such a case, the biological opinion must outline "reasonable and prudent alternatives" that should be taken to avoid jeopardy or adverse modification [59]

FWS estimates that of the 300,000 formal and informal consultations that occurred from 1998-2002, only 420 received a jeopardy opinion. NOAA estimates that it averages between 20 and 50 jeopardy biological opinions each year (between the years 1998 and 2003).[60] The vast majority of formal consultations, however, result in a determination of no jeopardy or adverse modification. If, howeve , the Services determine that the action will cause a take of a listed species, even if there is no jeopardy finding, the Services issue a biologica opinion that outlines "reasonable and prudent measures" that are "necessary or appropriate

to minimize" impacts of an incidental take of protected species.[61]

ESA §10: Section 10 of the act governs non-federal activities. Since 1982, FWS and NOAA have had the authority to permit the taking of a listed species by non-federal entities for activities that may cause incidental harm to a listed species, if the permittee agrees to develop a habitat conservation plan (HCP).[62] One of the conditions of the permit, known as a §10 incidental take permit, is that the applicant will, "to the maximum extent practicable, minimize and mitigate the impacts of such taking."[63] HCPs must identify the impact on the listed species, the steps the applicant will take to monitor, minimize, and mitigate those impacts, and the funding available to implement the plan.[64]

The HCP process, particularly that developed by FWS, continues to evolve. HCPs were firs adopted primarily to allow individual projects that are otherwise lawful but result in the incidental take of a listed species to proceed. More recent HCPs have attempted to address broader-based regional planning issues and, in some cases, multiple species in one plan.[65] This allows for a more coordinated, proactive, and regional approach to conservation and regulation.

The types of mitigation measures specified i an HCP are as varied as the HCPs themselves. However, an HCP handbook developed by the agencies states that they prefer to see the plans address impacts in the following order:

- *Avoid* the impact (such as changing the timing of the project, relocating the project, and restricting access);
- *Minimize* the impact (such as modifying land use practices, creating buffer areas, and reducing project size);
- *Rectify* the impact (such as enhancement, restoration, or revegetation of degraded or former habitat);
- *Reduce* or *eliminate* the impact over time (through proper management, monitoring, and adaptive management); or, finall ,
- *Compensate* for the impact (such as habitat restoration or protection on- or off-site).[66]

Activities approved under an incidental take permit often involve permanent habitat loss, for which permittees are required to provide "habitat mitigation" by "acquiring, or otherwise protecting, replacement habitat at an onsite or offsite location."[67]

Other Laws and Mitigation: Other laws require compensatory mitigation for impacts to wildlife and the environment. Among these are the natural resource damages provisions of the federal Superfund law (Comprehensive Environmental Response, Compensation, and Liability Act) and the oil pollution provisions of the Clean Water Act and the Oil Pollution Act.[68] Natural resources damages may also be recovered for impacts to the national park systems and marine sanctuaries.[69] These are not offsets in the sense of planned actions to compensate for authorized activities, but rather are restoration and recovery actions meant to restore damaged ecosystems and resources after the fact. There are detailed regulations covering the assessment and implementation of natural resource damage payments, and trustees are designated to assure that recovered funds are spent as necessary to restore the public natural resources.

Compensatory mitigation for hydropower projects may be mandated under the Federal Power Act and the Northwest Power Act.[70] Environmental measures often include mitigation for impacts to fish and wildlif habitat. Projects authorized under the biennial Water Resources Development Act(s) may also be required to undertake compensatory mitigation activities (see Chapter 4, "Civil Works compensatory requirements").

Federally supported transportation projects, including highways, bridges, airports, transit, and the like also may give rise to mitigation obligations. Most of these obligations stem from other laws, such as the §404 program or ESA. Transportation legislation has expressly recognized mitigation as an allowable project cost. The Federal Highway Administration (FHWA) has a well-developed environmental program, including research programs, meant to support environmental design, operation, and mitigation for transportation projects.[71] The state of North Carolina created a coordinated program, the Ecosystem Enhancement Program, to harness the stream of anticipated federal transportation mitigation dollars and direct the mitigation toward landscape and watershed-based objectives.[72]

Finally, the Coastal Zone Management Act (CZMA) allows coastal states to perform a consistency review of federally authorized activities in the coastal zone.[73] Section 401 of the CWA allows states to review federally permitted activities to determine whether state water quality standards will be violated by the proposed action.[74] The federal activities themselves may require compensatory mitigation, but the consistency review gives the state the ability to provide input on the mitigation actions.[75]

b. Scope of current programs: funding and acreage affected

Impacts to the environment from land development and other practices are frequent, widespread, and have a significant cumulativ effect on habitat. Although many impacts go unmeasured, five key federal program (CWA, ESA, federal natural resource damage programs, Federal Power Act, and the Northwest Power Act) do require offsets through monetary or in-kind compensation. In a 2007 report, ELI estimated that private and public expenditures for such compensation under these programs total approximately $3.8 billion annually (see Chart 1).[76]

About $2.9 billion of this spending – over 77 percent of the estimated annual amount of funds spent on compensatory mitigation – is generated through the compensatory mitigation requirements of §404 of the CWA. In terms of habitat programs, the next largest is the §10 of the ESA,[77] which represents an average annual commitment of $370.3 million per year.[78]

The size of these programs – in terms of acreage of adversely affected habitat and that provided as compensation – is difficul to determine. Some information is, however, available for the §404 program.[79] The Corps reports that in the seven-year period from 2000 to 2006 the annual amount of wetland acreage permitted for impacts ranged from 18,900 to 24,650 acres, for an average of 20,620 acres a year. Over the same time period, the amount of compensation required varied between 38,727 and 57,820 acres per year, and averaged about 47,384 acres per yea.[80]

c. Performance of existing mitigation programs

Because they have the longest track record and are the most active ecosystem-based markets in the U.S., the wetlands mitigation and endangered species programs provide the most relevant lessons for designing future mitigation programs that support the conservation of ecological and biological resources. This section will focus on the lessons learned from these programs to draw conclusions about the design of any future efforts to regulate impacts to key habitat and related natural systems.

i. The deterrent factor

The nation's current laws that regulate impacts to habitat and species have been a positive force for conservation. It is commonly understood that the very existence of these regulatory programs provide a deterrence to impacts and significant avoidance. When project proponents determine that potential sites are home to jurisdictional wetlands or threatened and endangered species, many of them will avoid these locations altogether. However, few, if any, data are available to demonstrate this effect.

ii. The role of avoidance and minimization

§404 Mitigation: One of the central concepts of the §404 program is that before a permit can be issued to fill a wetland or stream, impact must be avoided as much as possible[81] and those impacts that cannot be avoided must be minimized.[82] After all of the proposed impacts have been avoided and minimized, the Corps can require the permittee to develop a compensatory mitigation plan for offsetting the unavoidable impacts.[83]

Although the Corps' accounting for the number of acres of aquatic resource impacts that permittees have requested and acres that have been permitted is considered accurate, the data on acres that have been avoided is considered far more subjective.[84] That being said, the agency reports that in the seven-year period of fiscal year 2000 to 2006 projec proponents submitted permit requests for impacts that would have led to the loss of, on average, 26,730 acres a year.[85] During that same time period, the Corps reports that, on average, 5,967 acres a year of those impacts were avoided.[86] In other words, the sequencing provisions supported the avoidance of 22 percent of the requested acres of impacts on average over this time period.

Thus the avoidance provisions clearly help to direct projects to locations that have fewer impacts to aquatic resources. It is difficult t deduce, however, how effective the Corps avoidance and minimization procedures are, as there has been little objective evaluation of them. In addition, in many Corps districts, some amount of avoidance and minimization may take place during a "preapplication" consultation phase with the Corps before an application for a §404 permit is submitted.[87]

ESA Mitigation: Under §7, biological opinions outline "reasonable and prudent measures" to minimize impacts of an incidental take of protected species.[88] We were unable, however, to identify readily available data on how effective these minimization measures are in practice – in terms of acres of impacts or number of species affected. Nor were we

able to evaluate how effective avoidance and minimization measures are under §10.

iii. The role of compensatory mitigation

§404 Mitigation: Compensatory mitigation in the §404 program is the third and final step i the mitigation sequence. Offering to undertake compensatory mitigation does not, however, guarantee that a permit will be issued. The new Compensatory Mitigation Rule clearly states that the Corps may determine that a permit cannot be issued if the compensation that the permittee offers is not considered "appropriate and practicable."[89] However, it is difficult to determine how many permi requests are denied on the grounds that the offered compensatory mitigation is unlikely to successfully replace lost resources. In 2003, the Corps denied less than one percent of those permits requested.[90]

Unlike many of the other compensatory mitigation programs reviewed here and elsewhere,[91] the Corps does strive to track the number of acres of aquatic resources that are impacted through the §404 program and the amount of compensatory mitigation that is required. The database the Corps uses throughout its 38 district offices is referred t as the OMBIL Regulatory Module, or "ORM." Although ORM is being used nationwide, the Corps has yet to release updated data on acres of impacts and acres of mitigation required in recent years.

ESA Mitigation: There remains considerable uncertainly whether or not the minimization provisions of the §7 consultation process give the Services the authority to require compensation as a minimization measure. The 1998 FWS *Final ESA Section 7 Consultation Handbook* advises that "it is not appropriate to require mitigation for the impacts of incidental take," and that minimization measures should only occur within the action area, and only to minimize the impacts on specific species o habitat.[92]

Some FWS offices, howeve , have taken a different approach and have determined that impacts to listed species may be "minimized" by requiring conservation measures. The Sacramento field office of FWS, for exampl secures compensation for most, if not all, of the consultations that end in take.[93] Moreover, FWS's 2003 guidance on the use of conservation banks acknowledges that "activities regulated under Section 7 or Section 10 of the ESA may be eligible to use a conservation bank, if the adverse impacts to the species from the particular project are offset by buying credits created and sold by the bank."[94] The feeling of most FWS staff, however, is that the authority provided to the Service under §7 and the consultation process emphasizes the minimization or avoidance of project impacts through design and project changes, rather than compensatory measures.

Section 7 consultations conducted by NMFS rarely if ever result in compensatory mitigation as a requirement in an incidental take statement. NMFS instead relies on avoidance and minimization measures.

Our research revealed that the Services do very little in the way of tracking the nature or amount of compensatory mitigation required under §7 of ESA. This conclusion is supported by a 2009 report by Government Accountability Office and ELI s 2007 compensatory mitigation study.[95]

Unlike §7, §10 of ESA clearly states that permittees are required to minimize and mitigate the impacts to species "to the maximum extent practicable."[96] FWS does maintain a centralized database of Incidental Take Permits, HCPs, and other FWS agreements with non-federal landowners. The database, the Environmental Conservation Online System (ECOS),[97] provides information on the species covered by the HCP, the size of the HCP, and the duration of the HCP.

1. Replacement of functions and services and the need for effective ecological performance standards

§404 Mitigation: A review of the existing literature on the administrative and ecological performance of compensatory mitigation reveals that in many separate studies, a significant percentage of the compensator mitigation projects across the country fail to comply with their permit conditions and, even more frequently, fail to replace lost wetland acres and functions.[98] In its comprehensive national study on compensatory mitigation for wetland losses, the National Research Council reported that between 70 to 76 percent of mitigation required in permits is actually implemented.[99] Several other studies have had similar results.[100] In a 2001 review, researchers found that an average of only 21 percent of mitigation sites met various tests of ecological equivalency to lost wetlands.[101]

The lessons that wetland compensatory mitigation and wetland mitigation banking offer must be viewed not only in the context of the health of the ecosystem *market* it has spawned, but also in the health and resilience of the *habitats* they were designed to conserve. In the §404 program, market success has not, to date, been shown to translate into consistent ecological success.[102]

The ecological success of compensatory mitigation hinges on many factors, including whether or not the mitigation project is measured against performance standards that are ecologically based and adequately designed such that, if met, they will yield the desired aquatic resource functions. To date, the §404 program has fallen short in this regard.[103] Several field-based studies have concluded tha compliance with permit conditions is a poor indicator of whether or not mitigation projects are adequately replacing the appropriate habitat types and ecological functions of wetlands.[104] In many cases, compensatory mitigation sites meet all of their permit standards, but still have not yielded a wetland that meets the federal definition for jurisdiction

The Compensatory Mitigation Rule issued by EPA and the Corps in April 2008,[105] did not prescribe "one size fits all" ecologica performance standards to be included in mitigation plans.[106] In recognition that "ecological performance standards will vary depending upon aquatic resource type, geographic region, and compensation method," the Rule describes "general criteria" or "principles" for establishing appropriate ecological performance standards,[107] and requires that they be "based on the best available science that can be measured or assessed in a practicable manner."[108]

Developing science-based ecological performance standards remains a challenge for the regulatory agencies.[109] Although getting this part of the program right has proven to be essential, several problems remain. In some instances, the science is currently lagging

behind the regulatory requirements. In others, some reviewers have contended that the Corps has not effectively incorporated the "best available science" into performance standards.[110]

ESA Mitigation: In contrast to wetland compensatory mitigation, there is very little in the way of research or literature on either the compensatory mitigation measures that are being required of permittees under §7 or §10 or on the ecological effectiveness of these compensatory mitigation practices or conservation banking.

In 1998, Defenders of Wildlife sought to analyze a sample of HCPs to determine their effectiveness.[111] The report concluded that few of the plans reviewed were adequately based on science; nor were the plans consistent with species recovery. In 1999, the National Center for Ecological Synthesis (NCEAS) and the American Institute of Biological Sciences (AIBS)[112] undertook a study of the use of science in the development of 43 habitat conservation plans (HCPs). Although the study did not seek to evaluate the implementation of these HCPs, it did attempt to assess the likelihood of success of the mitigation measures. The authors concluded that "although HCPs most often identify the primary threat to the affected species, only a little more than half of the time do mitigation plans adequately address that threat."[113] Neither of these studies, however, were designed to determine if species compensatory mitigation measures are achieving their intended biological results.

One mechanism for the agencies to evaluate the ecological effectiveness of the compensatory mitigation provisions required under the Act is through the 5-year review process. The ESA requires the agencies to conduct a review of all listed species at least once every five years [114] This might be the appropriate opportunity for a summary of compensatory mitigation measures required and their ecological outcomes. In 2005, the services released guidance on "the scope and role" of the 5-year review, as well as a template for what should be included in the review. The guidance, however, makes no mention of summarizing or assessing the ecological outcomes of minimization or compensatory mitigation requirements.[115]

2. The need for adequate monitoring

In order for regulatory agencies and the public to determine whether or not individual compensatory mitigation projects are being carried out and if those that are carried out are replacing lost resources, it is essential that the permittees be required to monitor the outcomes of the required mitigation measures. Such monitoring should be directly tied to ecological performance standards outlined in the §404 permit or biological opinion.

§404 Mitigation: Under the 2008 compensatory mitigation rule, all compensatory mitigation projects are required to have a mitigation plan.[116] All mitigation plans must address 12 elements, including monitoring requirements. This section must lay out the parameters that will be monitored in order to determine if the compensatory mitigation project is on track to meet its objectives, as well as a schedule for monitoring and providing monitoring reports to the Corps.[117]

As some members of the 2001 NRC panel on wetland mitigation recently noted, "The manner in which Corps districts implement the ecological performance standards (§332.6/230.95) and the related monitoring section (§332.6/240.96) may well spell the ultimate success of the regulation."[118]

ESA Mitigation: Under §7 of the ESA, biological opinions should contain provisions for the permittee to monitor the effects of its action on listed species. A recent report by the Government Accountability Office (GAO found that "The extent to which the [Fish and Wildlife] Service includes monitoring and reporting requirements in its biological opinions varies considerably."[119] The report also notes the importance of the information provided in monitoring reports to the FWS's ability to assess the cumulative effects of the given take on the species.[120]

3. The need for rigorous oversight and enforcement

Performance standards and monitoring provisions cannot guarantee ecological success on the ground unless compensatory mitigation projects are rigorously measured against such appropriately designed standards and the regulatory agencies provide adequate oversight and enforcement.

§404 Mitigation: Many of the administrative and ecological deficiencies of the §40 program can be attributed to the insufficien resources provided to the Corps for oversight and enforcement.

In 2005, GAO released a report on the Corps' oversight and enforcement track record[121] that concluded that the Corps districts "performed limited oversight to determine the status of required compensatory mitigation."[122] GAO found that the agency provided "somewhat more" oversight for compensatory mitigation satisfied through mitigation banks and in-lie fee mitigation than permittee-responsible compensation[123] (the most frequent type of compensatory mitigation employed).[124] However, "oversight was still limited…" for mitigation banks and in-lieu fee compensation.[125]

GAO concluded that many of the deficiencies in oversight were due to "conflicting guidance, which notes that compliance inspections are crucial yet makes them a low priority," and the agency's limited resources.[126] In its response, the Department of Defense concurred and noted that the agency was working on revising their Standard Operating Procedures (SOP), which outlines the agency's priorities, to clarify discrepancies and provide more clear guidance on mitigation oversight. The agency hoped to finalize the revised SOP by the fall of 2005,[127] but Corps officials state that the revised SOPs are not yet available but should be released in the coming weeks.[128] With regard to enforcement, several different enforcement options are available to the Corps if the agency determines that required compensatory mitigation is not being performed or not meeting performance standards, the mitigation provider fails to submit monitoring reports, or there are other infractions. These include "issuing compliance orders and assessing administrative penalties, requiring the permittee to forfeit a bond, suspending or revoking a permit, and implementing the enforcement provisions of agreements with third parties to perform mitigation on permittees' behalf."[129] The Corps may also bring legal action against permittees in federal district court.

GAO found, however, that Corps districts rarely rely upon the enforcement measures at their disposal and instead rely "primarily on negotiation with permittees or third parties…"[130]

ESA Mitigation: The 2009 GAO report on §7 consultations concluded that "The [Fish and Wildlife] Service lacks a systematic means of tracking the monitoring reports it requires in biological opinions…and does not know the extent of compliance with these requirements.[131] The study reports that in the field offices included in the stu , GAO found that of the consultations that had reporting requirements, FWS "could not fully account for required monitoring reports in 40 of the 54 consultation files (63 percent)… [132] The 5-year review developed for the Valley Elderberry Longhorn Beetle in 2006 supports this finding. In the report, FWS estimate how much habitat has been restored as a result of §7 consultations and acknowledges that its estimate is "likely very inaccurate" because "due to staff and workload constraints, the [FWS] has been unable to determine which compensation measures were actually implemented and their success."[133]

Much like the situation encountered by the Corps', FWS field sta f get conflictin messages about how much of a priority they should place on tracking monitoring reports. FWS staff reported that "responding to requests for consultations often takes a higher priority than following up on monitoring reports…"[134] Part of this is due to the fact that tracking monitoring reports is not an agency performance measure.[135]

Very little information was readily available on the Services' oversight of compensatory mitigation measures that are required through HCPs under §10.

iv. The need for connectedness to a conservation vision

For several decades, federal §404 policy has stated a clear preference for compensatory mitigation to be carried out on-site and in-kind.[136] Lingering concerns over the ecological effectiveness of this approach, as well as its failure to take into consideration a wider view of conservation priorities, led the agencies to allow increasing flexibilit in siting compensatory mitigation projects, by shifting their focus to locating these projects where they are more likely to be ecologically successful. In 1995, the agencies released guidance on mitigation banking that encouraged the use of the off-site option, when it could be demonstrated that doing so was "environmentally preferable."[137] In 2001, the National Research Council (NRC) issued its influential stud , *Compensating for Wetland Losses Under the Clean Water Act.*[138] In it, the NRC Committee recommended that the federal wetland mitigation program make site selection decisions that "follow from an analytically based assessment of the wetland needs in the watershed" rather than through an automatic preference for on-site and in-kind compensation.[139] The Compensatory Mitigation Rule issued by EPA and the Corps in 2008 reversed the agencies' previously held position and established a "preference hierarchy" for selecting compensation options that favors off-site mitigation banks and in-lieu fee programs that are designed using a watershed approach, over on-site compensation. The "Watershed Approach" is described in the box below.

The Watershed Approach

The 2008 Compensatory Mitigation Rule defines the watershed approac as an "analytical process" for making compensatory mitigation decisions that involves consideration of watershed needs and relies upon a landscape perspective.[140] It incorporates many of the comprehensive conservation concepts laid out in this paper.

The agencies first state that if an existing "appropriate" watershed plan is available, it should be used to guide compensatory mitigation decision-making. If such a plan is not available, as will be the case in the vast majority of instances, the watershed approach should be used.

The Rule outlines the "*considerations*" that must be a part of the watershed approach:

> A watershed approach to compensatory mitigation considers the importance of landscape position and resource type of compensatory mitigation projects for the sustainability of aquatic resource functions within the watershed. Such an approach considers how the types and locations of compensatory mitigation projects will provide the desired aquatic resource functions, and will continue to function over time in a changing landscape. It also considers the habitat requirements of important species, habitat loss or conversion trends, sources of watershed impairment, and current development trends, as well as the requirements of other regulatory and non-regulatory programs that affect the watershed, such as storm water management or habitat conservation programs. It includes the protection and maintenance of terrestrial resources, such as non-wetland riparian areas and uplands, when those resources contribute to or improve the overall ecological functioning of aquatic resources in the watershed.[141]

The approach also acknowledges that the compensatory mitigation program does not focus solely on specific functions of aquati resources, such as water quality or habitat for certain species, but rather, "should provide, where practicable, the suite of functions typically provided by the affected aquatic resource."[142] In other words, the program is meant to take into consideration the full range of ecosystem services provided by aquatic resources.

The Rule also describes the *type of information* that should be utilized in watershed-based decision-making. It suggests that this information may be contained in existing plans or in information from other sources, including wetland and soil maps; U.S. Geological Survey topographic and hydrographic maps; aerial photographs; information on rare, threatened, and endangered species; local ecological reports or studies, etc.[143] The list of items that should be consulted includes "current trends in habitat loss or conversion; cumulative impacts of past development activities, current development trends, the presence and needs of sensitive species site conditions that favor or hinder the success of compensatory mitigation projects; and chronic environmental problems such as flooding or poor water qualit ."[144]

The watershed approach to compensatory mitigation decision-making fully contemplates the selection of sites that contribute to maintaining habitat diversity, connectivity, and the appropriate proportions of habitat types needed to enhance the long-term stability of watersheds. In most cases, such information is readily available in the State Wildlife Action Plans and other state and regional conservation plans.[145]

Chapter Four

A Framework for Advancing The Next Generation of Mitigation

This section sets forth a more detailed discussion of how the next generation of mitigation can be applied to existing, expanded, and new authorities that regulate impacts to habitat and species.

a. Essential components of the next generation of mitigation

The structure of and lessons from current mitigation programs suggest several essential components for an effective, comprehensive mitigation framework – the next generation of mitigation. These include:

- Extend mitigation concepts to all habitat types;
- A clear policy goal;
- Landscape-level planning for conservation and ecosystem services;
- Regulatory drivers;
- A defined mitigation protocol; an
- Implementation guidance to ensure that the mitigation protocol is consistently and rigorously applied and that accountability for results is assured.

These fundamental elements should be addressed by any regulatory program seeking to apply, expand, or extend protections to habitat and species through mitigation.

i. Policy goal

A policy goal for compensatory mitigation, such as the "no net loss" policy for wetlands[146] or the policy to offset adverse impacts to threatened and endangered species under habitat conservation banking,[147] greatly influences how regulatory agencies mak mitigation decisions and how regulations and guidance evolve over time. Establishing such a goal is essential for any regulatory program aiming to ensure the long-term conservation of wildlife habitat. Without it, we are left with a regulatory program that allows habitat loss without any effort to avoid or minimize impacts and without at least equivalent habitat gains. Ideally this goal will encourage more proactive, comprehensive efforts to conserve wildlife before it becomes threatened or endangered (and thereby more costly to protect and ensure survival). This would be in line with the State Wildlife Grants Program,[148] which was designed to prevent wildlife from becoming endangered and encourages improvements in conservation planning through the development of State Wildlife Action Plans.

ii. Landscape-level planning for conservation and ecosystem services

Mitigation programs should move away from piecemeal, project-by-project mitigation approaches, which often result in a patchwork of isolated, disconnected, and difficult-t - manage protected or restored habitats that fail to deliver effective conservation. Mitigation should be based on conservation planning developed in a landscape context to ensure mitigation contributes to the long-term conservation goals of a specified geographi area – a watershed for wetlands or a recovery unit for species. For example, under the Watershed Approach, the compensatory mitigation step is now required to take a

landscape-scale perspective (see Box "The Watershed Approach"). Under the approach, compensatory mitigation sites must be located within the same watershed as the impact site and where it can most successfully replace lost functions and services.[149] The approach requires that siting decisions take into account watershed scale features such as aquatic habitat diversity, habitat connectivity, relationships to hydrologic sources, land use trends, ecological benefits, and compatibility wit adjacent land uses.[150] Such landscape-level planning is essential for effective mitigation. It can support effective avoidance of impacts to critical resources, cumulative impact analysis, and the expenditure of compensatory mitigation funds in a manner that contributes to broader conservation goals for wildlife habitat and resilience to future stresses.

A framework is needed to guide landscape-level conservation planning and ensure coordination among the range of mitigation programs operating under different regulatory authorities. State Wildlife Actions Plans could serve this role, as they currently identify critical wildlife habitat and threats to that habitat in a landscape context. While in some cases State Wildlife Action Plans will need further development, additional data, and wider conservation planning input,[151] such improvements could make them a vital guide for effective mitigation. In addition to the State Wildlife Action Plans, there are also a wide range of other federally recognized and regional conservation plans that offer important conservation information that can be useful in guiding mitigation decisions. (These are outlined in Chapter 2, "The information basis for the next generation of mitigation.") Taken together, these plans may provide the necessary information on species, ecological communities, and habitats regarding their biodiversity significance, irreplaceability an vulnerability, historic and existing conditions, trends in loss and conversion, immediate and long-term conservation needs, and priorities for restoration, establishment, enhancement, and preservation activities. In some cases additional planning and analysis are needed to provide the detailed information required to make site-based choices concerning avoidance of habitat loss and to identify the best locations for habitat replacement through compensatory mitigation.

To be effective, landscape-level planning needs to more fully account for sources of, and threats to, "ecosystem services." Ecosystem services refer to the benefits tha nature provides to people, such as a forested watershed's contribution to drinking water quality. In 2008, ecosystem services were for the first time explicitly integrated a one of the decision-making factors in the regulatory permitting process of the wetlands compensatory mitigation program.[152]

To support this decision-making, more landscape-level information on ecosystem services will be needed, including the types of services, service stocks and production flows, service delivery pathways, servic beneficiaries, service values, e fects of cumulative service losses, and projections of service changes.[153] With such information, it will be possible to identify important areas for ecosystem services. And where ecosystem services can be integrated into landscape-level conservation plans, such as State Wildlife Action Plans, there will be the opportunities for compensatory mitigation to deliver both

wildlife and ecosystem service benefits. Fo more on ecosystem services, see Chapter 5.

iii. Regulatory drivers

Appropriate legal and regulatory drivers are needed to support mitigation programs. For example, regulations under §404 of the CWA support the goal of "no net loss" of wetlands. Likewise, mitigation carried out through conservation/habitat banking is driven by provisions of the ESA. Section 9(a)(1) prohibits the "take" of endangered fish and wildlife species and §4(d) extend this to threatened species. Implementation of regulatory approvals under §§7(a)(2) and 10(a) provide the basis for compensatory mitigation. For other programs, it may be necessary to strengthen existing regulatory drivers in order to expand mitigation for wildlife habitat.

iv. Mitigation protocol

All compensatory mitigation programs should follow the same mitigation protocol applied for wetlands and conservation banking. Referred to as "sequencing" in the §404 context, mitigation is generally a step-wise process designed to first avoid and minimiz impacts as much as possible and then require compensation for residual impacts. (For a description of the origins of this protocol and its application in legal contexts, see Chapter 3, "Legal framework of existing programs.") This mitigation framework is broadly accepted and has been adopted around the world (e.g., European Union, Australia). The aim is to ensure compensatory mitigation is used as an option of last resort, after appropriate efforts have been made to avoid and minimize impacts, and that compensatory mitigation is not used to make a potentially avoidable project appear more acceptable.

v. Implementation regulations and guidance

Regulatory agencies need clear implementation rules and guidance to advance the next generation of mitigation, especially with regard to ensuring conformance to the mitigation protocol. On-the-ground results from current programs, such as wetlands mitigation under the §404 program, suggest there is room to improve guidance on avoidance and minimization.[154] Specific issues to addres include:

- Clear provisions on how to implement the mitigation protocol to ensure effective avoidance and minimization;
- Consistent guidance providing for sufficient resources to suppor implementation of avoidance and minimization steps;
- Guidance and resources for oversight and enforcement supporting meaningful deterrence for non-compliance.

Improvements in implementation are also needed for compensatory mitigation – the third step of the mitigation protocol. To date, compensatory projects have not delivered consistent and effective outcomes for conservation (for a full discussion, see Chapter 3, "Performance of existing compensatory mitigation programs"). Based on lessons from wetlands compensatory mitigation, to advance compensation under the next generation of mitigation, further implementation guidance is needed to address the following issues:

- Types of compensatory mitigation (restoration, establishment, enhancement, preservation) that qualify as compensation;
- Basis for determining a new contribution to conservation ("additionality");
- Basis for determining equivalence between the impact site and the value of the compensation provided;
- Science-based replacement ratio requirements (amount of compensatory mitigation required per unit of impact);
- Location of compensatory mitigation sites relative to the impact site;
- Timing of project impacts vs. functionality of compensatory mitigation benefits, with adequat consideration of "advance" mitigation;
- Science-based performance standards or success criteria that, if met, will yield the intended ecological outcomes;
- Provisions for monitoring of compensatory sites that is directly tied to the ecologically based performance standards and measured against the impact sites; and defined length o monitoring periods;
- Provisions for protection of sites in perpetuity;
- Provision of adequate financia resources and legal assurances to support long-term stewardship; and
- Provisions for built in buffers to guard against failure, such as requiring compensation ratios above 1:1 or requiring preservation of intact habitat in addition to restoration, to guarantee a net gain in natural habitat functions.

Finally, measures should be in place to ensure that if independent field-based researc demonstrates that the compensatory mitigation program is not achieving the replacement of habitat area *and* functionality, or if the offered mitigation does not promise success, the regulatory agency has a clear avenue for denying the action and/or the mitigation approach. Mitigation that is based on a plan, particularly an ecologically based plan, can more readily be assessed and adjusted when results are not being achieved.

b. Existing or expanded provisions for next generation mitigation

Existing U.S. laws and programs offer a substantial basis for the next generation of mitigation. In this section we consider ways to improve implementation of these programs and offer opportunities to expand upon existing authorities in view of anticipated infrastructure developments and related activities.

i. Clean Water Act §404 mitigation

In the §404 program, the vast majority of the agencies' attention over the past 20 years has been paid to improving the third step in the mitigation process – compensatory mitigation. Very little attention, on the other hand, has been paid to more consistently and rigorously applying the first two steps – avoidance an minimization.[155] (For more, see Chapter 3, "The role of avoidance and minimization.") Particularly in light of the mixed track record of compensatory mitigation, the agencies should develop further tools, guidance and/or regulations to ensure the rigorous application of avoidance and minimization.[156]

The regulations that guide the mitigation sequence state that the Corps may not issue a permit "if there is a practicable alternative

to the proposed discharge which would have less adverse impact on the aquatic ecosystem…"[157] The permittee is required to submit documentation to the Corps on the alternatives that were considered. However, the Corps does not currently have the tools at their disposal to adequately evaluate whether or not all of the legitimate alternatives were considered. Developing a new tool or making an existing tool available that would allow the agency to check real estate records of available properties would go a long way to helping them evaluate whether or not the alternatives outlined reflect a consideration of all of th available properties.

The minimization provisions of the §404(b)(1) Guidelines are satisfied through procedure described in Subpart H of the Guidelines.[158] The section provides a broad array of possible methods for minimizing the impacts of a proposed activity. The regulatory agencies, however, do not have the in-house expertise they would need to effectively evaluate whether the minimization measures proposed are adequate or reasonable. Developing standards for how impacts can be minimized in broad categories – such as mining, port development, residential development, etc. – would improve the regulators' ability to evaluate whether impacts have been adequately minimized.

The ability of §404 compensatory mitigation to achieve the objectives of broad, non-aquatic resource conservation plans does have its limitations.[159] Given the nation's historic loss of wetlands and streams, this is a wise approach. The Corps has limited ability to force compensation providers – either permittees or bankers – to locate compensation projects in areas that are deemed ecologically desirable in a watershed plan or more comprehensive conservation plan. The 2008 Compensatory Mitigation Rule, however, provides a significant opportunity to link th §404 compensatory mitigation program to a broader habitat conservation vision.[160] Under the Watershed Approach outlined in the rule (see Box "The Watershed Approach"), the agencies state that compensatory mitigation decisions should be made in the context of a watershed plan, if one is available, and if one is not, should consider, among other things, "habitat requirements of important species" and "habitat loss or conversion trends."[161] In addition, the rule states that the watershed approach should consider "the requirements of other regulatory and non-regulatory programs that affect the watershed, such as…habitat conservation programs."[162]

Thus, the rule opens the door for viewing compensatory mitigation site selection within the context of whole watersheds. This approach will help the agencies more effectively identify the most critical sites to avoid, undertake cumulative impact analysis, and identify the most ecologically strategic sites to compensate for those impacts that cannot be avoided. The overall objective can then be to reinforce the health and resilience of the whole watershed.

ii. Federal Endangered Species Act

The federal Endangered Species Act does not apply the mitigation protocol in the same manner as the CWA § 404 program (see Chapter 3, "Legal framework of existing mitigation programs"). In order to clarify the mitigation protocol under §7, the agencies should develop rules or guidance outlining the process for avoidance and minimization

and should clarify that compensation is an appropriate measure to minimize impacts to species, particularly when the take leads to permanent habitat loss. As noted earlier (see Chapter 3, "ESA, Habitat Conservation, and Mitigation"), inconsistencies in FWS policy currently create uncertainty with respect to whether or not the minimization provisions give the Services the authority to require compensation as a minimization measure.

In addition, the Services should develop adequate tools for field staff to track impacts authorized through §7 consultations, migration measures required, and monitoring. The agencies should also provide clear signals and incentives for field staff to devote time to oversight. Tracking monitoring and undertaking oversight of mitigation measures will support more effective cumulative impact analysis. Nonetheless, the agencies should consider developing cumulative impact analysis guidance and tools to support field staff.

The §10 HCP process also specifically require review of alternatives, minimization of impacts, and mitigation (see Chapter 3, "ESA, Habitat Conservation, and Mitigation").[163] It too provides a basis to implement the mitigation protocol. Over the past ten years, HCP planning efforts have evolved from predominantly small-scale, project-by-project planning efforts to more large-scale or multi-species plans. These regional HCPs can cover hundreds of thousands of acres and numerous species. If based on the best available science, these larger-scale, more regional plans can allow for a more coordinated, proactive, and regional approach to mitigation. Regional HCPs can identify priority habitats for conservation and mitigation, while also prioritizing where to develop and what kinds of development should take place where. These larger scale plans may ensure that species and their habitats are preserved in a regional context and facilitate preservation of habitat connectivity and wildlife corridors.

As with the wetland program, federal agencies cannot require that mitigation carried out under the ESA be sited in a particular location, but the mitigation action must satisfy FWS or NOAA. In addition, because mitigation is targeted to offset impacts to a specific liste species, any compensation must contribute to supporting the preservation and recovery of that particular species.

However, compensatory mitigation carried out under ESA can support landscape-scale conservation, primarily by siting and managing conservation banks in support of more comprehensive conservation goals. When developing §7 and §10 minimization and mitigation measures, FWS and NOAA are required to gather all available data on surrounding habitat. Having a comprehensive conservation framework could also provide strategic guidance for HCP development. Comprehensive conservation plans could help support the development of multi-species HCPs that address broad-based, landscape-level planning issues.

But even apart from regional HCPs, the availability of detailed conservation information can help the Services determine how best to target mitigation in the context of individual HCPs as well as §7 consultations with federal agencies.

iii. The operation of the National Environmental Policy Act on federal lands and elsewhere

NEPA requires consideration of mitigation in the context of evaluating environmental impacts of major federal actions. There is no required sequence of mitigation that requires avoidance and minimization in advance of compensatory mitigation. However, alternatives and their impacts must be identified, including reasonable mitigatio measures. The mitigation protocol can be applied by federal agencies in their NEPA evaluations.

In the west, vast federal ownerships makes mitigation under NEPA at the landscape scale possible, but in the east where there is far less federal land ownership, there are fewer opportunities to use NEPA to drive the mitigation protocol. Even in the west, many critical valley areas and their riparian zones are outside of federal ownership and may not be directly subject to NEPA evaluations and consideration for mitigation actions, absent the need for a federal permit.

Impacts from mining, siting of renewable energy projects, rights-of-way, and other activities are subject to permitting, licensing, leasing, or other kinds of approvals. NEPA can serve as a means of identifying the mitigation that will be needed and that may be incorporated in such approvals.

Dealing with these issues on a landscape or ecosystem basis is supported by several provisions of the NEPA regulations. The firs is the use of "programmatic" Environmental Impact Statements to address the likely impacts, alternatives, and mitigations of a whole federal program (such as solar leasing on Bureau of Land Management lands). The programmatic statements provide an opportunity to conceptualize both impacts and mitigation at a macro scale. Then the preparation of leasing plans and approval of specific projects have their own NE A reviews, which can rely on the programmatic statement to guide the more fine-grained analysis in subsequent plan or project EIS or EA.[164] The NEPA regulations note that when preparing statements on "broad actions," agencies may find it useful to evaluate the proposals in on of several different ways, among which are "geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area," by generic type of action or impact or subject, or by stage of technological development or activity.[165]

Thus, a programmatic EIS could address the likely impact of a particular technology on a broad area of public lands and waters and identify likely bases of mitigation and sources of information that could best inform such mitigation. At the project level, this broader analysis would shape the specific mitigatio responses considered in the project EIS or EA. NEPA regulations also provide for consideration of cumulative impacts,[166] so that even if a programmatic EIS is not prepared, each project EIS will need to address the foreseeable impacts of the project and future projects. This too can serve as a basis for integrating broader-scale conservation plans into mitigation – rather than treating each project's mitigation requirement as an independent decision. Reliance on State Wildlife Action Plans and other federally recognized and regional plans will result in better predictions using NEPA, and may well help projects with avoidance of key habitats,

development of mitigated FONSIs (Finding of No Significant Impact), and design o useful compensatory mitigation measures for unavoidable impacts at the project level.

iv. Specific activities an circumstances under existing law

1. Energy development

U.S. energy demand is expected to increase by 0.5 percent annually through 2030,[167] requiring large investments in energy generation and transmission. This demand, in combination with broader aims to reduce carbon emissions and achieve energy independence, signals the potential for a dramatic expansion in the "footprint" of impacts from the energy sector. Consider the following projections:

- About one-fifth of the land area o the U.S. may need to be dedicated to energy production and transmission facilities to meet low carbon electricity and biofuel production requirements.[168]
- The Department of Energy's 20 percent wind goal will cause the fragmentation of approximately 12 million acres of land from the siting of wind turbine facilities and 11,000 miles of new transmission lines in the grasslands and forests of Central and Western U.S.[169]
- Solar energy is considered economically viable on about 35 million acres of land. With more than 100 permit applications for solar projects already pending, there is high potential for fragmentation of millions of acres of sensitive deserts in the Southwest U.S.[170]
- Over 100,000 additional oil and gas wells with a roughly 2 million-acre footprint are anticipated over the next 20 years in the U.S. Mountain West.[171]
- The need to transmit such energy to market and the demand for a so-called smart grid will result in the construction of new energy transmission lines that will also fragment important wildlife habitat

In light of this potentially large energy development footprint, a more comprehensive planning approach is needed. This approach should provide consistency and specificit to the application of the mitigation protocol for these impacts, with primary attention to avoidance and minimization of impacts to priority habitat and compensatory mitigation for unavoidable residual impacts. Currently, mitigation policy varies depending on the type of energy generation (oil and gas, wind, solar, and so on) and jurisdiction (e.g., Bureau of Land Management, USDA Forest Service, and federal and state endangered species policies).

A more comprehensive and consistent approach to mitigation planning would help in meeting federal mandates specified i the Federal Land Policy and Management Act of 1976 (FLPMA), the National Forest Management Act of 1976,[172] the National Environmental Policy Act of 1969, and CEQ Regulations for Implementing the National Environmental Policy Act.[173] These programs can already support a consistent and rigorous use of the mitigation protocol and a reliance on comprehensive landscape-scale planning as a basis for mitigation decisions. For example, §202(c) of FLPMA calls for land use planning to "(2) use a systematic interdisciplinary approach to achieve integrated consideration of the physical, biological, economic, and other sciences" and "(3) give priority to the

designation and protection of areas of critical environmental concern."

In addition to planning, there may be opportunities to strengthen guidance for compensatory mitigation under some programs, such as Bureau of Land Management's (BLM) Offsite Mitigation Policy[174] issued September 30, 2008. The guidance states:

> Offsite mitigation may be offered voluntarily by a project proponent, incorporated into the project proposal, and approved by the BLM as a condition of the permit authorization. In certain other cases, the BLM may fin it necessary to advise the applicant that the project proposal cannot be approved without additional onsite modificatio or additional mitigation, including offsite mitigation. There may be a need for offsite mitigation when:
>
> - Impacts of the proposal cannot be mitigated to an acceptable level onsite; and
> - It is expected that the proposed land use authorization as submitted would not be in compliance with law or regulations or consistent with land use plan decisions or other important resource objectives.[175]

This guidance would be strengthened by requiring the use of information from comprehensive landscape-level conservation plans, such as State Wildlife Actions Plans, to provide a clear basis for determining when onsite mitigation is insufficient and the "certain other cases" when compensatory mitigation is needed.

Application of the Next Generation of Mitigation to Oil & Gas Development
In the intensive natural gas development areas of south/central Wyoming, The Nature Conservancy worked with the Bureau of Land Management and the British Petroleum Company to employ new strategies for mitigation for oil and gas development. Using regional biological assessments from its ecoregional planning the Conservancy firs advised BP about the best locations to mitigate the impacts on important sage brush habitat of its exploration activities and, then, used the same ecoregional data to advise BP and the BLM about the most important places to avoid the direct impacts of drilling. This approach incorporates both more rigorous use of the mitigation protocol and viewing mitigation in a regional planning context to minimize and compensate for ecological impacts.

2. Transportation and infrastructure

In 2005, Congress enacted the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) to govern transportation policy and funding through 2009. A new federal transportation bill will need to be enacted to guide the next set of transportation expenditures and plans.

Section 6001 of SAFETEA-LU requires metropolitan and state transportation agencies to consider conservation, including landscape conservation relevant to wildlife. Under this section, each metropolitan planning organization (MPO) and state department of transportation (DOT) must "consult" with state, tribal, and local agencies "responsible for land use management, natural resources,

wildlife, environmental protection, conservation and historic preservation" when developing the required long range (20-year) transportation plans that govern planning and decision-making. This consultation "shall involve comparison of transportation plans to State and tribal conservation plans or maps, if available, and comparison of transportation plans to inventories of natural or historic resources, if available."[176] The conservation plans that must be consulted and compared should include, but are not limited to, State Wildlife Action Plans.

The law also requires long range transportation plans to include a discussion of the type and location of "potential environmental mitigation activities and potential areas to carry out these activities, including [mitigation] activities that may have the greatest potential to restore and maintain the environmental functions affected by the plan." This "discussion" must also be developed "in consultation with federal, state, and tribal wildlife, land management, and regulatory agencies."[177] Once again, these requirements present a significant opportunit to integrate mitigation for transportation projects with landscape scale, ecologically significant conservation plans, where thes exist or are under development.

Under current law, preparation of the long-range transportation plans by MPOs and state DOTs are not major federal actions subject to NEPA. Thus, the consultation, discussion, and comparison requirements that lend themselves to landscape-scale conservation *do not* include the evaluation of alternatives or rigorous environmental analysis that NEPA requires. Thus, even though the §6001 planning process offers significant opportunities for coordinatio and integration of conservation objectives with transportation infrastructure, it is not until the project level that the connection of actions to actual mitigation types and locations receives detailed consideration.

Moreover, with one exception, the transportation laws as they currently stand do not themselves specify compensatory mitigation of any particular type or form. Such obligations arise under other laws, including the ESA and §404 of the CWA.

The DOT does have one compensatory mitigation requirement under a section commonly known as "§4(f)," which refers to the section where it originally appeared in 1966 legislation.[178] This section prohibits federally supported transportation projects that require the use of "any *publicly owned* land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdictio thereof, or any land from an historic site of national, State, or local significance as s determined by such official *unless* (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreational area, wildlife and waterfowl refuge, or historic site resulting from such use."[179] Essentially this requires avoidance and minimization of impacts on public park land. The Federal Highway Administration interprets this provision to include compensatory mitigation.[180]

> Minimization of harm entails both alternative design modifications tha lessen the impact on 4(f) resources and mitigation measures that compensate for residual impacts. Minimization

and mitigation measures should be determined through consultation with the official of the agency owning o administering the resource. Neither the Section 4(f) statute nor regulation requires the replacement of 4(f) resources used for highway projects, but this option is appropriate under 23 C.F.R. 710.509 as a mitigation measure for direct project impacts. Mitigation measures involving public parks, recreation areas, or wildlife and waterfowl refuges may involve a replacement of land and/or facilities of comparable value and function, or monetary compensation, which could be used to enhance the remaining land.

Thus, where a transportation project unavoidably affects §4(f) resources, compensatory mitigation might be guided by a landscape scale mitigation plan or conservation plan that the relevant conservation agency has adopted or recognized.

3. Response to sea level rise

Section 404 is by no means the only or controlling response to sea level rise. It is one of many regulations, programs, and responses likely to be needed. But §404 and the watershed or regional approach can have an important function in mitigating the impacts of the infrastructure investment that may be employed to respond to rising sea levels.

The likelihood of significant sea level rise in response to global climate change presents special circumstances for the application of §404 in coastal areas. Current projections suggest increased sea levels of 1 to 1.5 meters by the end of the century, with the potential for

Advance Mitigation

Another framework that is gaining popularity is regional advance mitigation. Proactive regional advance mitigation planning allows state and federal agencies to anticipate the environmental impacts of several planned infrastructure projects at once, and to identify regional conservation opportunities that will satisfy anticipated mitigation requirements before the projects are in the final stages of environmental review, when the need to identify specific mitigation measures can delay project approvals. The result is cost-effective and efficient mitigation for infrastructure project delivery and more viable conservation investments by pooling mitigation needs across agencies over larger areas.

By addressing biological mitigation needs early in the projects' timelines, during project design and development, planners can reduce the cost of mitigation and integrate natural resource conservation in the project design and achieve more effective conservation. The benefits to natural resources and ecosystems are many, including better alignment of mitigation with existing conservation priorities, larger scale conservation allowing for protection of ecosystem function, buffering and securing past conservation investments and providing the resources to adaptively mange these lands in the face of accelerating change.

an even faster rate of increase. Rises of this magnitude would expose a number of large U.S. cities, such as Miami and Boston, to storm damage and, ultimately, inundation of low lying areas. It is unlikely that our society will abandon this level of investment, so engineers are already designing protection schemes. While non-structural "natural" protection measures may help at some locations, structural solutions will be required at others. As has been the case in the Netherlands, such solutions would likely involve extensive dredging and filling of coastal wetland and alteration of other natural coastal features. In the U.S., such activities would trigger §404. Given the risks to human and natural communities from sea level rise, a comprehensive approach to such measures would help to identify which areas of coastline can adapt to changing sea levels, where non-structural measures can be employed, where engineered protection must be put in place and how the impacts of such construction can be mitigated.

Such analysis can only be done on a regional basis and, given the long term character and high costs of such investment decisions, a specific process within the context of §40 should be adopted to ensure the widespread application of the mitigation protocol and application of mitigation criteria that takes into account regional issues. Using State Wildlife Action Plans and Coastal Zone Management Plans can guide this process.[181]

4. Department of Defense/Homeland Security applications

Military installations occupy approximately 30 million acres in the U.S. and are often located in rural or coastal areas that include or are adjacent to important natural resources. In many instances, military installations contain some of the largest unfragmented habitat in the area. For a variety of reasons, including their location, size, active ecosystem-based management,[182] and the loss and degradation of habitat and wetlands resulting from development on non-military lands in the vicinity, military installations contain the highest density per acre of ESA listed species of any federal lands.[183]

In addition to generally applicable statutes such as the ESA, CWA, and NEPA, management of natural resources on military lands is governed by the Sikes Act.[184] The Act includes requirements for the military to prepare Integrated Natural Resource Management Plans (INRMPs) that address the management of natural resources on Department of Defense (DoD) lands and waters. These plans are prepared in coordination with, and subject to the concurrence of, FWS and the relevant state fish and wildlife agencies, a requiremen unique to DoD. Importantly, the Sikes Act also requires that INRMPs provide for "no net loss in the capability of military installation lands to support the military mission of the installation."[185] DoD has for some time been exploring the desirability of fully integrating its own natural resource management plans with the relevant State Wildlife Action Plans in order to maximize the "ecological return on investment" of their own natural resource management activities.

In the past, compensatory mitigation actions under NEPA, §7 of ESA, and §404 of the CWA, have largely been undertaken within the boundaries of the same military installation where the action requiring compensation occurs. However, several factors have limited

the number of viable compensatory mitigation opportunities on DoD's own lands and waters. In response, the 2009 National Defense Authorization Act provided new authority to DoD to satisfy their compensatory mitigation requirements through the purchase of credits from conservation banks and participation in in-lieu-fee programs outside the borders of its own installations,[186] paralleling similar authority provided previously for DoD to participate in wetland mitigation banks and in-lieu-fee programs.[187]

The Department of Homeland Security (DHS), and specifically Customs and Borde Protection (CBD) within DHS, has undertaken significant infrastructure construction an other activities at or in the vicinity of the international borders of the U.S., especially the border with Mexico.[188] Under the "Real ID" provisions[189] of the Illegal Immigrations Reform and Responsibility Act of 1996,[190] the Secretary of Homeland Security received, and has exercised, sweeping and unprecedented authority to "waive all legal requirements," including environmental laws, that the Secretary deemed necessary in order to expeditiously complete construction of pedestrian fencing, vehicle barriers, and roads along the borders. Accordingly, for actions within the scope of the exercise of this waiver authority, application of the mitigation hierarchy is arguably not required as a matter of law. However, under a January 2009 Memorandum of Agreement between DHS and the Department of the Interior (DOI),[191] compensatory mitigation action is being planned for impacts of activities covered by the waivers, with an initial focus on compensatory mitigation action that otherwise would have been required under the ESA, especially on federal lands.

Recognizing the impacts of security infrastructure and operations along the border, legislation has been drafted and is pending introduction in the 111th Congress.[192] Under that Act, DHS would be required to develop and implement[193] a "comprehensive mitigation plan to address the ecological and environmental impacts of border security infrastructure, measures, and activities along the international land borders of the United States." The mitigation measures contemplated by the proposed legislation would be based on a broader approach than the ESA and similar statutes, and would be aimed at preserving the ecological health of natural communities as a whole, include maintaining and if necessary restoring wildlife migration corridors. In addition, the legislation would require provisions for monitoring the effectiveness of actions taken and provide for adaptive management and additional measures determined to be required on the basis of such monitoring.

5. Civil Works compensatory requirements[194]

The Water Resources Development Act (WRDA) is the biennial legislation that is the main vehicle for funding the Corps to study, plan, and carry out water resource development and restoration projects. WRDA 1986 required the Corps to "mitigate damages to fish an wildlife resulting from any water resources project under [its] jurisdiction."[195] Although the §404 program's Watershed Approach was still nine years away, the Corps' regulations guiding this provision of WRDA acknowledges the need to plan compensatory mitigation projects within a landscape perspective: "Ecosystem restoration projects should be formulated in a systems context to improve the potential

for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems."[196] The regulations also note that when planning the ecological restoration, the Corps must comply with the Fish and Wildlife Coordination Act by giving full consideration to, among other things, "the appropriate head of the State agency exercising administration over the fish and wildlif resources."[197]

The 2007 version of the bill, for the firs time, requires the Corps to consider the use of a mitigation bank if the bank is within the same service area as the impact and has the appropriate number and type of credits available.[198] Guidance issued in support of the Act in November 2008 states that when using a bank to compensate for impacts, the bank must "be approved in accordance" with the 2008 Compensatory Mitigation regulations.[199]

6. Federal Energy Regulatory Commission licensing[200]

The Federal Power Act (FPA) may require compensatory mitigation for impacts due to non-federal hydropower projects. The Federal Energy Regulatory Commission is the lead federal agency responsible for issuing licenses and renewals under FPA and for making the final determination about license conditions including protection, mitigation, and enhancement requirements. There are currently around 1,000 licensed non-federal hydropower projects (projects licensed to private or public agencies rather than federally-operated); FERC granted about 350 licenses (mostly renewals) from 1993 through 2005.[201] Given the life of the permit, 30 – 50 years, many of the projects up for re-licensing today were granted prior to the passage of modern environmental law - with few environmental requirements. New conditions set forth today may not be reviewed or revised for decades.

Several sections of the FPA relate to mitigation requirements. Section 4(e) requires FERC to consider competing objectives when issuing licenses or re-licenses. The law requires that "in addition to the power and development purposes for which licenses are issued" FERC "shall give equal consideration", but not necessarily equal treatment,[202] "to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of fish and wildlife (including related spawnin grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality."[203]

To receive a license, re-license, or to surrender a license applicants must comply with development, safety, and any environmental mitigation requirement set by FERC. Section 10(j) of the FPA requires that "in order to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlif (including related spawning grounds and habitat) affected by the development, operation, and management of the project, each license issued…shall include conditions for such *protection*, *mitigation*, and *enhancement*."[204] The law also requires that hydropower projects must be:

> best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstat or foreign commerce, for the improvement and utilization of water-power development, for the adequate protection, mitigation, and

> enhancement of fish and wildlif (including related spawning grounds and habitat), and for other beneficia public uses, including irrigation, floo control, water supply, and recreational and other purposes referred to in [Section 4(e)].[205]

Further, environmental conditions specifie by FERC in hydropower licenses are based on recommendations from fish and wildlif agencies (e.g., U.S. Fish and Wildlife Service, National Marine Fisheries Service, and state fish and wildlife agencies) [206] The wildlife agencies provide information to help determine the damage to fish and wildlife resource and the means and measures to be adopted to mitigate the damage.[207] Resource agencies can also impose mandatory licensing conditions in some cases, which can include compensatory mitigation requirements. These include mandatory conditions for projects 1) within a defined "reservation [208] area, imposed by the overseeing agency under §4(e) of the FPA[209] or 2) prescribed as "fishways" by FWS o NOAA's National Marine Fisheries Service under §18 of the Federal Power Act. The FPA recognizes impacts (e.g., fragmenting rivers, preventing up- and downstream movement of fish) to fishwa [210] as separate from other habitat and fish and wildlife impacts

These mitigation requirements provide an opportunity for FERC and the fish and wildlif agencies to use State Wildlife Action Plans, or other comprehensive conservation plans, as a reference for understanding state fis and wildlife diversity, threats, and priorities; helping the agencies to assess protection, mitigation, and enhancement measures and mandatory conditions in relation to the priorities of the conservation plans as well as the other goals of the FPA under §4(e) and 18.

The best available data on compensatory mitigation required by hydropower licenses come from Environmental Assessments (EAs) and Environmental Impact Statements (EIAs) issued by FERC during the licensing process. For the years 2003 to 2006, FERC issued 70 EAs and final EIAs that itemize mitigation measures. In total, the EAs and EIAs recommended an annual commitment of $210.3 million to compensatory mitigation annually.[211]

7. Natural resource damages

Assessment and compensation for natural resources damages under federal[212] can be considered another form of compensatory mitigation. While outside the scope of this paper, the use of State Wildlife Action Plans and the other plans referenced here can and should inform the selection of activities to offset the harm caused by spills and other environmental insults.[213] Such activities, however, cannot be anticipated and so they are outside the use of the overall mitigation protocol described in this paper.

c. Potential new authorities

i. On-shore energy development

New energy bills are likely to be introduced in the 111th Congress that provide incentives and/or a framework for the siting of conventional and alternative energy facilities on public and private lands. It is conceivable that environmental requirements could be added to this legislation that while facilitating siting

could also include requirements for evaluating environmental impacts and for mitigation.

There is the prospect for reform of electric power transmission in the U.S., both to bring more sources of renewable energy into the power grid, and to take advantage of improvements in technology and efficienc . If Congress adopts legislation to promote or facilitate siting of high voltage transmission across the landscape, it may also decide to impose mitigation requirements (in addition to those already applicable under ESA, §404, and identified under NE A review). Congress could specify that as a condition for siting and approval of these large-scale, linear infrastructure facilities, habitat avoidance, minimization, and compensation would be required. It would be logical to have such mitigation coordinate with existing large-scale conservation plans. Because much of the existing approval of transmission is under state law (or would require a federal override of state law under new authority), referencing state conservation plans has an attractive logic.

ii. Offshore energy/marine spatial planning

With likely increases in offshore oil and gas and alternative energy (wind, wave) development, there is increasing interest in comprehensive marine spatial planning driven by energy uses. As a result, the federal government and the states might be amenable to supporting legislation that, rather than using a case by case approach to locating offshore energy facilities, would evaluate environmental resources and human uses in coastal waters, identify areas of critical concern, and plan or allocate uses in ways that maximize public benefit while accommodatin energy development. Such a system of marine spatial planning could incorporate elements of the mitigation protocol described here. Most State Wildlife Action Plans do not include consideration of off-shore and marine resources. Organizations such as The Nature Conservancy and some state governments have been creating marine ecoregional assessments that identify critical biological resources in marine waters. These could be used as the basis for marine conservation plans that could guide marine spatial planning. Rhode Island has initiated an Ocean SAMP under the Coastal Zone Management Plan.

iii. Transportation legislation

As noted above, Congress is due to consider a new transportation bill to govern transportation planning and investment for the next six years. In the previous legislation, SAFETEA-LU, Congress built in references to conservation planning in the context of the preparation of long range transportation plans by MPOs and state DOTs.

The next transportation legislation could build on the prior experience by building the mitigation protocol and landscape-based mitigation into project decisions – thus providing accountability for the SAFETEA-LU §6001 planning efforts, which were intended to lead to greater care for state wildlife and conservation priorities when planning new and replacement transportation infrastructure. The legislative basis has been laid by the current authorization legislation.

iv. Habitat regulatory authority

The existing mitigation authorities discussed in preceding sections above afford habitat

protection to aquatic resources including freshwater and tidal wetlands (§404 of the CWA), critical habitat for listed species (federal ESA), impacts to the environment on public lands where required by federal agencies after review (NEPA), and various other habitats (e.g. Federal Power Act). They do not, however, afford specific protectio to wildlife habitat overall or even to areas of critical or exceptional habitat that do not support listed species. Nor do they, except in the §404 "Watershed Approach" example, seek to make decisions about avoidance, minimization, and compensation in the context of a larger conservation vision. There have been proposals advanced to create a new regulatory authority, perhaps tied expressly to State Wildlife Action Plans, which would afford protection of general habitat or key habitat identified in State Wildlife Action Plans from impacts from various land uses. Were such legislation to be adopted, it could then be tied to the mitigation protocol and with the next generation of mitigation proposed here. The introduction and passage of such broad legislation, however, does not seem likely in the near future. More targeted legislation tied to energy, marine spatial planning, or transportation offers a more likely prospect for mitigation improvements and expansions.

Chapter Five

Incorporating Ecosystem Services

Natural ecosystems provide more than biodiversity values; they support resources and processes that underpin human well-being. These "ecosystem services" – water quality and quantity, pollination of crops, flood mitigation, and recreation opportunitie to name a few – have real value. But when such ecosystem benefits are not included i conservation planning, we lose the opportunity to optimize conservation decision-making for nature and people.

According to the comprehensive Millennium Ecosystem Assessment,[214] ecosystems around the world have declined rapidly and extensively over the past 50 years, primarily as a result of human actions that cleared forests, plowed grasslands, dammed rivers, and overtaxed marine ecosystems. While this use of our natural capital supported significan increases in crop, livestock, and aquaculture production, it has also had a range of negative impacts. The Millennium Ecosystem Assessment estimates that 60 percent of ecosystem services are currently degraded or at risk of collapse, including freshwater, capture fisheries, wild foods, erosion regulation genetic resources, pollination, and natural hazard mitigation. And pressure on these services is expected to continue. Over the next 50 years demand for food crops is projected to increase by 70-85 percent and demand for water by 30-85 percent. Without a course correction in the management of our natural capital, this will lead to continued conversion of lands and waters and further loss of ecosystem services and biodiversity.

An important step toward addressing impacts to ecosystem services is recognizing their value. For example, a study by Defenders of Wildlife[215] provides a "first-orde approximation" of expected service benefit – from recreation, water supply, water quality, and a range of other services – that would be generated by establishing a national habitat conservation system. This system would focus on conserving unprotected areas identifie in State Wildlife Action Plans. The study compares the expected costs of conserving this national system under different approaches (i.e., fee simple, easement, and rental costs) to the system's expected ecosystem service benefits and finds that benefits outweigh co under all but one conservation strategy (fee simple plus management option under the low benefit scenario). This suggests that, due to ecosystem service values, conservation investments can result in net public economic benefits and that these investments ca be competitive with other types of public investments.

Another important step is the integration of services into regulatory frameworks for planning and mitigation. The wetlands Compensatory Mitigation Rule issued in 2008 takes this step, defining services a "the benefits that human populations receiv from functions that occur in ecosystems"[216] and requiring the consideration of services in mitigation decision-making.[217] Although the 2008 Compensatory Mitigation Rule requires consideration of services as one of many factors in mitigation determinations, guidance on how to implement this requirement is limited. This reflects the lack of baselin information and assessment methods for ecosystem services. As the Rule's preamble notes: "Although the services provided by

aquatic resource functions are important to consider when determining the type and location of compensatory mitigation projects, there are few methods available for assessing services. Therefore, in most cases consideration of services will be conducted through best professional judgment."[218]

Noting the limitations of the Compensatory Mitigation Rule's guidance and current reliance on "best professional judgment," Ruhl et al. (2009)[219] put forward a research agenda for developing a more robust foundation for assessing services. The aim is to: (1) identify the key questions that the Corps and EPA must address under the new ecosystem services provisions; (2) determine the information and methods the Corps and EPA will need to competently answer those questions; and (3) design research to compile information and develop methods. The steps aim to support the "co-evolution of policy and science" for addressing ecosystem services in wetlands mitigation.

In line with the agenda recommended by Ruhl et al. (2009), there is an opportunity to expand our understanding about ecosystem services beyond wetlands, to the wider role wildlife habitat plays in delivering services. Several efforts already underway seek to improve understanding about the service benefit of conservation. For example, the Natural Capital Project – a joint venture of Stanford University, The Nature Conservancy, and World Wildlife Fund – is developing decision support tools to assess the contributions of natural systems to human well-being, including carbon sequestration, drinking and irrigation water, flood mitigation, native pollination agricultural crop production, and recreation and tourism.[220]

Connecting this information to mitigation planning, the Nature Conservancy is advancing a landscape-level planning approach called "Development by Design," and applying it at a number of pilot project areas. The approach integrates conservation planning and ecosystem services information into the mitigation process, with the aim of more effectively avoiding impacts to priority areas for conservation and services, and identifying opportunities for more resilient, higher value compensatory mitigation.[221] Development by Design and the Natural Capital Project are just two of many initiatives that can support improvements in conservation planning frameworks, encouraging the incorporation of ecosystem services and providing a better basis for determining mitigation priorities.

State Wildlife Action Plans are not specificall structured around ecosystem services, but they identify many of the habitats and areas that are important for the function of the natural systems upon which both humans and animals rely. A key feature for improvement of State Wildlife Action Plans will be the identificatio of important areas for ecological restoration. Restoration priorities can, if well-targeted, result in the support of multiple ecosystem services and synergies with preserved habitats, rendering the latter more effective for both wildlife and other values.

Chapter Six

A Vision for the Next Generation of Mitigation in the U.S.

a. Overall conclusions

Our evaluation suggests that (1) a wider application of the mitigation protocol (avoid, minimize, compensate) to existing and future regulatory programs, and (2) a more comprehensive approach to mitigation informed and guided by State Wildlife Action Plans and other federally recognized and regional conservation plans (the next generation of mitigation), can yield more effective conservation outcomes for natural landscapes and whole watersheds than the current piecemeal approach to mitigation. Likewise, (3) reliance on ecologically-meaningful conservation plans allows existing and future compensatory mitigation funds to be directed efficiently and e fectively toward restoration and protection priorities, including appropriate mitigation in advance of impacts. Such an integrated approach will more effectively provide meaningful wildlife habitat and sustained ecosystem services.

<u>Findings:</u>

- Infrastructure investments for a growing population and the development and transmission of new sources of energy, will result in extensive impacts on natural systems.
- Between $3.5 and $4.5 billion are now spent annually on compensatory mitigation in the U.S., making it one of the largest sources of conservation outlays. Not all of the compensatory mitigation follows the mitigation protocol, nor is it all guided by regionally specific planning
- Several of the nation's existing regulatory programs (such as §404 of the CWA and ESA) can provide valuable lessons for the next generation of mitigation.
    - Mitigation programs must set aside sufficient funding t ensure adequate regulatory oversight, planning, and enforcement. These programs must also have a high degree of transparency and accountability to the public for outcomes. Without such components compensatory mitigation is unlikely to achieve its desired objectives.
    - Mitigation programs are evolving to take landscape, ecosystem, and watershed considerations into account. Larger conservation objectives will be difficult to achiev if there continues to be a piecemeal approach to mitigation.
- Impacts can be reduced and ecosystem-scale conservation objectives supported if government programs:
    - Employ the mitigation protocol (avoid, minimize, compensate) when locating, designing, and approving new development and infrastructure; and
    - Use State Wildlife Action Plans and other federally recognized and regional conservation plans to avoid key habitats and to guide compensatory mitigation for unavoidable habitat loss.

Recommendations:

- Federal and state agencies should play a role in supporting the wider application of the mitigation protocol and the ecologically comprehensive approach to mitigation on the landscape.
    - The President's Council on Environmental Quality (CEQ) should lead an effort to support consistent application of the mitigation protocol across federal agencies and programs.
    - The CEQ and federal agencies should strongly encourage federal agency use of State Wildlife Action Plans and other federally recognized and regional conservation plans for decision-making informed by environmental review under the National Environmental Policy Act.
    - State agencies responsible for permitting and decision-making should apply the mitigation protocol and make use of State Wildlife Action Plans and other federally recognized and regional conservation plans in their own decisions and approvals affecting habitat.
- State Wildlife Action Plans should be continuously improved to ensure that they support mitigation opportunities and decision-making. These Plans can more effectively guide the avoidance of key wildlife habitat, cumulative impact analysis, and the expenditure of compensatory mitigation funds if they set priorities for *protection* of high quality habitat and for *restoration* of important degraded habitat, related natural systems, and connectivity. They can also be improved by incorporating the findings of an referencing other federally recognized state plans.
- Over the long run, federal energy and infrastructure legislation should expressly include requirements to use the mitigation protocol as it is described here in the planning and design of large scale energy facilities on federal lands and waters, in the design and siting of new transmission corridors that involve federal agencies such as the Federal Energy Regulatory Commission (FERC), and in the siting of major energy generating facilities financed through federal program and loan guarantees. The mitigation protocol should also be incorporated into legislation guiding offshore energy siting for conventional and alternative energy sources.
- A federal agency or institution should be tasked with assessing the outcomes of mitigation on landscape and watershed conservation under all federal statutes and should make periodic recommendations on how to improve mitigation across federal agencies. Among the specific issue that should be evaluated are:
    - The appropriate role of §404 of the Clean Water Act in efforts to deal with the permitting of wetland alterations associated with shoreline protection from sea level rise.
    - Use of the mitigation protocol in the location and expansion of military facilities

- Use of the new generation of mitigation in the planning and location of transportation facilities
- The extent and effectiveness of current avoidance and minimization measures employed across all mitigation programs.
- The availability and quality of the tracking programs (impacts, compensation, monitoring) utilized across all mitigation programs.
- The effectiveness of current cumulative impact analysis conducted across all mitigation programs.

- Despite the substantial scale and scope of the nation's current mitigation programs, which primarily protect many wetlands, streams, and the habitat of threatened and endangered species, other high value, natural landscapes remain unprotected. Conservation agencies and organizations should explore opportunities to adopt mitigation requirements for impacts to these key areas.

b. Benefits and risks of a more comprehensive approach to mitigation

Employing a landscape or watershed approach to mitigation has several important benefits

- Understanding the ecological character of whole landscapes or watersheds can provide the framework for understanding what critical resources to avoid when planning for infrastructure development.
- Offsetting damage through mitigation projects that are of sufficient scale an are located in pivotal locations helps to ensure the successful restoration of those sites and reinforces the health and sustainability of the larger system. This kind of mutual resilience is particularly important given the pressures of climate change.
- Large and connected projects are easier to maintain, manage, and monitor than small mitigation projects or sites scattered across the landscape unconnected by any plan.
- Smaller projects can be more readily maintained, managed, and monitored, including those surrounded by urban land uses, if they are part of an ecological plan that addresses outcomes and relates the parcels to one another in terms of function and landscape.
- Truly functional systems can produce ecosystem services more effectively than fragmented mitigation.
- Comprehensive use of the mitigation protocol and using statewide and landscape scale plans to guide the siting of infrastructure can actually facilitate construction of alternative energy facilities and other infrastructure because it can help to avoid protracted siting conflict stemming from inadequate scientifi information and ill-informed siting decisions.

There are, however, also risks in the more comprehensive approach that should be addressed: Among these is the possibility that development of an effective overall mitigation framework could lead to by-passing the firs two steps in the mitigation protocol: avoidance

and minimization. Next generation mitigation approaches will also need to guard against the sacrifice or loss of smaller habitat patche that may be locally important, in the quest for large ecosystem results. In particular, in urban areas, small wetlands and other areas of natural habitat may have particularly important functions including providing the opportunity for urban area residents to experience nature. The new approach should not be used as a justification for the elimination of such site in favor of larger, more remote blocks of habitat.[222]

Chapter Seven

Next Steps: A Plan of Action

We propose that the following short term actions be taken to begin the process of moving toward the next generation of mitigation:

- The President's Council on Environmental Quality should convene a multi-agency workshop on the use of the mitigation protocol across federal agencies and on how mitigation could be used more effectively to achieve landscape/watershed scale conservation, considering both climate change and the likely impacts of new infrastructure and conservation investments.
- The U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency should undertake an evaluation of the effectiveness of the agencies' approach to avoidance and minimization and cumulative impact analysis. The agencies should consider developing guidance and tools to support the ability of field sta f to undertake this analysis.
- The U.S. Fish and Wildlife Service should meet with the Association of Fish and Wildlife Agencies and with other stakeholders to evaluate how State Wildlife Action Plans could be adapted and coordinated with other natural resource plans to better serve as the framework for the effective use of the mitigation protocol in multiple programs.
- U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration should commit resources to developing effective policies and tools to guide mitigation under the Endangered Species Act, such as: a system to track required mitigation measures, and monitoring; guidance and tools to support cumulative impact analysis; policy that clarifies the role of compensator mitigation under §7; and research on the ecological effectiveness of the compensatory mitigation measures undertaken under the Act.
- Amendments should be considered to the now pending energy legislation to expressly require use of the mitigation protocol for planning energy projects on federal lands and in federal waters, where the approval of transmission corridors directly involve Federal agencies such as FERC, or that affect federally protected resources as a way of both protecting the environment and improving the regulatory process.
- Building on the limited experience with consultation under SAFETEA-LU, the next transportation authorization bill should expressly refer to the State Wildlife Action Plans, and other regional plans where appropriate, in the sections that deal with project-level evaluation, and should expressly require that the mitigation protocol be employed to support the priorities in these plans.

Chapter Eight

Conclusion

At a time when the resources for conservation in the U.S. are limited and there are many competing needs, the strategic use of the mitigation protocol can save natural habitat by directing development away from sensitive areas and can use compensatory payments in a more targeted and effective way to accomplish restoration on a watershed or landscape scale that would not otherwise be accomplished. Given the real dollars involved, mitigation can be an important tool in restoring and conserving large ecosystems that will be resilient to climate change and to other environmental pressures. While new legislation might be useful in accomplishing this, much progress can be made by adjusting existing laws and regulations and better using the tools already available. And, importantly in today's economic crisis, mitigation used correctly can facilitate investment by helping to avoid environmental conflicts an adequately offset the conflicts that cannot b avoided.

ENDNOTES

1 Compensatory Mitigation for Losses of Aquatic Resources, 73 Fed. Reg. 19,593, 19,594 (Apr. 10, 2008) [hereinafter Mitigation Rule (2008)] (to be codified at 33 C. .R. pt. 325). §332.2.
2 *See* Endangered Species Act of 1973, 16 U.S.C. §§ 1531-1544 (2006).
3 *See* American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat. 115 (2009) (appropriating about $150 billion for infrastructure spending, including $50 billion for transportation infrastructure).
4 Environmental Law Institute. 2007. Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities [Hereinafter ELI (2007)].
5 ELI (2007).
6 40 C.F.R. § 1508.20 (2008). This definition of mitigation has been highly influential on federal agency practi and procedure, although it applies primarily to evaluation of impacts under NEPA.
7 16 U.S.C. § 669c (2006).
8 See: Ruhl, J. B. and James Salzman, 2006. "The Effects of Wetland Mitigation Banking on People." *National Wetlands Newsletter.* Vol. 28, No. 2:1. The authors argue that banking facilitates the redistribution of wetland resources from urban to rural areas, reallocating the important environmental services wetlands provide human communities. With no overall framework, important services (flood control, water quality) provide by wetlands can be lost from more urban areas, i.e., these values are not maintained over space. Also, see: Cooke, S.S. 1992. Wetland Buffers: Use and Effectiveness. Appendix A: Wetland buffers – A Field Evaluation of Buffer Effectiveness in Puget Sound. Washington Department of Ecology. Publication No. 92-10. The report shows that 18 of 21 buffers were subjected to a reduction in size over the eight year study period, likely resulting in reduced buffer functions and changes in wetland water quality over time.
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16 Food, Conservation, and Energy Act of 2008, 16 U.S.C. § 2101a (2006).
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20 16 U.S.C. §1533(f)(1)(B).
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30 Mitigation Rule (2008), §332.2.
31 Mitigation Rule (2008), §332.3(c)(1).
32 42 U.S.C. § 4321 (2006).
33 40 C.F.R. § 1508.20.
34 *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 332-52 (1989) ("There is a fundamental distinction, however, between a requirement that mitigation be discussed in sufficient detail to ensure tha environmental consequences have been fairly evaluated, on the one hand, and a substantive requirement that a complete mitigation plan be actually formulated and adopted.").
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36 16 U.S.C. § 551 (2006).
37 40 C.F.R. § 1508.13.
38 *See*, *e.g.*, *Cabinet Mountains Wilderness/Scotchman's Peak Grizzly Bears v. Peterson*, 685 F.2d 678 (D.C. Cir. 1982) (mitigating FONSI).
39 42 U.S.C. §§ 4332(1), 4335.
40 J. Mintz, "Taking Congress's Words Seriously: Towards a Sound Construction of NEPA's Long Overlooked Interpretation Mandate," 38 Envtl. Law 1031 (2008); see also Environmental Law Institute. 1995. Rediscovering the Environmental Policy Act: Back to the Future, available at http://www.elistore.org/reports_detail.asp?ID=376&topic=NEPA
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51 Mitigation Rule (2008), §332.1(c).
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53 "Under no circumstances" may the "same" compensation credits be used to provide mitigation for more than one permitted activity, but where appropriate mitigation projects may be designed to "holistically address requirements under multiple programs for the same activity" such as compensatory mitigation under the Endangered Species Act for the activity (Mitigation Rule (2008), §332.3(j)(1)(ii)(3)). Moreover, "credits for compensatory mitigation projects on public land must be based solely on aquatic resource functions provided by the compensatory mitigation project, over and above those provided by public programs already planned or in place" (Mitigation Rule (2008), §332.3(a)(3)).
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62 Id. § 1539(a).
63 *Id.* § 1539(a)(2)(B).
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66 U.S. FWS HCP Handbook (1996). *See also* 65 Fed. Reg. 35,242 (June 1, 2000) (an addendum to the Handbook). The addendum, known as the "five-point polic ," provides additional guidance on HCPs regarding: (1) establishment of biological goals and objectives for HCPs, (2) adaptive management, (3) monitoring, (4) determination of permit duration, and (5) the use of public participation.
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70 *See* Federal Power Act, 16 U.S.C. §§ 791a-828c (2006); *see also* Pacific Northwest Electric Power Plannin and Conservation Act, 16 U.S.C. § 839-839h (2006).
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81 Mitigation Rule (2008).
82 40 C.F.R. § 230.10(d).
83 Mitigation Rule (2008), §332.1(c).

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142 Mitigation Rule (2008), §332.3(c)(2).

143 Mitigation Rule (2008), §332.3(c)(3)(ii).

144 Mitigation Rule (2008), §332.3(c)(3).

145 Bean et al. (2008).

146 US EPA and Department of the Army 1990.

147 DOI 2003.

148 Pub. L. 106-553, codified at 16 U.S.C. § 669c

149 Mitigation Rule (2008), §332.3 (b)(1).

150 Mitigation Rule (2008), §332.3(b).

151 Bean et al. (2008).

152 The preamble to the Rule states that the term "services" is used to "signify the importance of ecosystem functions to human populations" (see p. 19625). In a discussion of the use of the term "services," the preamble also states that "The concept of ecosystem services is important for considering where compensatory mitigation projects should be located." (see p. 19625). §332.2 defines services as "the benefits that human populatio receive from functions that occur in ecosystems." Mitigation Rule (2008), §332.3(b)(1) and §332.3(c)(2)(ii).

153 Ruhl JB, J. Salzman, and I. Goodman. 2009. "Implementing the New Ecosystem Services Mandate: A Catalyst for Advancing Science and Policy." *National Wetlands Newsletter.* Vol. 30, No. 2. Washington, DC: Environmental Law Institute.

154 Murphy, James, Jan Goldman-Carter, and Julie Sibbing. March-April 2009. "Avoidance Avoided: How the New Rule Fails to Adequately Promote Avoidance and Places Difficult-to-Replace Systems at Risk. *National Wetlands Newsletter*. Vol. 31, No. 2. Washington, DC: Environmental Law Institute.

155 For more on federal avoidance and minimization policy, see: Environmental Law Institute. March 2008. *The Federal Wetland Permitting Program: Avoidance and Minimization Requirements*. Washington, DC: Environmental Law Institute.

156 "It should by now be obvious that avoidance of impacts to existing water resources, wherever possible, is the wisest environmental protection policy. Yet in practice, avoidance has received far too much lip service and far too little practical application." Murphy, James, Jan Goldman-Carter, and Julie Sibbing. March-April 2009. "Avoidance Avoided: How the New Rule Fails to Adequately Promote Avoidance and Places Difficul - to-Replace Systems at Risk." *National Wetlands Newsletter*. Vol. 31, No. 2. Washington, DC: Environmental Law Institute.

157 40 C.F.R. § 230.10(a).

158 40 C.F.R. § 230.10(d).

159 Existing federal mitigation policy is designed to support CWA goals and to achieve "no net loss" of wetland acres and functions. In an effort to achieve these national goals, the agencies have a stated preference for "in-kind" compensatory mitigation (Mitigation Rule (2008), §332.2) over "out-of-kind" compensation (Mitigation Rule (2008), §332.3(e)). In addition, compensatory mitigation must be required at a minimum of a one-to-one *acreage* replacement ratio (Mitigation Rule (2008), §332.3(f)(1)). Finally, because of the need to replace lost aquatic resource functions and acres, preservation of wetlands has long been discouraged as a compensation method (Mitigation Rule (2008), §332.3(h)).

160 Mitigation Rule (2008).

161 Mitigation Rule (2008), §332.3(c)(2).

162 Mitigation Rule (2008), §332.3(c)(2).

163 *See e.g.* 16 U.S.C. § 1539(a)(2) (2006) (alternatives, minimization, mitigation, other "necessary and appropriate" measures).
164 40 CFR § 1502.20 (2008).
165 40 CFR § 1502.4(c).
166 40 CFR § 1508.7.
167 Energy Information Administration (2009) Annual Energy Outlook 2009. http://www.eia.doe.gov/oiaf/aeo/.
168 McDonald RI, Fargione J, Kiesecker JM, Miller WM, Powell J (2009) Energy Sprawl or Energy Efficiency Tradeoffs in U.S. Climate Policy Effects on Natural Habitats. PLoS ONE (In Review).
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170 Western Renewable Energy Zones – A joint initiative of the Western Governors' Association and the U.S. Department of Energy http://www.westgov.org/wga/initiatives/wrez/index.htm.
171 Doherty K, Naugle D, Copeland C, Pocewicz A, Kiesecker J. 2009 Energy development and conservation tradeoffs: systematic planning for sage-grouse in their eastern range. Studies in Avian Biology (In Press); Morton, P., C. Weller, and J. Thomson, 2002a. *Energy and western wildlands: A GIS analysis of economically recoverable oil and gas*. The Wilderness Society, Denver, CO and Seattle, WA http://www.wilderness.org/Library/Documents/Energy_WesternWildlands.cfm>.
172 Federal Land Policy and Management Act (FLPMA), 43 U.S.C. §§ 1701-43 (2006).
173 40 CFR §§ 1500-1508.
174 b.l .M., dep't of Interior, Instruction Memorandum 2008-204 on offsite Mitigation (2008).
175 b.l .M., dep't of Interior, Instruction Memorandum 2008-204 on offsite Mitigation (2008).
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180 fed. Highway admin. office of planning, env't & Reality, § 4(f) Policy Paper 7 (2005), *available at* http://www.environment.fhwa.dot.gov/4f/4fpolicy.asp#measures.
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185 16 U.S.C. § 670a(b)(1)(H).
186 National Defense Authorization Act for Fiscal Year 2009, 10 U.S.C.S. § 2694c (2008).
187 10 U.S.C. § 2694b (2003).
188 These actions have been taken in response to Congressional mandates to "gain operational control" of our borders. *See* Act of Dec. 26, 2007, P.L. 110-161, 121 Stat. 2090 (amending Section 102 of the Illegal Immigration Reform and Immigrant Responsibility Act of 1996 (IRRIRA), 8 U.S.C. § 1103)
189 REAL ID Act of 2005, P.L. 109-13, 119 Stat. 306 (amending 8 U.S.C. § 1103 note, § 102(c)).
190 8 U.S.C. 103 note.
191 Memorandum of Agreement between US Customs and Border Protection and US Department of the Interior Regarding Natural and Cultural Resource Mitigation Associated with Construction and Maintenance of Border Security Infrastructure along the Border of the United States and Mexico. January 16, 2009.
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202 Federal Energy Regulatory Commission, Report on Hydroelectric Licensing Policies, Procedures, and Regulations: Comprehensive Review and Recommendations Pursuant to Section 603 of the Energy Act of 2000, at 10 (2001).
203 Federal Power Act, 16 U.S.C. § 797(e) (2006).
204 16 U.S.C. § 803(j)(1) (emphasis added).
205 *Id.* § (a)(1).
206 The FPA states "conditions shall be based on recommendation received pursuant to the Fish and Wildlife Coordination Act from the National Marine Fisheries Service, the United States Fish and Wildlife Service, and State fish and wildlife agencies." *see also* 16 U.S.C. § 662(a) (under the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661-666(c) (2006), when granting federal permits or licenses for projects such as dredging, impounding, or modifying water bodies, the granting agency first must consult with the agency administerin the resources (e.g. U.S. FWS or NMFS)).
207 16 U.S.C. § 662 (b).
208 For the Department of Interior, reservations "include lands and certain facilities under the jurisdiction of the U.S. Fish and Wildlife Service, National Park Service, Bureau of Land Management, Bureau of Reclamation, or Bureau of Indian Affairs." (Procedures for Review of Mandatory Conditions and Prescriptions in FERC Hydropower Licenses, Notice of Propose Rulemaking, 69 Fed. Reg. 54,602 (Sept. 9, 2004)) The U.S. Forest Service also may impose conditions for projects that may affect National Forests. (Hydropower Reform Coalition (HRC), Citizen Toolkit for Effective Participation in Hydropower Licensing (2005).
209 16 U.S.C. § 797(e) (2006).
210 …for the safe and timely upstream and downstream passage of fish [and]shall be limited to physical structures facilities, and devices necessary to maintain all live stages of such fish, and project operations and measure related to such structures, facilities, or devices which are necessary to ensure the effectiveness of such structures, facilities, or devices for such fish. (Fish and Wildlife Service and National Marine Fisheries Service, Interagency Guidance for the Prescription of Fishways Pursuant to Section 18 of the Federal Power Act (May 2002))
211 ELI (2007).
212 Depending on the source and location of the injury, a responsible party may be liable for NRDs under one or more of the following federal laws: Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. §§ 9601 et seq. (2000)); the Clean Water Act (33 U.S.C. §§ 1251 et seq. (2000)); the Oil Pollution Act (33 U.S.C. §§ 2701 et seq. (1990)); the Park System Resources Protection Act (16 U.S.C. § 19jj (2000)); or the National Marine Sanctuaries Act (33 U.S.C. §§ 1401 et seq. (2000)).
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216 Mitigation Rule (2008), §332.2.

217 "In general, the required compensatory mitigation should be located within the same watershed as the impact site, and should be located where it is most likely to successfully replace lost functions and services, taking into account such watershed scale features as aquatic habitat diversity, habitat connectivity, relationships to hydrologic sources (including the availability of water rights), trends in land use, ecological benefits, an compatibility with adjacent land uses" (Mitigation Rule (2008), §332.3(b)(1)). "Locational factors (e.g., hydrology, surrounding land use) are important to the success of compensatory mitigation for impacted habitat functions and may lead to siting of such mitigation away from the project area. However, consideration should also be given to functions and services (e.g., water quality, flood control, shoreline protection) that wil likely need to be addressed at or near the areas impacted by the permitted impacts" (Mitigation Rule (2008), §332.3(c)(2)(ii)).

218 73 Fed. Reg. 19659 (Apr. 10, 2008).

219 Ruhl JB, J. Salzman, and I. Goodman. 2009. "Implementing the New Ecosystem Services Mandate: A Catalyst for Advancing Science and Policy." *National Wetlands Newsletter.* Vol. 30, No. 2. Washington, DC: Environmental Law Institute.

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Appendix C

Compensatory Mitigation Site Protection Instrument Handbook

US Army Corps of Engineers®

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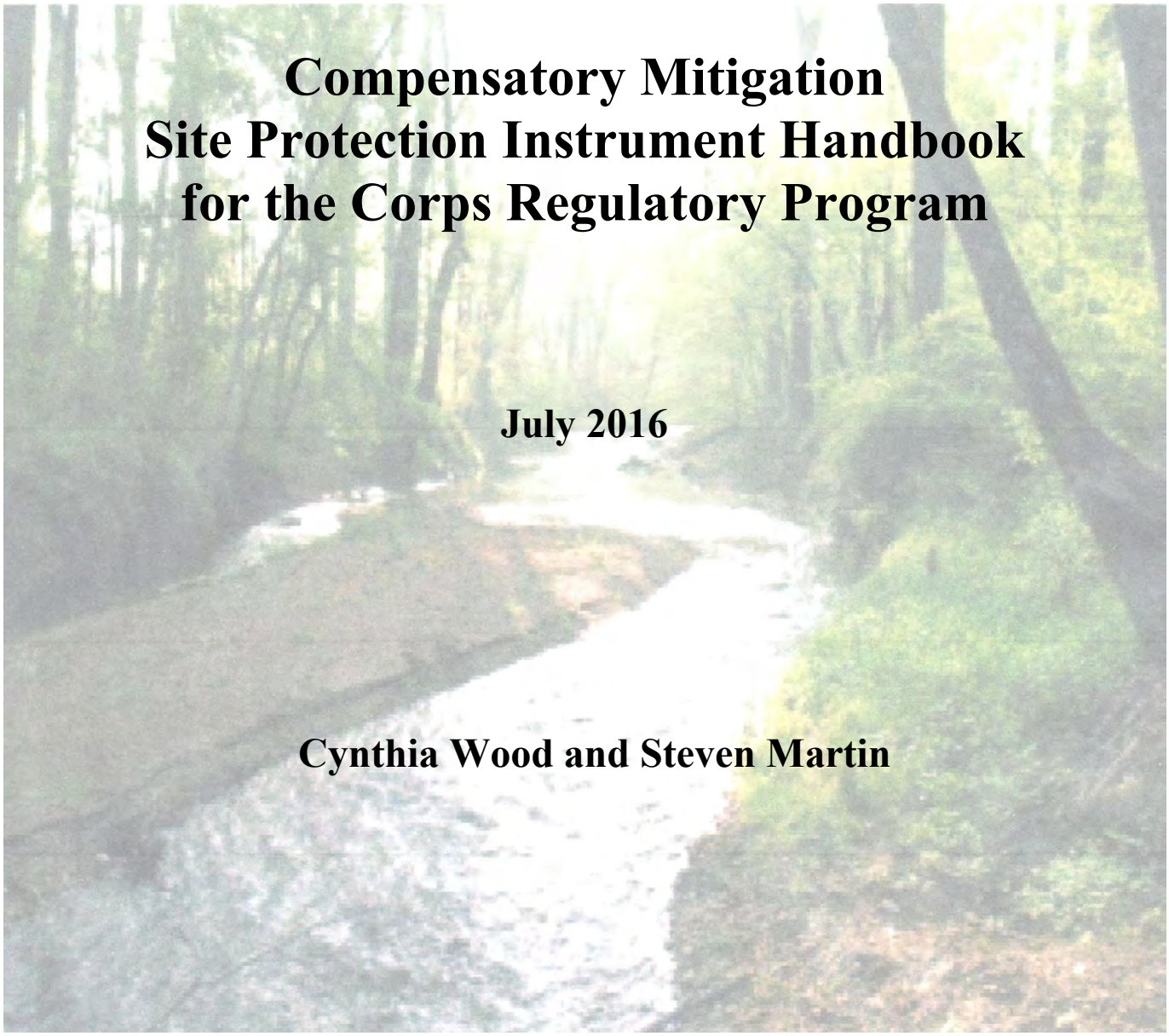

Compensatory Mitigation Site Protection Instrument Handbook for the Corps Regulatory Program

July 2016

Cynthia Wood and Steven Martin

This handbook is intended for use in the Regulatory Program only and is not intended to apply to Corps owned property or to where the Corps is a party to a real estate instrument.

Compensatory Mitigation
Site Protection Instrument Handbook
for the Corps Regulatory Program

Table of Contents

1. Introduction **1**

A. Purpose of the Handbook **2**

B. Legal/Regulatory Context and Issues **2**

II. Types of Site Protection Instruments and Advantages and Disadvantages **4**

A. Conservation Easements. **4**

B. Deed Restrictions (Restrictive Covenants) **6**

C. Transfer of Title. **7**

D. Multi-Party Agreements **8**

E. Other Approaches **9**

III. Important Issues to Consider **11**

A. What to include in a Site Protection Instrument **11**

B. When to Require, When to Record. **11**

C. Marketable Title **12**

D. Title Insurance **12**

E. Enforcement **13**

F. Eminent Domain **13**

G. Subordination **13**

H. Severed Rights/Split Estates **14**

I. Signage and posting **14**

J. Amendment/Notice/60-day language **14**

K. Merger **16**

L. Notice **17**

M.Suggestions for Prohibited Uses **17**

N.Possible Acceptable Permissive Uses of Land **17**

IV. Frequently Asked Questions and Issues **18**

V. Examples of Corps District & State Model Site Protection Instruments **19**

Developing suitable site protection instruments for mitigation projects can be challenging for the regulatory project manager placing demands on regulators outside their regular areas of practice and expertise. The Institute for Water Resources (IWR) prepared this white paper on site protection for compensatory mitigation projects to provide a reference resource for Corps district regulatory staff involved with ensuring that mitigation projects are protected.

"Compensatory Mitigation Site Protection Instrument Handbook for the Corps Regulatory Program" reviews different site protection approaches and considerations for protecting compensatory mitigation projects. It describes and compares key features of different site protection instruments.

Comments and information on experiences should be submitted in writing to Steve Martin (steven.m.martin@usace.army.mil).

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Compensatory Mitigation Site Protection Instrument Handbook

for the U.S. Army Corps of Engineers
Regulatory Program

1. Introduction

Under the Final Rule, Compensatory Mitigation for Losses of Aquatic Resources, 33 CFR part 332/40 CFR part 230, Subpart J ("Mitigation Rule"), all compensatory mitigation plans required for Department of the Army (DA) permits are required to address 12 fundamental components. One of these components is the "site protection instrument" (see 33 CFR 332.4(c)). In accordance with the Mitigation Rule, the long-term site protection required for compensatory mitigation sites must be provided through real estate instruments or other available mechanisms, as appropriate considering relevant legal constraints.
33 CFR 332.7(a)(1).

The site protection instrument[1] is a written description of the legal arrangements, including site ownership, management, and enforcement of any restrictions, that will be used to ensure the long-term protection of the compensatory mitigation project site. The Mitigation Rule requires adequate protection of all compensatory mitigation project sites to the extent appropriate,[2] whether the protection is accomplished through a real estate instrument, management plan, or other long-term protection instrument. Because real estate instruments have binding legal consequences and the legal frameworks for these instruments vary from state to state, it is necessary that U.S. Army Corps of Engineers (Corps) Regulatory Project Managers (PMs), in consultation with their Office of Counsel or Real Estate Office, understand key issues surrounding real estate instruments as they relate to the protection of compensatory mitigation sites in general, and specifically within the state in which the compensatory mitigation site is located.

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[1] The terms "Site Protection Instrument" will be used when generally referring to mechanisms use to protect the compensatory mitigation project site. The term "Real Estate Instrument" will be used when specifically referring to one or more types of real estate instruments used to protect compensatory mitigation project sites.

[2] The Mitigation Rule recognizes that there are situations where it may not be possible to require a real estate instrument, management plan, or other long-term protection instrument because the mitigation provider does not have the required property interest to impose an instrument or management plan (see 73 FR 19646):

> There are other examples of situations where it may not be feasible to require site protection through real estate or legal instruments for compensatory mitigation projects. One potential situation is the construction of oyster habitat or the restoration of sea grass beds in state-owned tidal waters, where the project proponent does not have a real estate interest, but may obtain authorization to conduct those environmentally beneficial activities. Another example may be the restoration of tidal marshes or other coastal resources, since the long-term sustainability of those projects in the dynamic coastal environment cannot be assured because of the natural littoral processes that occur in those areas.

A. *Purpose of the Compensatory Mitigation Site Protection Instrument Handbook*

This handbook is intended for Corps Regulatory program staff to identify and explain some of the key issues surrounding site protection instruments as they apply to the protection of compensatory mitigation sites. It is not intended for Corps owned property or situations where the Corps is a party to a real estate instrument.

B. *Legal/Regulatory Context and Issues*

1. Regulatory Context: The Mitigation Rule states that compensatory mitigation projects must be provided long-term protection though real estate instruments or other available mechanisms, as appropriate. **(**33 CFR 332.7(a))
2. A real estate instrument should be legally sufficient, enforceable, properly recorded in the chain of title, and be able to ensure long-term protection of the compensatory mitigation site. A nationwide standardized real estate instrument is not possible since real property laws differ from state to state.
3. For compensatory mitigation required by Department of the Army permits, there is no legal authority for the Corps to hold a real estate interest in land; therefore, site protection must be accomplished through recognized forms of property protection instruments, some of which are usually administered by a third party.[3]
4. Ownership of the Land: Because the protection of a compensatory mitigation site requires involvement of the owner of the property or an entity with the pertinent property interest, it is preferable that the owner of the compensatory mitigation site (or an entity with a property interest in the mitigation site) be a permittee of a DA permit and/or sponsor of the mitigation bank or in-lieu fee program.[4]
5. The Corps' Office of Counsel (Counsel) plays an essential role in providing advice and determining the legal sufficiency of real estate site instruments and other site protection instruments for compensatory mitigation sites. Timely involvement of Counsel will

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[3] Many states regulate wetlands, streams, and aquatic resources and take the lead in site protection of aquatic resources both on behalf of the state program as well as the federal Clean Water Act 404 program. In those states, the Corps generally plays an oversight role, may negotiate with the State as to the wording of site protection documents and may have third party right of enforcement. In Corps districts where the state is not as active in site protection of wetlands, streams and aquatic resources, the districts generally look to 501(c)(3) non-profit land trusts, departments within the state, or to county or city forms of government to hold conservation easements. Absent any willing easement holder (or Grantee), the Corps looks to the property owner to protect the compensatory mitigation site either through a declaration of restrictive covenant or simply by virtue of the terms and conditions of the permit.

[4] The advantage of having the owner of the land or land interest be the permittee or co-permittee and sign the site protection instrument is to prove that the owner was on notice as to why use restrictions were placed on the land and that he or she agreed to those restrictions. So long as the owner of the property is the permittee or co-permittee and signs the protective instrument, he or she is accountable for the impacts to waters, wetlands, and other resources on the land being provided as compensatory mitigation,, and accountable for the long term protection of the mitigation site according to the terms of the site protection instrument. Where the property owner is a limited liability corporation, partnership or business, it is advisable to identify the officers of the corporation, partnership or business and to require them to sign the permit or mitigation bank instrument as individuals and to take responsibility individually, jointly and/or collectively as owners of the land for the long term protection of the mitigation site according to the terms and conditions of the site protection instrument. For example in California, if the bank sponsor is not the property owner, the property owner is required to sign the banking instrument and a condition precedent to bank establishment is recordation of a conservation easement granted by the property owner. Further, in California, most (but not all) in-lieu fee (ILF) program sponsors are not the property owners of the lands on which an ILF compensatory mitigation project would be located. Generally, the ILF program sponsor purchases a conservation easement from the landowner.

enable the Corps Regulatory PMs to avoid various problems that can arise with the preparation of site protection instruments and writing permit conditions relating to site protection. The following offer examples of where Counsel's involvement is key:

a. Real Property law is based on statutes and case law within the state where the subject property is located, is subject to change, and its application often depends upon the facts in a particular permit situation. Because of this, Corps Regulatory PMs need to involve Counsel to ensure that the proposed site protection instrument reflects the current state of real property law within that state and is properly applied to the facts of a particular permit and mitigation plan.
b. Counsel is able to research real estate laws available in a particular state for long-term protection as well as to develop a real estate instrument that satisfies the requirements of the Mitigation Rule and reflects the conditions that PMs desire in the instrument. Counsel review of the language proposed for the site protection instrument is necessary to assure that it is legally sufficient, recordable, and enforceable within a legal context.
c. Counsel, after researching the real property law of a state, may prepare a real estate instrument template for use by the Corps Regulatory PMs in that state. Using this approach, Counsel's review of the real estate instrument will be significantly streamlined and can focus on instances in which the permittee, sponsor, and/or Corps Regulatory PM wishes to vary from the language of the template.
d. As part of our due diligence in accepting a site for compensatory mitigation, prior to approval of a mitigation plan, Counsel should be provided the opportunity to review any title search documentation and to evaluate property rights, interests (such as timber, or mineral rights), and encumbrances that could result in a site being deemed unacceptable as a compensatory mitigation site. Corps Regulatory PMs and their Counsel should be alert to the possibility of unrecorded interests, agreements, permits or licenses that may not show up in a title search or opinion, but which could impact the acceptability of a compensatory mitigation site.
e. Counsel also may review the real estate instrument and exhibits and interact with the property owner's legal representative.
f. Counsel can assist the Regulatory PM in determining the real estate instrument best suited for the specific circumstances.
g. Counsel and the Regulatory PM could develop a checklist of items the landowner should provide as part of the review process for the site protection element of the mitigation plan (e.g. deeds evidencing ownership, maps, a preliminary and final title report, title insurance, draft easement). In addition, outlining a sequence of events when these items are needed for review would be helpful.

Based on the above, it is advisable for the Corps Regulatory PMs to engage Counsel early in the permit review process if it is likely that site protection will be required. Inability to protect a compensatory mitigation site will affect permit compliance and may create enforcement issues.

II. Types of Real Estate Protection Instruments (including Advantages and Disadvantages)[5]

The real estate instruments most commonly used to protect compensatory mitigation sites and those cited in the Mitigation Rule at 33 CFR 332.7 include:

A. *Conservation Easements*
B. *Deed Restrictions (Restrictive Covenants)*
C. *Transfer of Title*
D. *Multi-Party Agreements, and*
E. *Other Documents,* such as Conservation Land Use Agreements, Federal Facility Management Plans or Integrated Natural Resources Management Plans, that *protect real property or mitigation projects on Federal lands*

(It should be noted that not all forms of site protection may be available for a given compensatory mitigation site. It is incumbent upon Corps Regulatory PMs, acting on the advice of Counsel, to determine whether that method of site protection proposed for the mitigation project is appropriate given the characteristics of the compensatory mitigation project.)

A. ***Conservation Easements:***

A conservation easement is an interest in real property that precludes the property owner from using the land in ways that would adversely impact the natural resources on the property. The property owner ("Grantor") makes a written conveyance of an easement (real estate instrument) which protects the natural resources and restricts the activities that can be conducted on the property. The party receiving the conservation easement is referred to as the "Holder" (or Grantee) and is usually a non-profit, land trust or governmental entity. The Holder does not gain ownership rights to or possession of the land, but does hold a real property interest. The conservation easement may also grant oversight and enforcement rights to a third party, typically in return for some benefit to the Grantor or property owner (such as issuance of a permit, mitigation bank approval, etc.).

1. Advantages.

A conservation easement may convey to a Holder the legal authority to access the property, monitor compliance, and to enforce land use restrictions in accordance with the terms of the real estate instrument. In cases of non-compliance, the Holder may be authorized to take action to address non-compliance, including in some cases initiating litigation. The conservation easement should include a provision requiring the Holder to notify the Corps and other appropriate entities of any non-compliance in accordance with the terms of the real estate instrument. The Corps may then determine whether an enforcement action is necessary to ensure

[5] Real property law differs from state to state. Also the entities engaged to protect DA permit compensatory mitigation sites may differ. In addition to (and especially in the absence of) the ability to use conservation easements, restrictive covenants, or the conveyance of the property to a conservation entity, the district looks to the permit conditions, the mitigation banking instrument, or the terms of the in-lieu fee program instrument to protect the compensatory mitigation site and ensure that the required compensatory mitigation continues to be provided over the long term. There are some statutes, such as the Uniform Environmental Covenants Act, that create environmental covenants that are perpetual. However, the state legislature must adopt the act and add language that would make it applicable to DA permit compensatory mitigation sites. An actual transfer of land from the owner to an entity that will hold and protect the land for its conservation values is another form of site protection.

compliance with the terms and conditions of the DA permit, the mitigation banking instrument or the ILF project instrument. The conservation easement, if properly drafted and recorded in the chain of title[6], remains in force even if the property is transferred to a new owner by sale or other means.

A conservation easement may allow the land owner to retain many property rights. For example, a property owner could convey a conservation easement over wetland property while retaining the right to hunt on the property or to enjoy other compatible uses.

The typical conservation easement statute provides for a third-party right of enforcement which may be used to augment and back-up the capabilities of the Holder by providing that third party with the right to ensure compliance with the conservation restrictions, through litigation if necessary. Although the Corps may not hold real property interests unless it has the specific statutory authority to do so, it may be the recipient of a third-party right of enforcement if permitted under State law. Having an explicit third-party right of enforcement recognized in the conservation easement: 1) provides a legal basis to enforce the easement based on state law in addition to the permit conditions, and 2) provides notice in the chain of title as to the nature of and reason for the easement to both tribunals and subsequent purchasers.

The Holder, such as a land trust or natural resource agency, may have experience in monitoring aquatic resources, managing wildlife habitat or protecting endangered species. Therefore, not only is the land protected from future development and other incompatible activities through conveyance of the conservation easement, but under proper management, the Holder may increase its environmental values and functions.

Another advantage of the conservation easement is that the Holder is responsible for monitoring compliance and can take action to address non-compliance rather than the Corps. This in turn reduces Corps' compliance workload.

2. Disadvantages.

Holders may have the discretion not to enforce the conservation easement terms.

A conservation easement could be extinguished for several reasons. One main reason is if the Holder of the easement ceases to exist, as in the case of a non-profit 501(c)(3) corporation or a land trust that dissolves.[7] A conservation easement can be extinguished for lack of a Holder. The easement may also be extinguished if the Holder does not enforce the use restrictions and/or if the land is used or developed for a contrary purpose to the easement.

It can often be difficult to find a Holder, especially for small compensatory mitigation sites. There may be no state or local governmental department or non-governmental agency willing or

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[6] The expression, "chain of title" simply refers to the recorded deeds of owners of a parcel of land going back over time. If a real estate instrument is not properly recorded to provide adequate "notice" to the public or future owners, it may not be recognized as an enforceable interest in land.

[7] In some districts, the requirement by the Corps that the compensatory mitigation site be protected by a conservation easement, or servitude, coupled with the lack of governmental entities or reputable land trusts who are willing to hold a conservation easement, has led to the formation of 501(c)(3) non-profit entities formed for the sole purpose of holding conservation easements on DA permit compensatory mitigation sites. Some districts have adopted standards for non-profit entities that are proffered as conservation easement holders, such as the "Land Trust Standards and Practices," set by the national Land Trust Alliance and accessible on their web site.

authorized to hold a conservation easement, especially if the property is small and difficult to access for enforcement purposes or if adjoining land uses are viewed by a potential Holder as incompatible with the conservation easement.

Insufficient funding is another reason that potential Holders may decline an easement. If an adequate endowment (funds necessary for easement Holder to meet their legal and management responsibilities) was not established or if the Holder's financial situation changes, the Holder may not have sufficient funds to monitor, manage and enforce the terms of the easement.

B. Deed Restrictions (Restrictive or Negative Covenants):

A restrictive covenant is a condition in a deed limiting or prohibiting certain uses of real property. Restrictive covenants should "run with the land," meaning that they are enforceable by and against later owners or occupiers of the land. Land developers typically use restrictive covenants when they subdivide property to impose limitations on the use of property such as set back lines, common area use, architectural design rules, etc. Restrictive covenants are also used to protect compensatory mitigation sites. For example, the owner (or permittee) may agree to place limitations on the use of the compensatory mitigation property as a condition of a DA permit, for authorization to operate a mitigation bank, or to proceed with an In-Lieu Fee (ILF) project. The "Declaration of Conservation Covenants and Restrictions," is recorded in a record of deed office. For compensatory mitigation sites, the recorded restrictive covenant should be written so that it runs with the land. The compensatory mitigation project site and its aquatic resources are protected as a benefit to the owner, subsequent owners and to the public.[8] The Corps may enforce the use restrictions under the deed restriction or negative/restrictive covenant as long as it is a condition of a DA permit, a mitigation banking instrument, or an in-lieu fee program instrument. In other words, violation of the restrictive covenant would be a violation of the applicable permit condition(s). Therefore, it is important that the conditions of the DA permit and the deed restriction be linked together to create an enforceable real estate instrument.

1. Advantages.

The restrictive covenant is written to "run with the land" in perpetuity or for a substantial period of time and the covenant remains in effect regardless of ownership of the land. Every subsequent owner or occupier must comply with the terms of the covenant. Also a deed restriction does not require a third party holder because the restrictions are on the land itself.

2. Disadvantages.

Deed restrictions are more difficult to enforce because a third party cannot be given legal responsibility for monitoring and protecting the site and ensuring compliance with the terms of the deed restriction. The burden of enforcing the deed restriction or negative/restrictive covenant is on the property owner and potentially the Corps and/or state regulatory agencies.

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[8] State statutes, corresponding case law and surveys of the law, like Restatements of Property, published by the American Law Institute, are used by counsel to determine if restrictive covenants may be used to protect compensatory mitigation sites. Where restrictive covenants are used, the property owner, by virtue of issuance of a DA permit, banking instrument, or in-lieu fee program instrument, agrees to declare covenants, conditions and restrictions that run with the land as to certain platted and legally described wetlands, streams, aquatic resources, and buffers, and to record the declaration in the chain of title where it will serve as notice to future owners.

State statutes may limit the number of years that a deed restriction or negative/ restrictive covenant is in force and consider "covenanting parties' intent" when determining whether enforcing the covenant would be adverse to "public policy".[9] Therefore, it is imperative that the restrictive covenant include the purpose of the covenant and state that the covenant is a requirement to secure a DA permit, a mitigation banking instrument, or approval for an in-lieu fee project.

In should be noted that marketable title statutes typically apply to deed restrictions which could have the effect of sunsetting these restrictions. One option might include provisions in the deed restrictions for periodic re-recordation of the restrictions knowing, however, that there is some risk that periodic recordation may not take place.

It is important that the deed restriction or restrictive covenant be written to "run with the land" and be recorded in the chain of title to serve as notice to anyone searching the property records. Without this, the deed restriction may not be enforceable to subsequent owners of the land. (This is also true of conservation easements.) Therefore, within the documentation that is filed with the deed, it is important to provide language and maps showing specific areas (e.g., aquatic resources such as wetlands, streams, upland buffers) on the parcel that are a protected interest on that property and indicate that they are part of a compensatory mitigation site required by a DA permit, or is a mitigation bank site or an in-lieu fee program project site.

C. Transfer of (Fee) Title:

In a transfer of title, ownership of the compensatory mitigation property is transferred to a natural resource management or other governmental agency, land trust, land management entity, or another non-profit entity deemed acceptable to the Corps. That entity must agree to manage and protect the mitigation site including its aquatic and other natural resources on the property.

1. Advantages.

Transferring real property to a land management entity (land trust, natural resource management or other governmental agency) is beneficial to the extent that the land management entity may have greater resources to staff, manage and protect the property including the aquatic resources on that property. Compensatory mitigation sites may become part of a larger protected area that is currently being managed by that land management entity.

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[9] In Indiana for example, the state Court allows restrictive covenants but only upholds them when they are justified and unambiguous and their enforcement is not adverse to public policy. Therefore, when a Court is called upon to interpret a restrictive covenant in that state, the restrictive covenant will be strictly construed, and if there are any doubts they will be resolved in favor of the free use of property and without the restrictions. The covenanting parties' intent must be determined from the specific language used in the covenant and from the situation of the parties when the covenant was made. Specific words and phrases cannot be read exclusive of other contractual provisions. In addition, the parties' intentions must be determined from the contract read in its entirety. When the restrictive covenant is a requirement to obtain a Corps permit, this should be stated clearly in the Declaration of Covenant document.

2. Disadvantages.

It may be possible that once the land has been transferred, the receiving entity could convert compensatory mitigation sites to other purposes.[10] The perpetual set aside of lands for natural resources alone is often times unsustainable. Land owners often have limited resources for operation costs (e.g. property taxes, surveys etc.) or the costs needed to repair or restore the site if it is damaged due to a natural or unforeseeable event. Limited resources sometimes result in the landowner adapting the site for uses that generate income such as planting of crops; licensed hunting activities and structures; or opening the site to ecotourism or passive recreation. These may be incompatible uses, depending on the provisions of the approved mitigation plan (see 33 CFR 332.7(a)(2)).

Some Districts have placed reversionary clauses in title transfer agreement to address incompatible uses by a land management agency. A problem with reversionary clauses is even if the compensatory mitigation site reverts to the original owner if the real estate instrument is violated, the original land owner (or estate in case of his or her death) may be unwilling take the land back and manage it as a compensatory mitigation site, or the original land owner may no longer exist. However, some states have included in their reversionary provisions the ability for title to be transferred to a designated state agency such as a state wildlife or natural resource management agency in the event of change in use.

D. Multi-Party Agreements

These are agreements among several interested parties to protect a property. Those agreements establish roles and responsibilities for each of the signatory parties consistent with applicable federal and/or state statutes, as well as the objectives of the land trust.

Example 1: A Land Trust has a willing seller of land that has been identified as a priority area for aquatic resource restoration or protection but the Trust lacks funds necessary for long-term protection of the property. There is an approved mitigation plan for restoration and protection of aquatic resources on the property. After the Land Trust acquires the property and after the compensatory mitigation has been successfully completed, the Land Trust plans to transfer the property to the U.S. Forest Service who will be responsible for long-term management. The parties execute a multi-party agreement to establish their respective roles and responsibilities which will be undertaken after the permittee responsible for providing compensatory mitigation makes the necessary payment to the Land Trust. The Land Trust acquires the property and implements the approved mitigation plan. If the project covered under this agreement is permittee-responsible mitigation then the permittee remains responsible for ensuring the mitigation project meets its ecological performance standards until it enters the long-term management phase.

Example 2: A state non-game agency owns a property and agrees to allow restoration and enhancement activities to be undertaken on the property by the State's Department of Transportation who needs compensatory mitigation credit. The state non-game agency does not have the funds to conduct the restoration and enhancement activities, and is unlikely to obtain the necessary funds. The state non-game agency also agrees to manage and preserve the DA permit

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[10] Monitoring of mitigation projects for incompatible uses or activities is appropriate at all compensation sites regardless of the site protection instrument.

compensatory mitigation area for its restored and enhanced aquatic resources. The parties enter into a multi-party agreement via an MOA or MOU.

1. Advantages.

There are more opportunities to leverage multiple agencies resources to ensure that a compensatory mitigation project is implemented and managed over the long term, through shared financial or monitoring obligations. Multi-party agreements also provide for participants with specialized areas of expertise which may increase the long-term ecological performance of the compensatory mitigation project and ensure that it will be protected and managed properly over the long term.

2. Disadvantages.

Where there are several parties, there can be more issues over agreements and it could be more difficult to achieve consensus. For example, if one party does not fulfill its responsibilities, it jeopardizes the success of the entire compensatory mitigation project, including its long term management and protection. It is important to ensure that the agreement is coordinated through Counsel and contemplates potential conflicts and ways to resolve those conflicts, such as a mediation or arbitration clause.

Agreements are not necessarily as binding as a conservation easement and may not necessarily "run with the land" and usually have termination clauses.

E. Other approaches to site protection, documents, such as Conservation Land Use Agreements, Federal Facility Management Plans or Integrated Natural Resources Management Plans, that Protect Real Property or Compensatory Mitigation Projects on Federal/State Lands

Conservation Land Use Agreements are agreements to conserve property while allowing certain compatible uses but restricting other uses that are incompatible with compensatory mitigation. These types of agreements can be used when the governmental entity is already the owner of the compensatory mitigation land and no transfer of title will be required. These types of arrangements may also be necessary when a governmental entity is responsible for providing compensatory mitigation, and uses government land for a compensatory mitigation project, but cannot use a conservation easement or deed restriction to provide long-term protection because of statutory or regulatory restrictions applicable to government lands.

The agreement may be recorded in a land records office. These agreements can also be used when the federal government is going to become the owner but is not authorized to allow recordation of any limitation on the property or its use. Federal agencies including the Department of Defense, the U.S. Forest Service, and Bureau of Land Management are typically precluded by law from recording easements or restrictive covenants on their lands. This complicates long-term protection of compensatory mitigation projects on federal lands. However, federal agencies are authorized to use other tools to protect and manage compensatory mitigation sites on federal lands. Such tools may include memoranda of understanding, integrated natural resource management plans, federal facility management plans, and conservation land use agreements.

A governmental permittee or third party mitigation sponsor can lease a compensatory mitigation or conservation property to a non-profit conservation organization as a mechanism to conserve or protect a compensatory mitigation site. Department of Defense agencies have out-leased some compensatory mitigation and conservation properties to conservation organizations on a long-term basis as a mechanism for providing long-term site protection.

Where there is a conservation land use agreement, lease, or similar agreement all parties involved sign the agreement that sets out the applicable authorizing state and/or federal statutes. The agreement includes a legal description and survey of the compensatory mitigation property, the approved mitigation plan, and provides for any acquisition and transfer of ownership as well as funding methods. The agreement names the entity that will ultimately record the Conservation Land Use Agreement and will manage the property over the long term according to a memorandum of agreement. Additionally and importantly, the agreement specifies the way to report to the Corps on management issues and to address modifications, renovations, or termination of the agreement.

Federal agencies typically identify the compensatory mitigation or conservation lands in their land management plans. These plans are generally identified as Integrated Natural Resource Management Plans (INRMP) by Department of Defense (DoD) agencies, Forest Management Plans by the U.S. Forest Service, or Comprehensive Conservation Plans by the National Wildlife Refuge System and Federal Facility Management Plans by other agencies. These plans clearly identify the location and extent of the compensatory mitigation properties, suitable management activities, and incompatible activities. They are typically utilized by agency staff in planning future activities on federal lands. These plans are typically referenced by Conservation Land Use Agreements and together with conservation land use agreements may provide acceptable compensatory mitigation site protection on federal lands. Other government agencies (e.g., state agencies) may use similar plans to protect compensatory mitigation or conservation lands.

1. **Advantages**

Land management plans or agreements are a mechanism to protect compensatory mitigation sites where laws prohibit recordation of real estate documents. Federal facility management plans, including INRMPs, are intended to be living documents, and may change over time. They are typically reviewed annually and may be revised every 5 years.

2. **Disadvantages**

Leases are typically granted for limited terms (typically 10 but can also extend up to 99 years). Compensatory mitigation lands protected under these agreements have limited time periods for protection. These agreements are subject to periodic review and renewal. With these reviews, there is a potential for revision to the management plans resulting in reducing or even removing of a mitigation site from the plan.

Compensatory mitigation sites can be utilized for other purposes, for instance when land management plans are changed to meet national security requirements. However, change in use of these sites requires notification to the Corps, and the Corps may require the compensatory mitigation provider to provide replacement compensatory mitigation acceptable to the Corps.

III. Important Issues to Consider

A. What to include in a Site Protection Instrument

a. Express statement that the purpose of the instrument is to protect a compensatory mitigation site under Federal and (where applicable) State law;
b. Express reference to the DA permit and/or mitigation banking or ILF program instrument.
c. Survey/Legal Description (Survey shows any easements that will remain in place)
d. Identification of other property rights/interests;
e. Baseline- Description of conservation resources on the site, including listed species, habitat, and available information concerning the contribution they provide in terms of functions and services;
f. Prohibited and Acceptable Uses (See K and L below);
g. Third-party right of enforcement, where appropriate;
h. State that any amendment of the instrument must be preapproved by the Corps and that approval must be reflected in an amendment recorded in the chain of title; and
i. Provision regarding what happens in a "taking" by the Government (eminent domain).

B. ***When to Require, When to Record:*** It is important to develop a local policy and process regarding development and recordation of site protection instruments for compensatory mitigation projects in coordination with Counsel. (The owner of the real property and/or the permittee/banker/ILF sponsor will most likely be represented by legal counsel as well). Provided the applicant has identified a compensatory mitigation site that is acceptable to the Corps, the appropriate time to require submittal of title insurance, title search and a questionnaire regarding land issues would be just after a public notice has been issued for the permit application, mitigation bank prospectus, or ILF project proposal. For DA authorizations that do not require a public notice such as NWP or general permit verifications, the appropriate time to submit real estate information would be upon receipt of a proposed detailed mitigation plan. The Corps Regulatory PMs should not wait until the DA permit, mitigation banking instrument, or in-lieu fee project approval is being finalized to begin review of site protection issues. There is no point in proceeding with those actions if there are outstanding issues regarding the land, since a permit, instrument, or instrument modification cannot be issued until the mitigation plans have been approved.

A real estate instrument is recorded at the county register of deeds office in the county or parish where the land is located. It then provides a public record of the interests associated with the land. Land management plans should be accessible at any registry of deeds office, military base, tribal land office, natural resource area office or similar location for review by interested parties. Among those interested parties could be:

- Potential buyer of land
- Title Search – open to public
- Financial institutions prior to lending
- Private and governmental developers
- Court proceedings
- Land planning

C. **Marketable Title**: A marketable title is a title that is clear of any conflict of ownership and can be transferred by sale, gift, death, or donation to another person, conservation group or government entity. Twenty-two states have passed Marketable Title Statutes to provide clear marketable title by removing encumbrances of old and perhaps abandoned claims (including conservation easements and restrictive covenants) after a certain number of years (25-40 years). Some states (e.g. Massachusetts, North Carolina, California, Rhode Island and Wisconsin) specifically exempt conservation easements from their Marketable Title Statutes. In the other states, it is important for Corps Regulatory PMs to be aware of how these statutes could affect the legal protection of a compensatory mitigation site and what language or condition could be added to prevent extinguishment of the real estate instrument. One option is to condition the DA permit or third party mitigation instrument to require periodic re-recordation of the site protection document.

D. **Title Insurance**: Title Insurance guarantees that the title is clear and there is no conflict of interest regarding ownership of a particular parcel. The requirement of title insurance means that a title insurance company is hired to go to the record of deeds office and research the history of the property (chain of title) going back 30-60 years (depending upon state law) to see if the owner has clear title and to see if there is any conflict in ownership. If there is clear title, then the company backs their determination with insurance**.** A title search provides a list of all interests in the real property that are recorded on the deed. It will not identify any agreements that have been made that bind the property but do not relate to ownership, unless a lien has been filed. Licenses or permits issued over the subject property are often not recorded and may not be identified. Title insurance does not identify any other interest such as mineral or timber rights, but rather insures the buyer against any future clouds on title that may be raised adverse to ownership. However, title insurance is not a substitute for a title report. A title report is a written analysis of the status of title to real property, including a property description, names of titleholders and how title is held, tax rate, encumbrances (easement, mortgages, liens, deeds of trusts, recorded judgments), and real property taxes due.

A title insurance company may be willing to insure property that is encumbered by easements or other interests that may be adverse to the use of the property as a compensatory mitigation site, but not adverse to ownership (e.g., oil wells, large pipelines, or drainage structures). Therefore, a title report should be requested and provided to Counsel for review. For smaller parcels of land, used for permittee-responsible mitigation title reports and title insurance may not be required by the Corps. Rather, the real estate instrument can include a statement by which the owner of the property (or entities with interests/rights in the property) warrants that there are no conflicting property interests or rights and pledges some type of corrective action or indemnification if it turns out that there are in fact conflicting interests or rights in the property.

Title insurance does not necessarily address all factors that could affect the suitability of the site for compensatory mitigation. Title insurance just assures clear title for the specified period of time. It often does not list all the existing easements, rights-of-way, tax liens, financial liens and other interests less than ownership. A title search for other interests should be conducted by a title company and provided to the Corps for review. The California Interagency Review Team has developed a template for this search for other property interests, known as a "Property Assessment and Warranty".

E. ***Enforcement:*** Where possible, the site protection instrument, DA permit, or third party mitigation instrument should establish a party with the right to access the site and enforce provisions in the site protection document that protect the compensatory mitigation site. The party(s) responsible for the overall enforcement of the site protection instrument should be clearly identified, and should have adequate resources to monitor and enforce the conditions that protect the compensatory mitigation site. For conservation easements[11], the Corps may accept a third-party right of enforcement consistent with State law (consult with your legal counsel). The regulatory agencies (Corps and/or state) should have a copy of the final site protection instrument or in the case of a real estate instrument a recorded copy

F. Eminent Domain refers to the power of the government to appropriate property for public use. Condemnation proceedings can result in the loss of title to the property or a portion of the property. However, the landowner is paid the fair market value of the land lost. If eminent domain is proposed on a compensatory mitigation site required for a DA permit, or for a mitigation bank site or an in-lieu fee project site, try to negotiate a solution with the governmental entity and educate them on the value of the compensatory site to encourage continued protection of the site. Additionally, a court might consider the consequential value loss or an uneconomic consequence argument in addition to the fair market value where the real estate instrument cites the conservation values provided to the public by the site. For example, the potential effect of exercising eminent domain on conservation values could be demonstrated by explaining that a road right-of-way through a compensatory mitigation site not only results in the direct fill area loss, but secondary impacts such as fragmentation, loss of hydrology, or loss of buffer area. Suggested language in the real estate instrument:

> *If protected compensatory mitigation property is taken in whole or in part through eminent domain, the consequential loss in the value of the property protected by the Corps' Regulatory Program is the cost of the replacement of the conservation functions, services and values of the aquatic and terrestrial resources on the compensatory mitigation property.*

G. Subordination: To subordinate means to make subject to or to relegate to a lesser position of priority. For compensatory mitigation sites, to subordinate would require that any pre-existing easements, liens or encumbrances take second priority to the use of the property as a compensatory mitigation site. For example, if a ***real estate instrument*** is recorded <u>after</u> a deed to secure a debt, the land may be foreclosed upon to settle the debt and the compensatory mitigation site protection instrument would be terminated. Subordination allows more assurance that the site will withstand adverse actions. Consider requiring language like the following in the ***real estate instrument***:

> *Consent and Subordination*
> *The undersigned (Lender) beneficiary under a Deed to Secure Debt (dated) and recorded in (Deed Book) and (Pages) in the (County, State) records, for itself, its successors and assigns, consents to the foregoing (easement/covenant).*
>
> *Lender agrees that, upon recordation of the (document), the provisions (of the document) shall run with the land which serves as security for the debt evidenced by the Security*

[11] These rights have been upheld in Federal court. See, e.g., U.S. v. Bedford, 2009 WL 1491224 (E.D. Va. 2009).

Deed and further agrees that any foreclosure or any other remedy available to Lender will not render void or otherwise impair the validity of the (easement, covenant).

The undersigned acknowledges that it has received and reviewed a copy of the (document and exhibits).

Why would a financial institution agree to or consent to subordination? The lender is in the business to loan money and may be confident that the party responsible for the compensatory mitigation project (e.g., developer or mitigation banker) will succeed and therefore pay interest on the loan so the lender can profit. The lender also acknowledges the Corps' compensatory mitigation requirements associated with a DA permit, mitigation banking instrument, and in lieu fee program instrument and understands that the areas placed in site protection would normally need permission from the Corps to be impacted. Additionally, the lender may determine that the real estate instrument does not diminish substantially the value of the property which may contain uplands outside of the protected compensatory mitigation area that still could be developed. For example, a lien or other financial debt owed may encumber a large tract of land where the area needed for compensatory mitigation only covers a small fraction of the total acreage. Therefore, to subordinate the encumbrance to the compensatory mitigation only may not substantially diminish the value of the property as a whole.

If, however, an institution is unwilling to subordinate, this might be reason to reject a proposed compensation site.

H. Severed Rights/Split Estates: For many properties, subsurface rights (including oil and gas) may be severed from surface rights. Timber rights might be another severed right. These interests may have been severed in the past through a conveyance or reservation of rights. The owner of these severed rights or interests may not be the owner of the land surface and has the right to access those materials and to convey the associated rights. Long-term protection of a mitigation project may be complicated when the owner of mineral or timber rights is unwilling to agree to extinguish or subordinate its interest for the mitigation interest. The inability to resolve conflicts between surface rights, mineral, and timber rights has prevented development of a number of compensatory mitigation projects. In some cases, regulators have worked with the holders of those interests to minimize the impact of exercising those rights on compensatory mitigation projects. Mechanisms that have been used to minimize those impacts include mitigation providers purchasing those rights, and for holders of subsurface mineral rights directional drilling and establishing minimal pads or access areas for development, etc.

I. Signage and posting: Proper signage and posting should be used to alert the public to the presence of the compensatory mitigation site. Signage should clearly indicate prohibited uses. Provisions for signage and posting should be required as permit special conditions or as part of the approved mitigation plan or third party mitigation instrument.

J. Amendment/Notice/60-day language: Requests to amend a recorded ***real estate instrument*** or another type of site protection instrument are inevitable. Corps Project Managers should consider including the following language in the instrument to discourage such amendments:

This (document) shall not be amended or extinguished except by written approval of the (Corps). Amendments to the (document) for the purpose of proposing additional impacts are not favored and will be considered only in rare circumstances following (Corps) policy and procedures.

or

After recording, these restrictive covenants may only be amended by a recorded document signed by the Corps and_____. The recorded document, as amended, shall be consistent with the District model conservation restrictions at the time of amendment. Amendment shall be allowed at the discretion of the Corps and _____, in consultation with resource agencies as appropriate, and then only in exceptional circumstances. Compensatory mitigation for amendment impacts will be required pursuant to District mitigation policy at the time of amendment. There shall be no obligation to allow an amendment.

The 60-Day Notice Requirement on Amendments. To insure the Corps is aware of any proposed changes to a recorded site protection instrument, the instrument should include language requiring a 60-day advance notice before any amendment to a conservation document can occur (33 CFR 332.7(a)(3)). Assuming the site protection instrument is properly recorded, a title search of the property will provide notice to any subsequent owner of this requirement.

Some of the reasons or justifications for amendments sought by the permittee include:

1. **It will only impact the buffer/upland and therefore no waters of the U.S. will be affected.** The compensatory mitigation was required after consideration of the functions and value of the entire tract, including any buffers. Impacting those buffers may affect the ability of the compensatory mitigation site to fulfill the ecological objectives stated in the DA permit conditions or approved mitigation plan. Corps regulations at 33 CFR 332.3(i) indicate that buffers are required where necessary to ensure long-term viability of a compensatory mitigation site

2. **It is the best alternative for a linear project (e.g., roads or pipelines) because all other alternatives involve impacts to homes, businesses or developed areas. A publicly-sponsored project could save taxpayer money by crossing a protected site instead of having to go around it.** Cost savings, although a factor, are not the most significant consideration. A thorough alternatives analysis taking into account additional compensatory mitigation cost could prove that the requested amendment is not the least costly alternative.

3. **The wetland area to be impacted is small, the functions and values are low, or the area is no longer jurisdictional.** The Corps may determine that the impact regardless of its size or quality could affect the entire site and not just the portion directly proposed for impact. Compensatory mitigation sites do not have to be jurisdictional under Section 404 of the Clean Water Act and/or Sections 9 and 10 of the Rivers and Harbors Act of 1899 (see 33 CFR 332.1(b)).

4. **An impact to the protected wetlands is needed for some national security interests (i.e., the military needs to impact the site for training activities).** Typically, acceptable replacement compensation would be required by the District.

Consider the following requirements when developing any policy for amendments:

- **a.** The owner of the property must consent and, if accepted, the amendment to the real estate instrument must be drafted, reviewed and pre-approved by the Corps, signed by all parties, and recorded in the record deeds office.
- **b.** The party responsible for the compensatory mitigation should conduct and provide to the Corps an alternatives analysis regarding other options that may be available. Cost saving, although a factor, should not be the controlling consideration.
- **c.** The Rule requires that when a change(s) is proposed to compensatory mitigation projects on public lands that would result in an incompatible use, acceptable alternative compensatory mitigation must be provided to the Corps (33 CFR 332.7(a)(4)) .
- **d.** Each district should develop a clear and consistent policy for amendments and post them on the district's Regulatory web site.
- **e.** It is not relevant whether the impact is to aquatic resources or to terrestrial resources (e.g. upland buffers) that are part of the approved compensatory mitigation project. The entire site was required as compensatory mitigation for permitted impacts and buffers provide important functions and are valuable to the sustainability of the aquatic resource. The Corps may determine that the impact will affect the sustainability, functions and services of the aquatic resources on much or even the entire site (for example due to changes in hydrologic regime) and not just the acreage on which the impact is proposed.
- **f.** Additional compensatory mitigation may be required to replace the resource functions, quality, temporal losses, etc. of the compensatory mitigation project that will be lost as a result of the impact resulting from the amendment.

Transfer of ownership of compensatory mitigation parcel may entail amendment of the permit, mitigation plan, and/or third party mitigation instrument. For mitigation banks and in lieu fee projects, it may be considered a streamlined modification of the instrument under 33 CFR 332.8(g)(2). It is especially important that the Corps PM be made aware of any change in property ownership. Language in the site protection instrument should be included to notify the Corps of such a change, such as:

> "*At any time during the life of the mitigation bank or compensatory mitigation project, should the real property be transferred, sold or conveyed, be subject to foreclosure, bankruptcy or transferred by any other means whatsoever, the owner, sponsor or administrator shall immediately notify the Corps in writing and no further mitigation credits shall be sold or credited toward fulfilling mitigation requirements pending review and approval of the transfer by the Corps.")*

(In the case of a mitigation bank wishing to continue to sell credits, add the following:

> *The new transferee shall provide the Corps with a letter agreeing to adopt the terms and conditions of the mitigation banking instrument and provide acknowledgement of the terms and conditions of the recorded (*real estate instrument *).*

K. **Merger.** Merger occurs when the Holder of the conservation easement becomes the owner of the land and the two entities "merge." When this happens, there is no longer a third party who

has an interest in the land. In order to prevent the extinguishment of the conservation easement, it is recommended that the following language be included in the conservation easement:

> *The doctrine of merger shall not operate to extinguish this Conservation Easement if the Conservation Easement and the Mitigation Property become vested in the same party. If the doctrine of merger applies to extinguish the Conservation Easement then, unless Grantor, Grantee and the Signatory Agencies otherwise agree in writing, a replacement conservation easement or restrictive covenant containing the same protections embodied in the conservation easement shall be recorded against the Mitigation Property. The owner of the Mitigation Property may suggest a new conservation easement holder and upon approval by the agencies, grant a conservation easement protecting the Mitigation Property.*

L. Notice of Conservation Restrictions in other Permit Applications. To ensure that other governmental entities are not induced to take action without knowledge of the conservation restrictions, consider including the following provision:

> *Any permit application, or request for certification or modification, which may affect the Property, made to any governmental entity with authority over wetlands or other waters of the United States, shall expressly reference and include a copy (with the recording stamp) of these restrictive covenants.*

M. *Suggestions for Prohibited Uses*[12] *(PM can add or subtract from this list)*

- Clearing, cutting, mowing
- Earthmoving, grading, filling, topography change
- Mining, drilling, timbering
- Draining, diking
- Diverting or affecting the natural flow of surface or underground waters
- Spraying with herbicides or pesticides that violate water quality standards
- Grazing or use by domesticated animals
- Use of off-road vehicles and motor vehicles
- Creating fuel modification zones

N. Possible Acceptable Uses of Land[13] *(PM can add or subtract from this list)*

- Walking trails in uplands using pervious materials
- Minimal structures and boardwalks for the observation of wildlife, stream and wetland ecology
- Hunting, fishing, canoeing, hiking, passive recreation
- Carrying out approved conservation and wildlife management plans
- Fencing to prohibit entrance of livestock and trespassers

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[12] Incompatible uses are determined on a case-by-case basis during review and approval of the mitigation plan, and should be identified in the site protection instrument (see 33 CFR 332.7(a)(2)). In some cases what might be incompatible uses for one site may be considered necessary for maintenance of another mitigation site, such as grazing, burning, etc.

[13] In some cases, uses that are typically considered acceptable may be inappropriate for a particular site, for example walking trails in a wetland that is sensitive to disturbance.

- Posting of acceptable signs
- Grazing or use by domesticated animals, especially if an objective of the compensatory mitigation project is to maintain a plant community that is dependent on grazing

IV. Frequently Asked Questions and Issues (Examples of questions that may arise and are good to consider in reviewing **site protection instruments**)

A. Questions to ask before accepting the land as part of the compensatory mitigation site to be provided long-term protection. Remember, a record search and even title insurance search does not reveal everything. Ask the property owner the following questions:

1. Are there any outstanding mineral rights or leases? Contracts?
2. Are there water rights affecting the property?
3. Are there any outstanding timber rights or leases?
4. If there are other rights/leases, do they conflict with the protection requirements on the compensatory mitigation site?
5. Is this land subject to any litigation? Zoning disputes?
6. Is the property subject to any uses not of record?
7. Who or what entity owns it?
8. Does the owner have good title and title insurance?
9. Is the land protected already?
10. Who has an interest in the land? (i.e. ownership; individual, couple, family, partnership, LLC, business, in common, trust, government)
11. Are there any existing easements (utility, water/sewer, cable, drainage) on the property?
12. Are there any existing Right-of-Ways (roads, access)?
13. Are there any Lien Holders (Financial institutions- mortgages)?
14. Is this a property that will pass by probate (wills and trusts)?
15. If a road is shown on the plat, ask if it is a private or public road and will it remain as part of the compensatory mitigation area?
16. Will the owner have access to his or her land on the other side of the stream when the stream and buffers are protected with the real estate instrument? How will the owner get across? Does the title of the land go only to the middle of the stream channel?
17. Who is responsible for installing/maintaining fences, signs, etc. Are they located inside or outside the site protection boundary?
18. Does the Grantee have sufficient resources to maintain the property in a manner consistent with the terms of the conservation easement? Are there provisions for an endowment?
19. When can the real estate instrument be recorded?
20. Does the grantee have a schedule for performing site inspections?

B. Other questions to ask when preparing the site protection instrument:

1. **What if the applicant provides wrong information?** Consider including the following language in the DA permit, and/or third party mitigation instrument to protect the compensatory mitigation site in case any information provided is inaccurate or fraudulent and becomes an issue after the compensatory mitigation is accepted:
   Should an easement, right, interest, or lease on or to the property not shown on the survey or listed in the (document) and prior in time and recording to this

(document), or unrecorded, be exercised in such a manner that it conflicts with or voids the uses of the property set out in this (document), then the owners of the property shall be responsible for providing alternative compensatory mitigation in such amounts and of such resource type and function as the Corps or any enforcer of this (document) shall determine in accordance with the DA permit.

2. **Does your Corps District offer a credit incentive (such as an incremental increase in mitigation credits) for every additional layer of legal site protection? Why would you want to provide extra credit for multiple site protection methods on a compensatory mitigation property?** Each additional layer of protection makes it more likely that the compensatory mitigation site will be protected by multiple parties under changing circumstances. It will also make it more difficult for any one entity to extinguish the site protection instrument(s) in the future. For example: If the site is protected by two instruments (e.g., restrictive covenant and a conservation easement), then additional mitigation credit might be issued. Likewise if statutory protection is added by a governmental entity, then additional credit might be issued.

3. **What might happen when one entity owns the land and another entity owns the mitigation bank with the right to sell credits?** The mitigation bank land is legally considered "real property." On the other hand, mitigation credits that have monetary value are considered "personal property." However, statutes and case law treat them differently. This issue should be discussed with Counsel and how it may affect enforceability of the site protection instrument. For example, in a bankruptcy case in Virginia, a federal judge determined that the bank lands were real property and separate from the bank credits (personal property) and allowed the bank lands to be auctioned as part of the resolution of the bankruptcy case.

4. **Can the Corps be allowed to intervene in a litigation case to enforce a real estate instrument?** To preserve the Right to Intervene in Litigation, the following language could be inserted into the real estate instrument:
In any state court action or Federal Bankruptcy action affecting waters of the U.S., the United States Army Corps of Engineers reserves the right to request to be represented by the U.S. Department of Justice and/or to move for a removal of actions affecting waters of the U.S., to the United States Federal District Court in the district where the land lies.

V. Examples of Corps District and State Model Site Protection Instruments, Documents, and Templates

North Atlantic Division
Baltimore District
(Draft) Declaration of Restrictive Covenants

New York District
New York Model Conservation Easement
New Jersey Model Conservation Easement

Norfolk District
Model Declaration or Restrictions (March 2015)

Northwestern Division
Kansas City District
Checklist for review of Conservation Easements and Restrictive Covenants
Conservation Easement Holder List December 4, 2012
Missouri Conservation Easement Template 2013
Kansas Conservation Easement Template
Kansas Declaration of Restrictions

Omaha District
Appendix I1: Conservation Easement for Mitigation Banks – template
Appendix I2: Deed Restriction - template

Portland
Portland District requires long-term site protection on compensatory mitigation projects In accordance with the Federal Compensatory Mitigation Rule for Losses of Aquatic Resources (33 CFR 332.7(a)).

South Atlantic Division
Charleston District
Charleston District Conservation Easement Model of September 2010
Charleston District Restrictive Covenant Model of September 2010

Mobile District
Conservation Easement Template (Mitigation Bank)
Model Conservation Easement for Individual Permit
Instructions for using the Model Conservation Easement
Model Declarations of Restrictions

Savannah District
Amendments to the Declaration of Covenants and Restrictions Department of the Army Corps of Engineers, Savannah District 7 Jan 2004
U.S. Army Corps of Engineers, Savannah District Regulatory Program Standards for Qualified Conservation Easements
Model Declaration of Conservation Covenants and Restrictions updated December 2009

Wilmington District
Model Conservation Easement
Model Declaration of Restrictions
Wilmington District Process for Preservation of Mitigation Property November 25, 2003
Restrictive Covenant Guidance August 2003

South Pacific Division
San Francisco District
(Draft) Conservation Easement Deed
(Draft) Property Assessment and Warranty

Southwest Division
Ft. Worth District
(Draft) Conservation Easement Agreement

Galveston District
Example Deed Restriction
Example Conservation Easement

Appendix D

Implementing Financial Assurance for Mitigation Project Success

IWR White Paper

March 2016

Implementing Financial Assurance for Mitigation Project Success

US Army Corps of Engineers®

IWR

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Implementing financial assurances for mitigation project success can be challenging and place demands on regulators outside their regular areas of practice and expertise. The Institute for Water Resources (IWR) prepared this white paper on financial assurance for mitigation project success to provide a reference resource for Corps district staff involved with establishing and overseeing financial assurances.

"*Implementing Financial Assurance for Mitigation Project Success*" reviews key design and implementation issues and considerations relating to the use of financial assurances for mitigation project success. It describes and compares key features of alternative assurance instruments.

This is an update to the original that was released in 2011. This 2015 update reflects experiences with financial assurances for compensatory mitigation since the original document. The update was conducted by Steve Martin with IWR.

The paper is intended to be a "living document" that will be updated periodically as more information becomes available. Therefore, IWR is soliciting comments relating to whether key design and implementation issues and considerations have been adequately addressed and accurately represented, as well as information on Corps district experiences in establishing and using financial assurances in the mitigation context.

Comments and information on experiences should be submitted in writing to Steve Martin (steven.m.martin@usace.army.mil).

Financial assurance for mitigation project success can be defined as a mechanism that ensures that sufficient resources will be available for use to complete or replace a mitigation provider's obligations to implement a required mitigation project and meet specified ecological performance standards in the event that the mitigation provider proves unable or unwilling to meet those obligations.

Implementing Financial Assurance for Mitigation Project Success

June 2011

Updated March 2016

Paul Scodari, Steve Martin and Aaron Willis

Institute for Water Resources
U.S. Army Corps of Engineers
Alexandria, VA

Table of Contents

1. Introduction 1
1.1 Purpose and Scope 2
1.2 Background 3
1.3 Report Organization 5
2. Design and Implementation Issues 5
2.1 Applicability 5
2.2 Coverage, Timing and Release 8
2.3 Amount 10
2.4 Claims & Performance 12
2.5 Instruments 14
2.5.1 Letter of Credit 16
2.5.2 Performance Bond 17
2.5.3 Escrow Agreement 17
2.5.4 Casualty Insurance 18
2.5.5 Legislative Appropriations 18
2.5.6 Alternative: Credit Sales Revenue to Escrow 18
3. Comparative Review of Assurance Instruments 19
3.1 Availability and Procurement 19
3.2 Price and Opportunity Cost 21
3.3 Term and Renewal 22
3.4 Claims and Performance 23
3.4.1 District Experiences with Assurance Claims 24
3.5 Security of Assuring Entities 26
4. Concluding Remarks 29
Appendix A: Illustrations of Alternative Assurance Instruments 31
Appendix B: HQ USACE Office of Counsel Memo on Financial Assurances 36
Appendix C. Links to Samples of Financial Assurance Instruments 42

List of Tables

Table 1. Overview of Alternative Financial Assurance Instruments 15
Table 2. Comparative Overview of Assurance Instrument Features 27

1. Introduction

The U.S. Army Corps of Engineers (Corps) has the authority to issue permits under Section 404 of the Clean Water Act for discharges of dredged or fill material into waters of the United States, including jurisdictional wetlands, and Section 10 of the Rivers and Harbors Act of 1899 for structures or work in navigable waters. This federal regulatory program requires applicants for section 404 permits to satisfy "mitigation sequencing" as a condition for permit issuance. Mitigation sequencing requires permit recipients to first avoid and minimize impacts on aquatic resources to the extent practicable. Permit recipients may also be required to provide "compensatory mitigation" for any remaining unavoidable impacts to aquatic resources. Compensation is expected in the form of restoration of former or severely degraded aquatic resources, the enhancement of somewhat degraded aquatic resources, the establishment of new aquatic resources, and the preservation of well-functioning aquatic resources.

The program allows permit recipients to provide compensatory mitigation using three different types of mitigation providers. One allowable mitigation type is "permittee-responsible mitigation" in which a mitigation activity is undertaken by a permit recipient as compensation for the permit recipient's own permitted impacts on aquatic resources, and for which the permit recipient retains full responsibility. Permittee-responsible mitigation may be undertaken at or contiguous to the site of the permit recipient's discharge (on-site), and/or at a location away from the discharge site (off-site).

Two other allowable types of mitigation involve third-party mitigation providers that assume legal responsibility for providing the required compensatory mitigation of multiple permit recipients at one or more off-site locations. One form of third-party compensatory mitigation is mitigation banking. Mitigation banks produce large areas of restored, enhanced, established, and preserved aquatic resources for the express purpose of providing consolidated, off-site compensatory mitigation for the permitted aquatic resource impacts of multiple permit recipients. Most mitigation banks are commercial ventures developed by private entrepreneurs to create mitigation "credits" for sale to the general universe of permit recipients in need of compensatory mitigation. In-lieu fee (ILF) programs are another form of third-party mitigation provider in which permit recipients pay mitigation fees to non-federal government or non-governmental natural resource management entities that consolidate and use the fee revenues to construct large-scale, off-site mitigation projects. The use of mitigation banks and ILF programs to provide compensatory mitigation can reduce the costs and delays associated with the permit review process, and the large-scale mitigation projects they provide are generally more ecologically valuable and protected than smaller and scattered permittee-responsible mitigation projects.

In 2008, the Corps and the U.S. Environmental Protection Agency jointly promulgated regulations governing compensatory mitigation for permitted losses of aquatic resources under the federal regulatory program (33 CFR Part 332). The rules establish standards and criteria for the use of all types of compensatory mitigation. Among the rule provisions are general requirements for implementing financial assurances for compensatory mitigation projects that state in part, "The District Engineer shall require sufficient financial assurances to ensure a high level of confidence that the mitigation project will be successfully completed." [33 CFR 332.3(n)(1)]. Further, the rules state that financial assurances "…may be in the form of performance bonds, escrow accounts, casualty insurance, letters of credit, legislative appropriations for government

sponsored projects, or other appropriate instruments subject to the approval of the district engineer." [33 CFR 332.3(n)(2)].

Financial assurances are one of a number of "tools" used by the Corps to better ensure compensatory mitigation success. Other tools available include: (1) enforcement of the Corps permit and its conditions; (2) enforcement of the real estate protection instrument; (3) monitoring of attainment of ecological performance standards; (4) maintenance of projects; and (5) adaptive management of projects.

1.1 Purpose and Scope

This report reviews key design and implementation issues and considerations relating to the use of financial assurances for mitigation project success, and describes and compares key features of alternative assurance instruments, including letters of credit, performance bonds, cash-in-escrow, casualty insurance, legislative appropriations, or other appropriate instruments. The information contained herein is intended to serve as a reference resource for Corps regulators involved with establishing and overseeing financial assurances for compensatory mitigation projects pursuant to the federal rules cited above.

Financial assurance for mitigation project success, also known as short-term financial assurances, can be defined generally as a mechanism that ensures that a sufficient amount of money will be available for use to complete or replace a mitigation provider's obligations to implement a required mitigation project and meet specified ecological performance standards in the event that the mitigation provider proves unable or unwilling to meet those obligations. They are distinct from financial resources set aside for the long-term management of the compensation site, commonly referred to as long-term stewardship funds (see below). Short-term financial assurances can be provided by third-party institutions, such as a surety (bonding) companies, insurance companies, banks and other financial institutions that agree to hold themselves financially liable for the failure of a responsible party to perform compensatory mitigation obligations.

The purpose of requiring short-term financial assurance in the mitigation context is to indemnify the public (through the Corps) against the potential loss of aquatic resources due to the failure of mitigation providers to perform their compensatory mitigation obligations. Mitigation project failure is always a possibility. Mitigation projects are generally complex and the final outcomes are uncertain even when mitigation providers fully implement approved mitigation plans and diligently apply adaptive management and corrective measures as problems are encountered. Mitigation providers might also become unable to successfully complete mitigation projects because of financial difficulties, which in the extreme could cause a mitigation provider to enter into bankruptcy or dissolution. Financial assurances for mitigation project success are meant to counter these risks.[1]

When mitigation projects are constructed, the required performance standards have been met, and the period of monitoring and maintenance (the performance period) is successfully completed, then any remaining

[1] The risk of project failure can also be managed through other mechanisms that are beyond the scope of this paper including mitigation project site selection, ecological performance standards, and the use of credit release schedules.

financial assurances posted to ensure mitigation success can be released. However, mitigation providers are also required to provide for the long-term protection and long-term management of compensatory mitigation projects. Financial resources are typically associated with both activities, commonly referred to as long-term stewardship funds. Long-term protection is provided through conservation easements or other suitable mechanisms and may entail protection of the mitigation site from encroachment. Typically resources are allocated to allow for monitoring of the protection of the site. Similarly, long-term management activities typically begin after performance standards have been achieved and the project has been closed (i.e., the Corps has made a written determination that the mitigation project has satisfied its performance standards and no further performance monitoring is required.) Long-term management is generally focused on maintaining the mitigation project as a well-functioning aquatic resource and ensuring the integrity of the site. Long-term management may include active management measures such as posting property boundaries, repair and replacement of fencing, prescribed burning, and control of invasive species. Both long-term protection and long-term management of the mitigation project may necessitate the mitigation provider to establish funding mechanisms that provide the landowner (or some other entity that is charged with maintaining the site) with the resources needed for these activities. Site protection and long-term management activities are considered under the 2008 Mitigation Rule to be separate from financial assurances in the mitigation plan (see 33 CFR 332.4(c)(2) - (14) and the associated funding serves different purposes than financial assurances for mitigation project success, and are not addressed in this report. Separate papers addressing site protection and long-term management and associated funding are in preparation. All further references to financial assurances in this report deal with short-term financial assurances.

1.2 Background

Private entities and public agencies, including the Corps, routinely require financial assurances from the general contractors they hire for construction projects. Assurances are also regularly required of certain regulated entities pursuant to a variety of federal regulatory programs, including the owners of municipal landfills, waste treatment facilities, mining operations, nuclear power facilities, underground gasoline storage tanks, ships carrying oil and hazardous materials, and offshore oil and gas facilities. Of these federal assurance requirements, perhaps the most analogous to compensatory mitigation are those required for the reclamation of surface mines pursuant to the Surface Mine Control Reclamation Act, and for the closure of solid and hazardous waste treatment, storage, and disposal facilities under the Resource Conservation and Recovery Act.

Financial assurances were rarely required for compensatory mitigation projects until the widespread emergence of Corps-approved, commercial mitigation banks beginning in the mid-1990s. Before then, most compensatory mitigation was provided through permittee-responsible mitigation projects for which financial assurances were seldom required. When Corps regulators were faced with the first few proposed commercial mitigation banks seeking regulatory approval in the early 1990s they had to confront the issue of whether those banks could be allowed to sell credits before their mitigation projects were fully constructed and/or had achieved ecological success. That issue was important because the sponsors of the proposed banks argued that the commercial viability of those banks depended on their ability to generate revenue from credit sales before mitigation bank projects were demonstrated to be fully successful. The

bank sponsors were concerned that if they were not allowed to sell any credits before their mitigation projects met specified performance standards, the credit prices they would need to charge to ensure a competitive, risk-adjusted rate of return would be above that which permit recipients would be willing to pay. Corps regulators, on the other hand, were concerned about allowing such "early" credit sales, given the potential for the failure of mitigation bank projects. These competing concerns were reconciled by allowing those early commercial mitigation banks to engage in limited credit sales before mitigation obligations had been fully met in return for posting financial assurances for mitigation project success.

In subsequent years, as more commercial mitigation banks were proposed and approved, several states passed laws and promulgated regulations governing mitigation banking, and at least one Corps district (Chicago) issued mitigation banking guidelines that allowed for early credit sales when backed with financial assurances. Such provisions were also included in 1995 *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks* issued by the Corps and several federal resource agencies. In its 2001 evaluation of compensatory mitigation, the National Research Council suggested incorporation of financial assurances to guarantee that mitigation projects were initiated, completed, and managed, whether on the project site or at an alternate site[2]. In 2005, Corps Headquarters issued a regulatory guidance letter that provided general guidance for the use of financial assurances for compensatory mitigation projects when assurances were included as a permit condition[3]. Finally, the 2008 federal rulemaking for compensatory mitigation for losses of aquatic resources, which supersedes much of the earlier guidance, codified new directives for the use of financial assurances for mitigation project success, but did not provide specifics on the various types of financial assurance instruments.

Mitigation banks, ILF programs, and permittee-responsible mitigation projects are used by permit recipients to meet their compensatory mitigation obligations. In general, those mitigation banks that have been allowed to sell credits before mitigation obligations have been fully met have been required by the Corps to post financial assurances for mitigation project success. On the other hand, financial assurances have often not been required for many permittee-responsible mitigation projects. For many smaller permittee-responsible mitigation projects, it may be determined to be impractical to require conventional financial assurances, so alternative mechanisms may be used instead, such as permit special conditions requiring projects to be constructed and managed to meet performance standards, establishing a time frame for mitigation project compliance, and if unsuccessful, provision of replacement compensatory mitigation through the use of third party compensatory mitigation (mitigation bank or ILF programs). Enforcement actions have often been taken to ensure compliance with permit conditions relating to compensatory mitigation as well.

For some ILF programs, contingency funding is built into the advance credit prices charged or into compensatory mitigation project budgets as an alternative to more conventional types of financial assurances (e.g. letters of credit, performance bonds, cash in escrow, casualty insurance) used to ensure

[2] National Research Council (NRC). 2001. Compensating for Wetland Losses Under the Clean Water Act. National Academy Press (Washington, DC) pages 150-153

[3] Regulatory Guidance Letter 05-1. Guidance on Financial Assurances

compensatory mitigation performance.

In making any decision about financial assurance requirements consideration should be given to the preamble to the mitigation rule (pages 19638-9) which cautions that, "*Decisions regarding the appropriate type and amount of financial assurances should not be based solely on the size of the compensatory mitigation project, or whether it is a mitigation bank. The risk and uncertainty associated with a specific compensatory mitigation project should be considered.*" Financial assurances are an important mechanism for managing the risk of project failure, including failure to complete the project, to meet performance standards, or to maintain the mitigation project. Holding all forms of compensatory mitigation to equivalent standards, including financial assurances; helps to reduce uncertainty, including risk of project failure. Many permittees may conclude that utilizing a bank or ILF program is more efficient than developing a mitigation project that complies with all the same standards required of mitigation banks and ILF programs.

1.3 Report Organization

This report is organized as follows. Section 2 reviews key design and implementation for the use of financial assurances in the mitigation context. This review includes a description of the various alternative assurance instruments specifically mentioned in the mitigation rule. Section 3 provides a comparative review of key features of alternative assurance instruments, highlighting features that may be advantageous or potentially problematic for the Corps and mitigation providers. Section 4 provides concluding remarks on the challenge of implementing financial assurances for mitigation project success. Figures that illustrate the basics of how alternative assurance instruments work are provided in Appendix A. Headquarters USACE Office of Counsel's 2011 memo on financial assurances for compensatory mitigation is provided in Appendix B. Links to examples of some district template financial assurance instruments are provided in Appendix C.

2. Design and Implementation Issues

The goal of the federal regulations found at 33 CFR 332 is to ensure that compensatory mitigation projects offset the aquatic resource functions lost through permitting. There are a number of mechanisms used to better ensure compensatory mitigation project success, including strategic selection of compensatory mitigation project sites, use of financial assurances, ecological performance standards, monitoring attainment of performance standards, maintenance of projects, credit release schedules, adaptive management, and long-term management of mitigation projects. The role of financial assurances is to ensure that mitigation projects are successfully completed and meet their established performance standards. The federal mitigation rule speaks at some level to the applicability, timing and release, amount, and types of financial assurance instruments that may be used to assure the success of compensatory mitigation projects. What the rule says about these assurance design and implementation issues, and how different Corps districts have handled these issues in practice, are reviewed below.

2.1 Applicability

The mitigation rule says the following with respect to when financial assurances for mitigation success are applicable:

> "*The district engineer shall require sufficient financial assurances to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with applicable performance standards. In cases where an alternative mechanism is available to ensure a high level of confidence that the compensatory mitigation will be provided and maintained (e.g. a formal, documented commitment from a government agency or public authority) the district engineer may determine that financial assurances are not necessary for that compensatory mitigation project."* [33 CFR 332.3(n)(1)]

This rule language indicates that financial assurances are applicable whenever there is doubt about whether a mitigation project will be completed and meet specified performance standards. At the same time, it recognizes that there may be alternative means of ensuring mitigation success, and gives regulators discretion to decide when those alternatives are sufficient substitutes for financial assurances. The ways in which different districts have used this discretion with respect to different types of mitigation providers are outlined briefly below.

In general, Corps districts have required commercial mitigation banks to post financial assurances when those banks have been allowed to engage in limited credit sales prior to the achievement of specified performance standards at bank projects. In some cases, however, districts have delayed release of commercial mitigation bank credits until mitigation success has been achieved instead of requiring them to post financial assurances. Sometimes this alternative has been workable due to the particular circumstances of the mitigation project. For example, one mitigation bank sponsor in Idaho agreed to an arrangement whereby bank wetland restoration credits would not be released for sale until all performance standards were met, while bank credits generated from wetlands preserved at the bank site were released for sale when the bank instrument went into effect. In some districts financial assurances have not been required to guarantee mitigation bank construction, but credits are not released until the bank site begins to meet performance standards.

Approximately 25% of the approved mitigation banks nationally are "single-user" banks developed by state Departments of Transportation (DOTs) to fulfill their own compensatory mitigation needs (rather than to sell credits to others). Many state DOTs have track records of successful completion of compensatory mitigation and have not typically been required to post financial assurances. Other state or local government agencies may be required to provide financial assurances until they can demonstrate sustained performance. Some DOTs do not have the authority to secure conventional financial assurances. Where performance has been problematic, districts have required DOTs to provide financial assurances to guarantee project completion.

At least one district (Seattle) has established standards for determining whether an alternative to conventional financial assurances would be considered for government-sponsored compensatory mitigation projects. The governmental mitigation provider must:

- Demonstrate that a constitutional, statutory, or similar prohibition exists that precludes the future commitment of those appropriated funds;

- Be a public body, and either a political subdivision of the State of Washington or a political subdivision of a federally recognized tribe;
- Fund all its compensatory mitigation obligations solely through legislatively appropriated sources;
- Not rely on the expenditure of any mitigation credit sale revenue to fund any of the sponsor's responsibilities including establishment, management, and remedial action activities

Some ILF program sponsors, including non-governmental agencies, have suggested that consideration be given to a sponsor's extensive experience in restoration and protection of lands and financial resources in determining whether financial assurances are necessary. The argument is that consideration of those factors could lead to the conclusion that the likelihood of success is very high, and that if there is a problem with a particular project, then the program sponsor could be relied upon to correct the deficiency. Some ILF programs sponsored by state resource agencies have not been required to post short-term financial assurances. Instead, these state agencies have committed in writing to successful completion of ILF project mitigation. For example, the North Carolina Department of Environment and Natural Resources provided a formal commitment to the Corps guaranteeing completion of mitigation projects undertaken by the North Carolina Ecosystem Enhancement Program. Similar practices have not been approved for ILF programs sponsored by non-governmental agencies.

Some other ILF programs sponsored by non-governmental entities have not been required to post conventional financial assurances (e.g. performance bonds, letters of credit) for mitigation success. Instead, these programs have been required to build into credit fee rates a contingency charge intended to provide funds for correcting any deficiencies in mitigation project work. This practice is consistent with the mitigation rule, which states, *"For in-lieu fee programs…the cost per unit credit must include financial assurances that are necessary to ensure successful completion of in-lieu fee projects."* [33CFR 332.8(m)(ii)]

The Virginia Aquatic Resources Trust Fund (VARTF), an ILF program sponsored by the Nature Conservancy of Virginia, uses another alternative to conventional financial assurances. The VARTF earmarks 20% of each mitigation project's estimated full cost of completion for implementing remedial or corrective measures if necessary during the construction and performance monitoring phases of the project. Once performance monitoring is complete and performance standards have been met (typically 10 years following construction), the earmarked funds are applied to long-term stewardship of the project site.

In the case of permittee-responsible mitigation, many districts have required financial assurances for relatively large mitigation projects. Financial assurances may not be required for smaller mitigation projects associated with either individual permits or general permits. These cases generally rely upon compliance with permit special conditions in lieu of financial assurances. For example, assurances may be handled through permit special conditions that indicate that if the project does not meet its performance standards within a specified time frame, the permittee would then have to secure replacement mitigation.

Another consideration for districts in determining when to require financial assurances for all forms of mitigation (mitigation banks, ILFs, and PRM) involves whether comparable requirements are already mandated by state or local regulations. States that typically require posting of financial assurances for mitigation projects include Florida, New Jersey, Ohio, Oregon, and West Virginia, among others. The Corps districts permitting activities in these states may review and determine whether the assurances posted to comply with state or local rules provide sufficient assurances for mitigation project success.

2.2 Coverage, Timing and Release

The issues of assurance coverage, timing, and release are closely interrelated. Assurance "coverage" relates to the specific mitigation responsibilities that are backed by an assurance instrument. For example, separate assurance instruments might be employed to first assure project construction and then assure project success in accordance with performance standards. And in the case of large mitigation bank projects that are implemented in phases, one or more assurances might be employed to cover each different project phase in succession. Assurance "timing" relates to the time at which assurances are posted, and assurance "release" relates to the time at which the Corps determines that the mitigation responsibilities covered by the assurance have been met, enabling the assurance mechanism to be terminated.

The mitigation rule speaks directly to assurance timing and release. With respect to timing in the case of permittee-responsible mitigation projects, the rule states, *"If financial assurances are required, the permit must include a special condition requiring the financial assurances to be in place before commencing the permitted activity."* [33 CFR 332.3(n)(3)]. In this case "commencing "means the discharge of dredge or placement of fill material in waters of the U.S. associated with the permitted impact. With respect to assurance timing for mitigation banks, the rule states, *"The mitigation banking instrument may allow for an initial debiting of a percentage of the total credits projected at mitigation bank maturity, provided the following conditions are satisfied: the mitigation banking instrument and mitigation bank plan have been approved, the mitigation bank site has been secured, appropriate financial assurances have been established…"* [33 CFR 332.8(m)(ii)].

With respect to assurance release, the rule states, *"Financial assurances shall be phased out once the compensatory mitigation project has been determined by the district engineer to be successful in accordance with its performance standards. The DA permit or instrument must clearly specify the conditions under which the financial assurances are to be released to the permittee, sponsor, and/or other financial assurance provider, including, as appropriate, linkage to achievement of performance standards, adaptive management, or compliance with special conditions."* [33 CFR 332.3(n)(4)].

The rule does not speak directly to assurance coverage, and there is considerable variation in the ways in which districts have approached coverage issues, particularly for mitigation banks. Different approaches to assurance coverage, timing, and release are outlined briefly below.

When financial assurances have been required for permittee-responsible mitigation projects, many districts have required a single financial assurance instrument to assure project construction and

successful attainment of performance standards. The dollar amount of the assurance initially established is then generally reduced in phases as project performance milestones are met, such as completion of construction, attainment of hydrology, and annual monitoring reports that show the project is trending toward successful attainment of performance standards. This approach to implementing financial assurances for permittee-responsible mitigation projects is used in the Buffalo, Norfolk, San Francisco, and Seattle districts. In the case of mitigation banks, several districts (including Baltimore, Chicago, Mobile, Omaha, Savannah, and in some cases, Seattle) have required bank sponsors to post a single financial assurance instrument to assure construction and success for the entire mitigation bank project. These assurances are then released in phases as performance milestones are reached. Release of assurances may actually mean termination of the existing assurance mechanism (such as a bond or letter of credit) and reissuance for a lower dollar amount.

Other districts have required two distinct assurances for mitigation bank projects, one to assure project construction (a "construction assurance") and the other, often called a "performance assurance" to guarantee that the project meets its performance standards during the required monitoring period (which typically ranges between 5 and 10 years). The construction assurance is released when construction has been completed and deemed successful by the interagency review team, often through review and approval of as-built drawings. The performance assurance is released in phases as ecological success milestones are reached. This is a common practice in the New Orleans, Seattle, and Baltimore districts.

A variant of this approach is used in the Buffalo and Norfolk Districts. Once a mitigation bank instrument has been finalized, these districts will release a limited share of bank credit for sale prior to project construction in return for a financial assurance that assures construction for only that part of the project that backs the released credits (rather than construction for the entire bank project). Once construction associated with the initial release of credits is complete, that assurance may be released to the sponsor. At that point the bank sponsor is required to post another financial assurance to assure successful monitoring and maintenance of the project during the monitoring period. This assurance is usually an escrow account funded by a portion of the revenues generated through credit sales. This assurance may be reduced in phases as monitoring reports show the project is trending toward attainment of performance standards. Recently, Norfolk District approved the use of other forms of financial assurances (casualty insurance, performance bond, letter of credit) as alternatives to an escrow account to guarantee successful project monitoring and maintenance. Norfolk District also requires bank sponsors to fund an escrow account that provides funding to address project deficiencies caused by catastrophic events such as hurricanes, droughts, fires, and other unexpected events.

Perhaps the most comprehensive approach to financial assurances for mitigation banks is employed by the Corps districts in California (Los Angeles, Sacramento, and San Francisco). These districts use a state-wide Mitigation Bank Enabling Instrument template that requires three different assurances over the life of a mitigation bank (as well an endowment for long-term site management). These include a construction assurance, a performance assurance, and an interim management assurance.

The construction assurance remains in effect only during bank site construction. The performance

assurance goes into effect when the first credit is sold and remains in effect until all performance standards are met. The interim management assurance goes into effect following construction and stays in force until all performance standards are met and after the first anniversary of the full funding of the endowment for long-term site management.

2.3 Amount

Among the most challenging aspects of implementing financial assurances for mitigation success is setting the dollar amount. With respect to this issue the mitigation rule states,

> *"The amount of the required financial assurances must be determined by the district engineer, in consultation with the project sponsor, and must be based on the size and complexity of the compensatory mitigation project, the degree of completion at the time of project approval, the likelihood of success, the past performance of the project sponsor, and any other factors the district engineer deems appropriate … The rationale for determining the amount of the required financial assurances must be documented in the administrative record for either the DA permit or the instrument. In determining the assurance amount, the district engineer shall consider the cost of providing replacement mitigation, including costs for land acquisition, planning and engineering, legal fees, mobilization, construction, and monitoring."* [33 CFR 332.3(n)(2)]

In order to ensure that sufficient funds are available to remediate or replace a failed mitigation project, the assurance amount should reflect all possible component costs of remediation or replacement, including possible contingencies. Component costs can include costs for land purchase and surveys; project planning, design and engineering; site construction and planting; monitoring and maintenance; remedial work and other contingencies, and legal and administrative tasks. These component costs can be further divided into costs for specific tasks; for example, construction could include earthwork, sediment and erosion controls, and installation of water control structures among other tasks.

Not all of the component costs listed above might be applicable in every case. Land cost, which is often the single largest mitigation project cost component in many areas of the country, may or may not be relevant for determining assurance amounts. Determining whether land costs are relevant depends on whether or not it is believed, a priori, that the mitigation project in question could and should be successfully completed in the event that the mitigation sponsor was unable to meet its mitigation obligations. If it is believed that mitigation project remediation would be desirable and likely to be successful (e.g., the mitigation site is an excellent candidate for a successful restoration project), then there would be no need to include component costs for land purchase when setting assurance amounts.

Alternatively, if there is uncertainty surrounding the possibility or benefits of remediating a failed mitigation project, then assurance amounts should be based on the cost of completing a separate mitigation project at another location. Assurance amounts based on such off-site replacement would need to include component costs for land purchase.

In general, remediation of a failed mitigation project might be deemed a priori to be desirable and likely to succeed if all of the following criteria were met:

- The mitigation project site is in a favorable location—that is, the site has a high probability of providing the desired resource type and current and projected uses of adjacent lands would not threaten the sustainability of the mitigation project, and long-term protection of the project site is secured.
- There is a high likelihood that mitigation project remediation would succeed in achieving mitigation performance standards and provide the project's intended functions and services.
- An independent third-party can be secured that is willing and able to use the assurance monies to remediate a failed mitigation project, and that party's access to the mitigation site for remediation work and monitoring and maintenance is assured.

Generally, the mitigation provider is expected to provide the Corps with estimates of the cost of the sponsor's mitigation project, itemized by project task, for purposes of establishing financial assurance amounts. Some districts have required mitigation providers to provide cost estimates developed by independent sources or contractors. Other sources of cost data that may be useful for preparing a mitigation project cost estimate or for validating the accuracy of an estimate provided by a mitigation provider include:

- Corps in-house engineering costs estimates.
- Independent cost estimates for similar mitigation projects in the area.
- Publicly-available bid data for similar projects included in proposals for mitigation work, such as data available online from the North Carolina Division of Mitigation Services (http://deq.nc.gov/about/divisions/mitigation-services).
- Cost estimates from proprietary software such as the Property Analysis Record developed by the Center for Natural Lands Management.

Consideration should be given to several factors when developing or reviewing project cost estimates, including:

1. Quality of the source data (is it from a reliable source and current?);
2. Completeness (are costs for all reasonable and expected project elements included in the estimate?);
3. Potential for escalating costs over time (does the estimate include an adjustment for inflation or increasing component costs?), and;
4. Potential for project failure (what is the mitigation provider's previous experience and record in providing compensatory mitigation?).

If the assurance mechanism is expected to last 5 or more years, consideration may be given to requiring an annual adjustment for inflation over the life of the assurance. The rate of inflation used may be subject to discussion. A number of districts have used the Consumer Price Index for their area to estimate the rate of inflation.

The proposed assurance amount should include sufficient resources for the beneficiary of the assurance to develop a plan-of-action (if necessary), to implement the remedial work, and to cover the administrative costs of receiving and applying those funds to appropriate remediation activities. Although it may be difficult to predict in advance the cost of administration of these funds, at least one assurance provider (National Fish and Wildlife Foundation) recommends allocating 10% above and beyond the projected cost of remediation.

Another alternative for costing assurances to provide replacement mitigation for a failed mitigation project involves basing costs on credit prices of Corps-approved mitigation banks and ILF programs in the same service area. Such banks or ILF programs provide a ready supply of mitigation credits that could be purchased to replace a failed mitigation project, and the credit prices they charge could be used to establish required financial assurance amounts. This obviates the challenge of developing cost estimates for the purpose of setting assurance amounts, as well as the need to secure a third-party that is willing and able to use assurance monies to remediate a failed mitigation project or provide a replacement project. This approach to setting financial assurance amounts has been employed by some districts where mitigation banks and ILF programs are located. One potential concern with this approach is that the credit prices charged by mitigation banks may be higher than the actual costs of corrective action on a failed or non-performing mitigation project. This is because bank credit prices reflect not only the costs of producing the mitigation including securing a land interest but also a competitive, risk-adjusted rate of return to bank owners. Although the costs may be higher than most corrective actions, purchasing credits from a mitigation bank may be one appropriate corrective action that the Corps could take to address a failed mitigation project.

2.4 Claims & Performance

The term "claim" refers to calling-in a financial assurance when the Corps determines that a mitigation provider has defaulted on the provider's mitigation obligations. The term "performance" relates to use of a financial assurance to ensure remediation or replacement of a failed mitigation project.

With respect to assurance claims that involve the transfer of assurance monies, the rule states,

> "*Financial assurances shall be payable at the discretion of the district engineer to his designee or to a standby trust agreement. When a standby trust is used (e.g. with performance bonds or letters of credit) all amounts paid by the financial assurance provider shall be deposited directly into the standby trust fund for distribution by the trustee in accordance with the district engineer's instructions."* [33 CFR 332.3(n)(6)].

In addition,

> "*The compensatory mitigation project must comply with all applicable federal, state, and local laws. The DA permit, mitigation banking instrument, or in-lieu fee program must not require participation by the Corps or any other federal agency in project management,*

> *including receipt or management of financial assurances or long-term financing mechanisms, except as determined by the Corps or other agency to be consistent with its statutory authority, mission, and priorities."* [33 CFR 332.3(o)]

The above rule language is meant to ensure that the Corps does not participate in any management of mitigation projects, including receiving or managing financial assurance funds. The prohibition on Corps receipt and management of assurance monies stems from statutory restrictions imposed by the Miscellaneous Receipts Statute [31 USC 3302(b)], which requires that funds obtained by any federal agency that does not have statutory authority to collect or use those funds must be deposited in the U.S. Treasury. Congress has not given the Corps regulatory program explicit authority to collect or use mitigation assurance funds. This statutory restriction can be addressed either by ensuring that financial assurance payouts are made payable to a standby trust or to a third-party that is acceptable to the Corps who agrees to complete the project or provide alternative mitigation.

In 2011, Corps Headquarters Office of Counsel provided additional clarification on what role the Corps should play in administering the financial assurances funds (see Appendix B). Office of Counsel cautioned that even if financial assurance funds are held by a third party, the Corps could be viewed as being in "constructive receipt" of the funds if the Corps plays too great a role in directing the use of those funds.

One mechanism identified for avoiding constructive receipt is through a contingency mechanism in the mitigation plan, permit, financial assurance document, or bank instrument that indicates how compensatory mitigation requirements would be met if a claim on the financial assurance becomes necessary. In the event of a claim, it would be the responsibility of the entity receiving the funds to develop a proposal for accomplishing the mitigation project goals. The Corps would have the ability to review and approve the plan but would not have control over the funds obtained through an assurance claim, which would be used by the recipient to fulfill the mitigation obligations of the mitigation provider. Other tools and strategies can also be implemented to limit the Corps control of the funds and state agencies may have greater flexibility in directing how the funds are used and can be an important partner for the Corps.

A standby trust is an agreement between a neutral third party, such as a financial or legal institution (the trustee), and a mitigation provider whereby the trustee agrees to hold any money collected when a claim has been made on a financial assurance, and then disperse that money to implement a plan approved by the District Engineer. Standby trusts may be established at the time of bank approval or later. Standby trusts may be useful when the financial assurance instruments used to assure mitigation obligations do not directly name a designee acceptable to the Corps as the beneficiary of monetary claims. Any assurance monies deposited in a standby trust will remain secure until the Corps can approve a designee to receive the funds and develop and implement a proposal for completing the compensatory mitigation or provide replacement mitigation. The holder of the trust is under no obligation to find a beneficiary. It is the Corps responsibility to identify a willing beneficiary to implement remedial action. It may be preferable to address these issues prior to bank approval where the banker can work to identify an appropriate beneficiary in advance.

An appropriate beneficiary of a financial assurance or a standby trust should have the experience and capability to complete the compensatory mitigation obligation. When deemed applicable, a standby trust could be established by a mitigation provider at the same time that the sponsor established the required financial assurance; the trust would remain dormant until a claim on assurance funds was made. The mitigation provider is required to pay an annual premium to maintain the standby trust. Standby trusts have been used with compensatory mitigation projects in Florida, Virginia, and Washington. Care must be exercised to ensure that the standby trust is structured in a way that avoids the appearance of constructive receipt.

Corps districts have approved a number of different entities as beneficiaries of the financial assurances who would use those assurance funds to ensure performance in the event of default by mitigation providers. Beneficiaries have included non- governmental resource conservation organizations, state, county and municipal resource agencies, and quasi-state agencies such as soil and water conservation districts. In some Corps districts, the conservation easement holder for a mitigation project may be named as the beneficiary of financial assurances for that project. In several districts, approved ILF programs and mitigation banks have been identified as acceptable beneficiaries of financial assurances.

It is important to note that some assurance instruments promise performance of the mitigation sponsor's obligations by the assuring entity rather than simply payment of funds for that purpose. That feature of assurance instruments is considered in Section 3.

2.5 Instruments

With respect to the different types of financial assurance instruments (sometimes referred to as assurance "forms") that can be used to assure mitigation obligations, the mitigation rules states,

> *"…Financial assurances may be in the form of performance bonds, escrow accounts, casualty insurance, letters of credit, legislative appropriation for government sponsored projects, or other appropriate instruments, subject to the approval of the district engineer…"* [33 CFR 332.3(n)(2)]

This rule language gives the District Engineer flexibility in the review and approval of financial assurance instruments used to assure successful compensatory mitigation, including the potential to allow combinations of different instruments to fulfill a responsible party's assurance requirements[4].

Under the mitigation rule, notification of the Corps is required at least 120 days prior to the termination or revocation of the financial assurance (33 CFR 332.3(n)(5)).

Table 1 presents a basic description of alternative assurance instruments. Figures that illustrate the basics of how they work are presented in Appendix A. The narrative that follows briefly reviews how these instruments can be set up to work in the mitigation context in compliance with the federal rule on

[4] Another important feature is the requirement to notify the district at least 120 days prior to the revocation or termination of financial assurance instruments (33 CFR 332.3(n)(5).

compensatory mitigation. A comparative review of important features of these assurance instruments is provided in Section 3.

Table 1. Overview of Alternative Financial Assurance Instruments

Instrument	Use to Assure Compensatory Mitigation Obligations
Letter of Credit	A letter of credit is a document issued by a financial institution (the issuer) on behalf of a mitigation provider (the account party) that provides for payment of the account party's obligations to another party (or beneficiary) designated by the Corps who is willing to accept responsibility for completing or replacing the mitigation project. Payment is assured up to a specified dollar amount during a specified period of time (typically no more than one year). If the Corps determines that the account party has failed to fulfill its obligations referenced in the letter, the Corps can demand payment to the beneficiary of all or part of the dollar amount specified in the letter to complete or replace the mitigation project. When the beneficiary draws on the money, the account party then owes that amount to the issuer according to the terms of a loan agreement between the issuer and the account party established to secure the letter. These loan agreements often require the account party to post collateral with the issuer (e.g., maintain a certain cash balance at the financial institution).
Performance Bond	A performance bond is an assurance contract with a specified dollar limit (penal sum) for a specified period of time whereby a bonding company (the surety) assumes the obligations of a mitigation provider (the principal) for the benefit of the Corps (the obligee) in the event that the principal fails to fulfill those obligations. The surety may fulfill the principal's obligations either by performing those obligations up to the limit of the penal sum, or by paying an amount up to the penal sum (less any costs already incurred by the surety) to a willing party designated by the Corps, who would develop a proposal to fulfill the mitigation obligations. . To secure a performance bond, the principal must enter into an indemnity agreement with the surety that requires the principal to reimburse the surety for any loss the surety may incur under the performance bond, and such agreements often require the principal to post collateral with the surety. The indemnity agreements can put at risk the personal assets of mitigation providers and their investors.
Cash in Escrow	An escrow is an agreement between a mitigation provider (the grantor) and the escrow agent to transfer ownership of cash to a beneficiary (grantee) approved by the Corps if the mitigation provider fails to meet its obligations specified in the agreement. The escrow agent is a neutral third party such as a law firm or financial institution (the depositary) which receives and holds the money and assures its transfer to the grantee if the grantor fails to fulfill its obligations. Prior to a claim, legal title to the money in escrow remains with the grantor; however, after the money has been transferred to the depositary, the cash cannot be returned to the grantor until the Corps notifies the depositary that the grantee has fulfilled its obligations.

Table 1. Overview of Alternative Financial Assurance Instruments	
Use to Assure Compensatory Mitigation Obligations	
Casualty Insurance	Casualty insurance is a contract between a mitigation provider (the insured) and an insurance company (the insurer) for claims against the policy made by the Corps (the regulatory body) up to a specified dollar limit (limit of liability) for a specified period of time. The insurer agrees to fulfill the obligations of the insured in the event that the Corps makes a claim on the policy after the Corps has notified the insurer that the insured has not met its obligations. The insurer may satisfy the claim by fulfilling the obligations of the insured or by cash payment (up to the limit of liability) to a Corps designee. The insured is required to repay to the insurer any insurer costs that result from claim up to a specific deductible amount. If the insured is unable to do so, then the insurance company would incur those costs.
Legislative Appropriations	Legislative appropriations are a government appropriation of funds to guarantee that the mitigation responsibilities of a government agency such as a Department of Transportation are met for a specific period of time. This appropriation may be a line item in a government budget, such as a capital improvement budget. Should the Corps determine that the agency has defaulted on its mitigation obligations the agency must provide a plan to fulfill its obligations or provide alternative mitigation acceptable to the Corps utilizing the appropriated funds.

2.5.1 Letter of Credit

In the mitigation context, a letter of credit is an agreement between a financial institution such as a bank (the issuer) and a mitigation provider (the account party) whereby the issuer agrees to provide cash for the benefit of the Corps or its designee (the beneficiary) if the Corps determines that the mitigation provider has not fulfilled its mitigation obligation, which is the condition for payment that is directly referenced in the letter (see Appendix A, Figure 1). Essentially, the issuer extends its credit to cover the mitigation provider's obligations. The letter assures payment for the mitigation provider's unmet mitigation obligation up to a specified dollar amount during a specified period of time.

To make a claim, the Corps must present to the issuer the letter of credit along with documentation of mitigation project failure and an estimate of the amount of assurance funds needed to repair or replace the project. Since the Corps does not have the authority to directly collect and use assurance payouts, the letter should do one of the following :1) name as beneficiary a willing party that is designated by the Corps, 2) name the Corps as the beneficiary for the purpose of making the default determination and allow the Corps to at that time identify an appropriate designee to receive the funds and develop plans for addressing the default [5]or 3) identify a state or local entity that will nominate a suitable party to receive the funds to implement plans to address the default.

Most letters of credit are issued for no more than one year terms, but in some states, such as Louisiana, letters may be issued for 1, 3, or even 5 year terms. , Letters of credit may be set up to be "evergreen,"

[5] This approach is used in South Pacific Division and in New Orleans and Wilmington Districts.

meaning they can be automatically extended for another term if necessary. But even with an evergreen letter of credit, the issuer always has the option not to renew the letter of credit at the end of the specified term. Such letters should be "irrevocable" (that is, it cannot be revoked during its term without the agreement of the beneficiary) to ensure that the bank will honor all claims by the Corps or its designee that occur during the letter term.

2.5.2 Performance Bond

In the mitigation context, a performance bond is an agreement between an insurance or bonding company (the surety) and a mitigation provider (the principal) whereby the surety agrees to fulfill the principal's mitigation obligation to the Corps (the obligee) if the principal has failed to meet that obligation, which is the condition for surety liability directly referenced in the bond (see Appendix A, Figure 2). As with a letter of credit, a performance bond specifies a dollar limit of liability for the surety (called the penal sum) and a term during which claims can be made against the bond. Typically, performance bonds are issued for 1-2 year terms, although the period of coverage can be longer. If a claim is presented on the bond during its term, the surety agrees to complete the mitigation provider's obligation either by performing that obligation itself (up the dollar limit of the penal sum) or by paying the penal sum (less any costs already incurred by the surety) to the obligee. If the Corps is the named obligee, then the bond should stipulate that any bond payouts be made payable to an established standby trust or to the Corps' designee. To the greatest extent practicable, the designee or a pool of potential designees should be identified at the time the bond is written.

2.5.3 Escrow Agreement

In the mitigation context, an escrow is an agreement between a mitigation provider (the grantor) and the escrow agent (depositary) to transfer ownership of up to a certain amount of cash from the mitigation provider to a designee of the Corps, if the Corps determines that the grantor has failed to meet its mitigation obligation (see Appendix A, Figure 3). The depositary is a neutral third party such as a law firm or financial institution who agrees to hold and transfer the funds per the terms of the agreement. Under an escrow agreement, the grantor deposits cash into an escrow account administered by the depositary. The agreement identifies non-compliance with the provider's mitigation obligation as the condition for transfer of cash held in escrow to the Corps' designee. To make a claim, the Corps must provide to the grantor documentation of mitigation project failure and an estimate of the amount of assurance funds needed to repair or replace the project.

The mitigation provider retains legal title to the cash in escrow (and may earn interest on the funds held that is invested in safe, liquid investments such as certificates of deposit). However, once the cash has been transferred to the depositary, the cash deposit (including principal and earnings) cannot be returned to the mitigation provider until the Corps notifies the depositary that the mitigation provider's obligation has been fulfilled.

An escrow agreement can be established for an indefinite period to accommodate the time necessary for successful completion of the mitigation obligation. Upon notification by the Corps that a mitigation provider is in default of its compensatory mitigation obligation, the escrow agent would transfer all or part of the funds held in escrow to a Corps designee that is identified either in the escrow agreement or

named at the time that the Corps demands payment. Alternatively, the escrow agreement could specify that claims will be made payable to a standby trust that is to be established by the depositary at the time a claim is made. Some Districts, such as New Orleans and Norfolk, have developed model escrow agreements. To the greatest extent practicable, the designee or a pool of potential designees eligible to accept the funds should be identified at the time the agreement is written to reduce the likelihood of having to identify a designee immediately prior to making a claim on the assurances.

2.5.4 Casualty Insurance

In the mitigation context, casualty insurance is an agreement between an insurance company (the insurer) and a mitigation provider (the insured) whereby the insurer agrees to fulfill the mitigation obligation of the insured, up to a specified dollar limit within a specified period of time, if the Corps determines that the mitigation provider has failed to meet its mitigation obligation (see Appendix A, Figure 4). An insurance product now in use by mitigation banks and permittee responsible mitigation (PRM) projects is a "claims made" policy that can be established to allow for claims over as much as a 10 year time period during which the mitigation bank or PRM project is required to achieve mitigation success. A claim can only be filed by the named regulatory body (Corps or identified state regulatory agency). The policy specifies that the insurer will satisfy a claim (up to the dollar limit of liability) by remediating the failed mitigation project, providing replacement mitigation, or making payment to a Corps designee. In general, there is no need for a pre-established standby trust or for parties to be designated in advance to accept the funds because the insurance company will proffer parties to execute the work for Corps approval.

2.5.5 Legislative Appropriations

There are a few cases where legislative appropriations (established by state or local governments) have been identified to guarantee successful completion of mitigation projects by government agencies as compensation for the permitted impacts of those agencies (for example, compensation associated with road projects). In those situations, the legislative body has appropriated specific funds to be set aside (for example, in a capital improvement budget) to guarantee fulfillment of mitigation obligations. Should the responsible government agency default on its obligations, the agency would either draw on the funds to correct mitigation project deficiencies or to provide alternative compensatory mitigation. This approach has been used by local governments and by a number of states, including Illinois, Maine, and Washington.

2.5.6 Alternative: Credit Sales Revenue to Escrow

In the immediate aftermath of the financial crises of 2007-2008, some mitigation bank sponsors reported difficulties finding financial institutions and sureties willing to issue letters of credit and performance bonds at affordable terms, as well as obtaining the funds necessary for establishing upfront cash escrows as assurances for mitigation obligations. One way around these difficulties that was used in at least one district (Norfolk), allowed for an initial release of a limited share of bank credits available for sale without the posting of financial assurances, but required establishing an escrow account prior to the initial release of credits. All the revenue from the sale of those credits would be placed in escrow until attainment of performance standards for a portion of the bank project equivalent in size to the initial credit release. This escrow option differed from the traditional use of escrow as financial assurance only in that there was no requirement for upfront posting of funds to escrow as a condition of credit release. This

alternative is no longer used as a financial assurance mechanism and it is not included in the comparative review of assurance instruments presented below.

3. Comparative Review of Assurance Instruments

The following narrative provides further elaboration of these features for different assurance instruments, and provides limited commentary on their possible implications for mitigation providers and the Corps. The review considers the following assurance features:

1. Availability and procurement, which relates to the general availability of the assurance instrument and the process and demands that a mitigation provider must meet in order to secure it.

2. Price and opportunity cost, which relates to the fee charged to a mitigation provider to secure the assurance instrument as well as the costs to the mitigation provider of tying-up money in the assurance instrument or in any collateral that may be required by the assurance provider.

3. Term and renewal, which relates to the period of assurance coverage provided by the assurance instrument as well as prospects for renewal if more time is needed.

4. Claims and performance, which relates to the process required for making and honoring a claim against an assurance instrument, and whether additional steps are needed to secure the repair or replacement of a failed mitigation project.

Table 2 (located at the end of this section) compares alternative financial assurance instruments in terms of these features.

3.1 Availability and Procurement

Letters of credit and performance bonds have been used fairly extensively to assure mitigation obligations. In certain years, however, some mitigation providers have had difficulty securing these instruments from financial institutions and sureties. For example, financial and market conditions during the economic downturn of 2007-2010 reduced the credit capacity of some financial institutions and sureties and reduced their willingness to extend credit generally.

Currently, letters of credit are fairly readily available to qualified parties, and because of national and international standards and practices (the Uniform Commercial Code and the ICC Uniform Customs and Practice No. 600), they can be issued with minimal customization or negotiation. Procuring a letter of credit is essentially a credit transaction that requires the mitigation provider to successfully complete a loan application with the issuing financial institution. In the event that a claim is made against a letter of credit during its term, the issuer of the letter of credit (the financial institution) pays the claim. The mitigation provider then owes the issuer the amount of the claim per the terms of the loan agreement.

There was a general retrenchment in the willingness of sureties to issue performance bonds during the early 2000's following a spike in surety industry losses experienced during previous years. Sureties may have become even more conservative during the economic downturn due to economic stress in the construction industry during that period, which is the main market for performance bonds.

A further issue that may limit the availability of performance bonds in the mitigation context relates to the possibly nebulous nature of what constitutes mitigation project success from the perspective of sureties. Sureties are accustomed to issuing bonds for construction projects that have a clear expected end result that can be readily evaluated against pre-established plans and specifications. Thus, when sureties are willing to issue bonds in the mitigation context, they may limit their bonding to assure mitigation project construction (e.g., grading and placement of water control structures to produce the needed topography and hydrology) while choosing not to bond the risk that mitigation success will not be achieved in accordance with performance standards.

Bond sureties view their underwriting as both a performance obligation and a credit transaction and emphasize careful selection of buyers based on an exhaustive review of the buyer's capacity and resources for completing its obligation, as well as the buyer's character. Procuring a performance bond as assurance for mitigation obligations can be a time-consuming and onerous process for mitigation providers. Once a bond "line of credit" is secured, approval of subsequent bonds may be easier to secure so long as the total dollar limit of bonding capacity remains below that threshold. Sureties will also require a mitigation provider to enter into an indemnity agreement whereby the provider agrees to reimburse the surety for any losses the surety incurs from claims made on the bond. Such indemnity agreements can potentially put at risk the personal assets of the mitigation provider as well as those of any investors in the provider's mitigation venture.

The availability of letters of credit and performance bonds in the mitigation context is related to any collateral requirements imposed on prospective buyers of these instruments. Generally, financial institutions will issue letters of credit and sureties will issue performance bonds for mitigation project success when the buyers agree to post collateral in amounts that approach the full face amount of a letter of credit or bond. Such collateral requirements greatly increase the cost of these assurance options, however, and thus limit their potential affordability for mitigation providers.

Escrows established to hold cash as assurance for mitigation obligations can be readily established at many legal and financial institutions. The main hurdle with establishing a cash escrow as assurance is the ability of mitigation providers to post the required cash at the same time that they need substantial funds to implement their mitigation projects.

At the end of 2014, casualty insurance policies had been approved and were in force for 32 operational mitigation banks and 7 PRM projects in 12 districts. They are generally used to secure both construction and performance (monitoring, maintenance, and remediation) obligations. This insurance product is being marketed to mitigation banks and permittee responsible mitigation nationwide and has been proposed as financial assurance for many prospective mitigation banks now under review in a number of additional districts. This product is available to any mitigation provider deemed qualified by the insurer. To obtain a policy, a mitigation provider must show the insurer that the provider has the capacity and resources to complete their mitigation obligations, though this qualification process is much less detailed and time-consuming than required of applicants for performance bonds. The policy also includes a deductible that requires the mitigation provider to reimburse the insurer for any costs the insurer incurs from claims up to a stated amount. The insurer recognizes that it will not recoup all of its claim costs, and

pools that risk across many premium-paying policyholders.

3.2 Price and Opportunity Cost

The prices charged for letters of credit can vary according to the credit-worthiness of buyers, but generally range from 1.5 - 3% of the specified annual credit limit. More importantly in terms of cost to mitigation providers, financial institutions often require buyers to post collateral for the credit line by, for example, maintaining a certain cash balance in an account at the issuing institution. Buyers with large balances in financial institutions (such as large timber and construction companies and large non-governmental organizations) may have little problem securing letters of credit. Smaller mitigation providers may have to post collateral to secure letters of credit. A letter of credit will typically reduce a mitigation provider's other available credit lines by a corresponding amount.

The prices charged for performance bonds can range from 1.5-5% of the bond dollar limit, where prices at the high end of the range are associated with bonds issued for activities that carry risks that are considered "substandard" (i.e., higher than normal) by the surety. As with issuers of letters of credit, sureties may require mitigation providers to post significant collateral with the surety as a condition for bond issuance.

The institution that serves as depositary for an escrow account will charge the mitigation provider a minimal annual fee, which is often paid from the interest earned on the deposited cash that is invested in safe, liquid investments such as certificates of deposit. The main cost of establishing an escrow account relates to the opportunity cost to the mitigation provider of tying-up significant sums of money in escrow at the same time that the provider needs substantial funds to implement the provider's mitigation project.

As noted above, letters of credit and performance bonds can impose significant costs on mitigation providers when, as a condition of issuance, providers are required to post collateral with the assurance provider. If collateral requirements were set at 100% of the face value of the letter of credit or bond, the opportunity cost of these assurance options would reach the level incurred by mitigation providers when they deposit cash in escrow as assurance for mitigation obligations, but sometimes collateral requirements are less than this. To the extent that some mitigation providers are unable to post the funds needed to establish an escrow or to meet any collateral requirements of a letter of credit or performance bond, these instruments are unworkable assurance options for those providers.

The casualty insurance policy marketed to mitigation providers was developed in recognition of potential limits on the availability and affordability of other assurance options for mitigation providers. To secure a policy, a mitigation provider must pay a one-time, non-refundable premium equal to about 2-4% of the sum of dollar limit of insurance for each year that is written into the policy. For example, consider a mitigation bank that is allowed to sell a limited share of bank credit capacity when a casualty insurance policy has been established to assure that the mitigation work associated with those credits is completed and meets performance standards within a ten-year monitoring and maintenance period. The premium for this policy would be based on a Corps-approved estimate of the amount of assurance dollars required for the release of credits during each year of the required monitoring and maintenance period. The insurer charges the full premium amount for the ten year period upfront, because once in

force the insurer cannot cancel the policy during its multi-year term.

The casualty insurance policy does not require a mitigation provider to post collateral as a condition of policy issuance. However, the insurance underwriter or broker does examine the mitigation provider's financial and technical qualifications as part of its risk assessment for prospective policy. For mitigation providers this is an important potential advantage of the insurance option over cash in escrow, as well as letters of credit and performance bonds when those instruments impose significant collateral requirements. Unlike those instruments, casualty insurance does not require a mitigation provider to tie-up large amounts of cash as assurance or collateral at the same time that the provider needs substantial resources to implement the mitigation project. This obviates the need for mitigation providers to secure additional funds for assurances or collateral, and then carry the cost of those funds until mitigation obligations are met. Casualty insurance has been used by many approved mitigation banks and a number of permittee-responsible mitigation projects, and proposed in connection with many more prospective mitigation banks, suggesting that it may be the most cost-effective available assurance option for some mitigation providers.

3.3 Term and Renewal

Letters of credit are generally issued for no more than a one-year term, and performance bonds are also generally issued for limited terms (1-2 years), although sureties have issued bonds for longer terms in the mitigation context. In the New Orleans district some mitigation providers have been able to secure letters of credit for 3 or even 5 year periods. Issuers generally offer prospects for the automatic renewal of letters of credit and performance bonds at the end of their terms, although they always have the option not to renew these instruments. Non-renewal of a letter of credit or performance bond could result from a negative judgment by an issuer about a mitigation provider's ability to complete the mitigation obligation, or from external factors that reduce the issuer's willingness to extend credit to certain types of projects generally.

The limited terms of letters and performance bonds, and the less-than-certain prospects for their renewal, can be problematic for mitigation providers and the Corps alike. Both parties must closely monitor mitigation progress against the remaining term of the assurance instrument, and the mitigation provider must move to secure renewal of the instrument when necessary. A renewal may be offered by an assuring entity but at a higher price or involving higher collateral. If a needed renewal were not forthcoming, a mitigation provider would then have to quickly secure a Corps-approved replacement assurance. If such replacement assurance were not quickly secured, the Corps might feel compelled to take regulatory enforcement action. In the case of a mitigation bank, such enforcement might involve suspension of further credit sales, reduction in the amount of credits awarded to the bank, or suspension or termination of the instrument.

Escrows and casualty insurance, on the other hand, do not involve complications relating to limited assurance terms and uncertain renewal prospects. The term of an escrow agreement can be set up to coincide with the time period required for mitigation success set forth in a permit or mitigation bank instrument, or could be established for an indefinite period to accommodate the amount of time needed to successfully complete a mitigation project. Similarly, casualty insurance provides coverage for up to 10

years which is often equivalent to the full term over which a mitigation bank is required to achieve mitigation success in accordance with performance standards. The extended period of coverage provided by escrows and casualty insurance is an important advantage of these assurance options from the perspectives of mitigation providers as well as the Corps.

3.4 Claims and Performance

In the case of escrows and letters of credit, claims made against the assurance instruments will be honored if received within the specified term as long as the Corps provides notification indicating that the mitigation provider is in default of its mitigation obligation. That is, a depositary for an escrow account or an issuer of a letter of credit will not contest a claim that meets the stated conditions of the assurance instruments. Sureties for performance bonds, on the other hand, generally do have the ability to contest a claim against a bond, and may do so if they disagree with a Corps determination that a bonded mitigation obligation has not been met. From the Corps' perspective, the possibility that a surety will resist a bond claim is a potential drawback for the use of performance bonds to assure mitigation obligations. Casualty insurance is relatively new in the mitigation context and no claims have been made on policies so the actual treatment of claims is unknown. However, the presumption is that the insurer would honor legitimate claims following claims adjustment, but as with performance bonds, there is the potential for an insurance provider to dispute a claim.

Although escrows and letters of credit provide an assured source of funds when the Corps makes a claim against these instruments within the terms and stated conditions of the instruments, these funds provide the means to effect a remedy for a failed mitigation project, but not the remedy itself. An acceptable designee must be identified to receive and apply the funds to implement a remedy in the event of a claim. The Corps is charged with approving arrangements for an appropriate remedy, such as having the designee remediate the failed mitigation project or implement or secure replacement mitigation.

Unlike escrows and letters of credit, performance bonds promise the performance of mitigation obligations rather than simply cash payout. When a surety receives what it deems to be a valid claim against a bond, the surety will seek to fulfill the mitigation provider's obligation in the most cost- effective way for the surety. This could involve hiring contractors to remediate a failed mitigation project. Typically, monetary payment to a Corps designee or to a standby trust would be a last resort for a bond surety (and would be limited to the penal sum of the bond less any costs already incurred by the surety in trying to fulfill the mitigation obligation).

As noted above, a surety may resist a Corps determination that the mitigation provider is in default, or maintain that surety expenditures to remedy a failed mitigation project have been successful, even if the Corps does not agree. Such an impasse could lead to litigation or other enforcement actions. For that reason it is important to clearly identify in the instrument or mitigation work plan what constitutes successful performance.

Some districts have developed rigorous standards for surety bonds to address these concerns, but which may reduce the likelihood of mitigation providers being able to procure a performance bond. Other districts do not support use of performance bonds because of the potential challenge on whether a default has occurred, since a surety might challenge first and then provide performance or payment only

after an investigation of liability has been completed.

Districts have developed two strategies to minimize potential disputes with performance bond sureties: 1) Insist that the performance bond specify transfer of funds to a conservation entity to perform the work in accordance with a plan approved by the Corps; and 2) Clearly specify in the project's mitigation work plan what is meant by project success. However, a permittee may have difficulty finding a designee willing to commit in advance to mitigation work when the possible need and timing of that work are unknown.

The casualty insurance policy that is available to mitigation providers is a unique assurance mechanism in that it offers a claim service whereby the insurer will settle a claim in any manner deemed acceptable by the Corps (up to the dollar limit of insurance). The policy states that when presented with a claim by the Corps that includes documentation of mitigation default, the insurer will either: 1) work with the Corps to settle a claim to the full satisfaction of the Corps by a certain date agreed to by the Corps, or 2) pay to the Corps' designee a claim amount that the Corps determines is necessary to complete or replace the mitigation provider's compensatory mitigation obligation. It should be noted that it may be a challenge to identify a designee prior to or concurrent with any claim on an assurance. This assurance mechanism is a relatively new one and to date no claims have been made on any of the policies in force. It is not clear whether an insurer would or could dispute a claim.

The insurance option affords the Corps flexibility in ensuring the performance of mitigation obligations when the Corps determines that a mitigation provider has failed to meet its compensatory mitigation obligation. If the Corps deems the mitigation project is remediable, the Corps might invoke the first option by requiring the insurer to hire contractors to develop and implement a remediation plan. If, on the other hand, the Corps determines that the mitigation project could not be successfully remediated, the Corps could invoke the second option by requiring the insurer to propose an acceptable alternative mitigation plan such as purchasing credits at an approved mitigation bank or ILF program or identifying an alternate site and implementing replacement compensatory mitigation. From the Corps' perspective, the flexible claims service provided by casualty insurance may be advantageous since it can provide several different remedies for a failed mitigation project as well as the ability for the Corps to review and approve the form of that remedy.

At the same time, some districts have questioned whether these casualty insurance policies allow the Corps clear authority to approve a plan to correct a mitigation project deficiency. In some applications the policy, associated endorsements, notices and in some cases bank instruments have been modified to address this concern.

3.4.1 District Experiences with Assurance Claims

Based on the information on district experiences with financial assurances obtained for this report, it appears that there have been very few cases where an assurance claim was made because of non-compliance with compensatory mitigation obligations. A number of districts reported that mitigation providers, especially bank sponsors, worked to correct deficiencies on mitigation projects rather than face a claim on financial assurances, project suspension, or enforcement actions. Several experiences with claims and near-claims involving permittee- responsible mitigation projects and mitigation bank

projects are outlined briefly below.

In one case involving a permittee-responsible mitigation project for which a letter of credit (LOC) was posted as financial assurance, a claim was made on the LOC because the permittee proved unwilling to correct project deficiencies. Funds from the LOC were released to a state resource agency that was named as the LOC beneficiary; that state agency applied the assurance funds to bring the project into compliance.

In another case, a district attempted to draw funds from a LOC posted as project assurance because of non-compliance with a permittee-responsible mitigation project. When the district presented a copy of the LOC to the financial institution that issued it, the financial institution said that it would honor the assurance only if provided with the originally-issued LOC document (not a copy). The district could not locate the original LOC, however, and the result was that the claim was not honored and non-compliance issues were not resolved. This case highlights the need for districts or the named beneficiaries of LOC to maintain all original assurance documents, as well as to monitor them over time to ensure that their terms do not expire before any needed renewals or replacement assurance can be obtained.

In a case involving a permittee-responsible mitigation project that was assured with a performance bond, project deficiencies remained after the district had notified and given the permittee time to bring the project into compliance. At that point the district notified the permittee as well as the surety that had issued the bond. A meeting was held involving the district, the permittee, and the surety to review project deficiencies and possible corrective actions, at which the district informed the surety that a claim would be made on the bond if project deficiencies were not promptly corrected. In the aftermath of the meeting the permittee corrected all project deficiencies, obviating the need to make a claim on the bond.

In one case involving a problem with invasive vegetation at a bank project assured with funds in escrow, the bank sponsor requested a partial release of funds to address the problem. Upon district approval, escrow funds were released to the bank sponsor who used the funds to bring the invasive vegetation under control.

Another near-claim involved an LOC posted as an assurance for a mitigation bank project. Project deficiencies remained after the district had notified and given the sponsor time to correct them, and again remained when the district subsequently informed the sponsor that it would suspend credit sales if corrections were not made. At that point the district suspended credit sales at the bank and informed the bank sponsor that it would draw from the LOC if project deficiencies were not addressed. The sponsor subsequently corrected project deficiencies before a claim on the LOC was made.

This last example illustrates that the Corps has other options apart from financial assurances for enforcing mitigation performance and other obligations set out in mitigation banking and ILF program agreements. For example, the Corps can suspend or otherwise restrict credit sales, reduce the amount of credits awarded, and suspend or terminate the venture. Use of these enforcement options may be sufficient to compel compliance without the need to make a claim on financial assurances.

3.5 Security of Assuring Entities

Another relevant issue for establishing financial assurances involves the financial strength and stability of the assuring entities, which bears on their ability to provide payment or perform obligations when an assurance claim is made. Under the Miller Act, which requires performance bonds for federal construction contracts exceeding $100,000 in amount, bonds can be accepted only from sureties that are listed as qualified by the U.S. Treasury [6]. Although the Miller Act may not apply to performance bonds for mitigation projects required by federal permits, many districts will only accept bonds as assurances for such projects from sureties that are on the Treasury list and that are licensed to issue bonds in the state where the assurances are provided.

With respect to letters of credit, districts typically require that the issuing financial institution be federally regulated and insured, and rated investment grade or higher. In the case of the institutions that serve as depositaries for escrow accounts, districts often require that they be licensed, neutral third-parties that have no personal or professional ties to the relevant mitigation sponsor.

For insurance, the underwriter should be licensed in the state where the insured mitigation project is located. Further, several independent rating agencies provide ratings of the financial strength of insurance underwriters that can be used to assess the financial security of the insurer. These include A.M. Best, which provides an independent opinion of an insurer's financial strength and ability to meet its ongoing insurance policy and contract obligations. Other agencies that rate the ability of insurers to meet their policy obligations include Standard & Poor and Moody's Investor Services, among others. If an insurer has been rated by one or more of these agencies, the ratings should be available from the insurer's website and from the relevant insurance broker.

[6] A list of qualified sureties can be found in the U.S. Treasury Department's circular 570 found at http://www.fiscal.treasury.gov/fsreports/ref/suretyBnd/c570_a-z.htm

Table 2. Comparative Overview of Assurance Instrument Features

Instrument	Availability and Procurement	Price and Cost	Term and Renewal	Claims and Performance
Letter of Credit	Letters of credit (LOC) are issued by many financial institutions,. Procuring a LOC is a credit transaction that requires the mitigation provider (buyer) to complete a loan application process with the issuing financial institution. If a claim is made against a LOC, the buyer will owe the issuer the claim amount per the terms of a pre-established loan agreement.	Prices vary but generally are around 1.5-3% of the credit limit per year. Financial institutions often require buyers to post collateral by, for example, maintaining a certain cash balance in an account at the issuing institution. Procuring a LOC may also decrease by a corresponding amount any other credit lines that might be available to the buyer.	LOC are typically issued for no more than a one year term. An "evergreen" LOC provides for automatic renewal at the end of the term, but financial institutions have the option not to renew the instrument. Non-renewal could result from a negative judgment by financial institutions about a buyers' ability to complete its obligation, or from external factors that limit the willingness of financial institutions to extend credit generally.	LOC provide a guaranteed source of funds when the Corps determines that a mitigation sponsor is in default. The financial institution will not contest a claim against a LOC during the coverage period when provided with Corps documentation indicating default under the terms of the LOC and an estimate of the amount of assurance money needed to repair or replace a failed project. Any money drawn from a LOC must be made payable to a designee of the Corps or to a standby trust. LOC provide the funds to implement a solution to a failed mitigation project, but not the solution itself; the Corps is still faced with arranging for another entity to use the money to remediate the failed project or provide replacement mitigation.
Performance Bond	Bonds are issued by many insurance and bonding companies primarily for standard classes of business within the construction industry. Sureties appear to be less willing to bond mitigation projects, or may provide bonding for the construction phase of mitigation projects but not for mitigation success. Sureties emphasize careful selection of buyers based on an exhaustive review of buyers' capacity to complete the obligation, financial standing, and character. The buyer must enter into an indemnity agreement whereby it agrees to reimburse the surety for any loss the surety may incur under the bond; such indemnity agreements can reach down to the personal assets of the buyer and the buyer's investors.	Prices range from 1.5- 5% of the bond dollar limit (penal sum), and sureties often require a buyer to post liquid collateral with the surety.	Typically, bonds are issued for limited terms (1-2 years) with the potential for renewal. Renewals may not be forthcoming, however. Non-renewal of a bond could result from a negative judgment by the surety about the buyer's ability to complete its obligations, or from external factors that reduce the surety's willingness to bond certain types of projects.	When a claim is made, a surety will try to fulfill the buyer's obligation in the most cost-effective way for the surety; payout of part or all of the penal sum (less any costs already incurred by the surety) is a last resort. Payout must be made payable to a designee of the Corps or to a standby trust. Bond payouts provide the funds needed to implement a solution to a failed mitigation project, but the Corps must still arrange for another entity to use the funds to remediate the project or provide replacement mitigation. A surety may dispute a bond claim if the surety disagrees with a default judgment by the Corps.

Table 2. Comparative Overview of Assurance Instrument Features *(continued)*

Instrument	Availability and Procurement	Price and Cost	Term and Renewal	Claims and Performance
Cash in Escrow	Escrow accounts hold cash as assurance for performance of mitigation obligations and can be easily set-up at many law firms and financial institutions (the depositary). The main hurdle with establishing cash escrow as assurance in the mitigation context relates to the mitigation provider's ability to post the required cash in escrow at the same time that the mitigation provider must expend funds to implement the mitigation project.	The depositary will charge a minimal fee to the mitigation sponsor who secures the account. The main cost of establishing an escrow account relates to the opportunity cost to the mitigation sponsor of tying-up cash in escrow.	The term of an escrow account can be set up for an indefinite period to accommodate the amount of time necessary to successfully complete the mitigation project.	An escrow account provides a ready source of cash that is available to a designee of the Corps when demanded by the Corps. The depositary cannot contest a claim against an escrow account and will pay out all claims when provided with Corps documentation indicating default under the terms of the escrow agreement and an estimate of the amount of assurance money needed to repair or replace a failed project. One challenge is in finding a designee willing to take on the obligation to repair or replace a project. Draws on escrow provide the money to implement a solution to a failed mitigation project, but arrangements must be made for another entity to use the money to repair or replace the mitigation project.
Casualty Insurance	Casualty insurance to assure mitigation obligations had been approved and is in-force for many banks and PRM projects in 13 districts, and has been proposed for mitigation banks in development in several other districts.This product is available to any mitigation provider deemed qualified. To obtain a policy, mitigation providers must show the insurer that they have the capacity and financing to complete their obligations, The policy includes a deductible clause that requires the mitigation provider to reimburse the insurer for any costs that the insurer incurs up to the deductible amount.	A mitigation provider must pay a one-time, non-refundable premium of about 2 to 4% of the dollar limit of insurance written into the policy. The policy does not require the insured party to post collateral with the insurer. Prices vary with the size of the mitigation bank project and other underwriting considerations.	The policy period can be established to cover the time period over which a mitigation project is required to achieve success (e.g., the term of a mitigation bank as set forth in the banking instrument) up to 10 years. Once in force, the policy cannot be canceled within the policy period unless the Corps releases the insurer from coverage.	Claims against the policy can be made only by the identified regulatory body (Corps or state counterpart). The insurer will respond to a claim by either 1) working with the Corps to settle claim to the full satisfaction of the Corps (up to the limit of insurance), or; 2) pay to a Corps designee the claim amount that the Corps determines is necessary to meet the compensatory mitigation requirement (which could involve purchase of mitigation bank or ILF credits, as approved by the Corps).

4. Concluding Remarks

Implementing financial assurances for mitigation project success can be challenging and place demands on regulators that are outside their regular areas of practice. The information included herein is meant to provide regulators with a basic understanding of different assurance instruments and how they work, as well as key design and implementation issues and how those have been handled in practice by different Corps districts. This information is intended to provide a useful reference for regulators who face the task of implementing assurances.

Nevertheless, it is important to recognize that there are few hard and fast rules for implementing financial assurances in the mitigation context. The decision on when assurance is needed as well as decisions relating to what instrument is to be used and how it is to be structured involve judgment calls that must be made in consideration of all the other regulatory requirements imposed on a specific mitigation provider, as set out in the provider's permit or mitigation bank or ILF program instrument.

One important decision involves the choice of assurance instrument. As a general matter, it is the mitigation provider's responsibility to propose a financial assurance instrument. This proposal will be made in consideration of the availability, cost, and other terms of alternative assurance instruments and other factors specific to each mitigation provider. At the same time, individual Corps districts may hold preferences for using certain assurance instruments based on various factors, including issues relating to assurance term and renewal, ease of access to funds and performance considerations, as well as past district practices and experiences with alternative instruments. However, regulators should maintain at least some flexibility in the choice of assurance instrument, given that in some cases a district-preferred instrument may not be available or workable for a particular mitigation provider. In such cases, creativity may be necessary to fashion an assurance form that is both acceptable to the regulator and workable for the mitigation provider.

Setting the dollar amount of assurance is perhaps the most challenging task faced by regulators. The assurance amount should reflect all possible component costs of repairing or replacing a failed mitigation project under the worst case scenario (i.e. complete project failure). However, assurance amounts should not be set at amounts that are greater than that which could possibly be needed, as this could limit the availability or workability of assurance instruments for mitigation providers. That said, from the perspective of regulators, the simplest way to secure replacement mitigation for a failed mitigation project may be through the purchase of credits from approved mitigation banks or ILF programs in the same area, and when this option is workable, the credit prices they charge may provide a benchmark for setting assurance amounts.

When necessary, regulators should consult with and solicit the help of district staff with experience in establishing assurances for mitigation success. Regulators should also seek

review by district counsel before finalizing an assurance instrument in any particular case.

Finally, work to establish assurances in those cases where regulators deem them necessary should begin well before the finalization of a permit or mitigation bank or ILF program instrument. Given the many challenges of establishing assurances, work on this task should not wait until all other permit or instrument provisions have been fully addressed.

Appendix A:

Illustrations of Alternative Assurance Instruments

Figure 1 Letter of Credit with Standby Trust

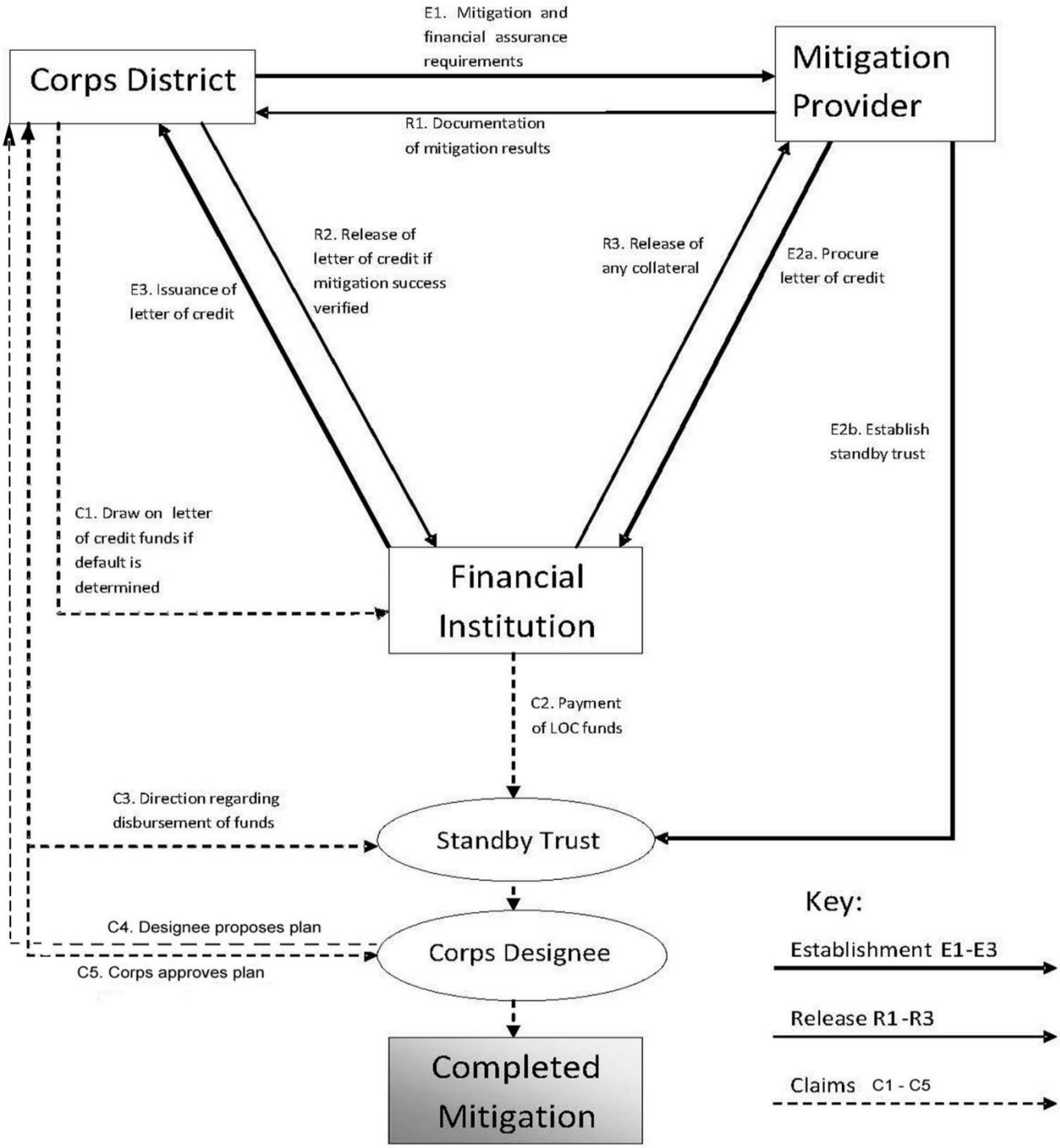


Figure 2 Performance Bond with Standby Trust

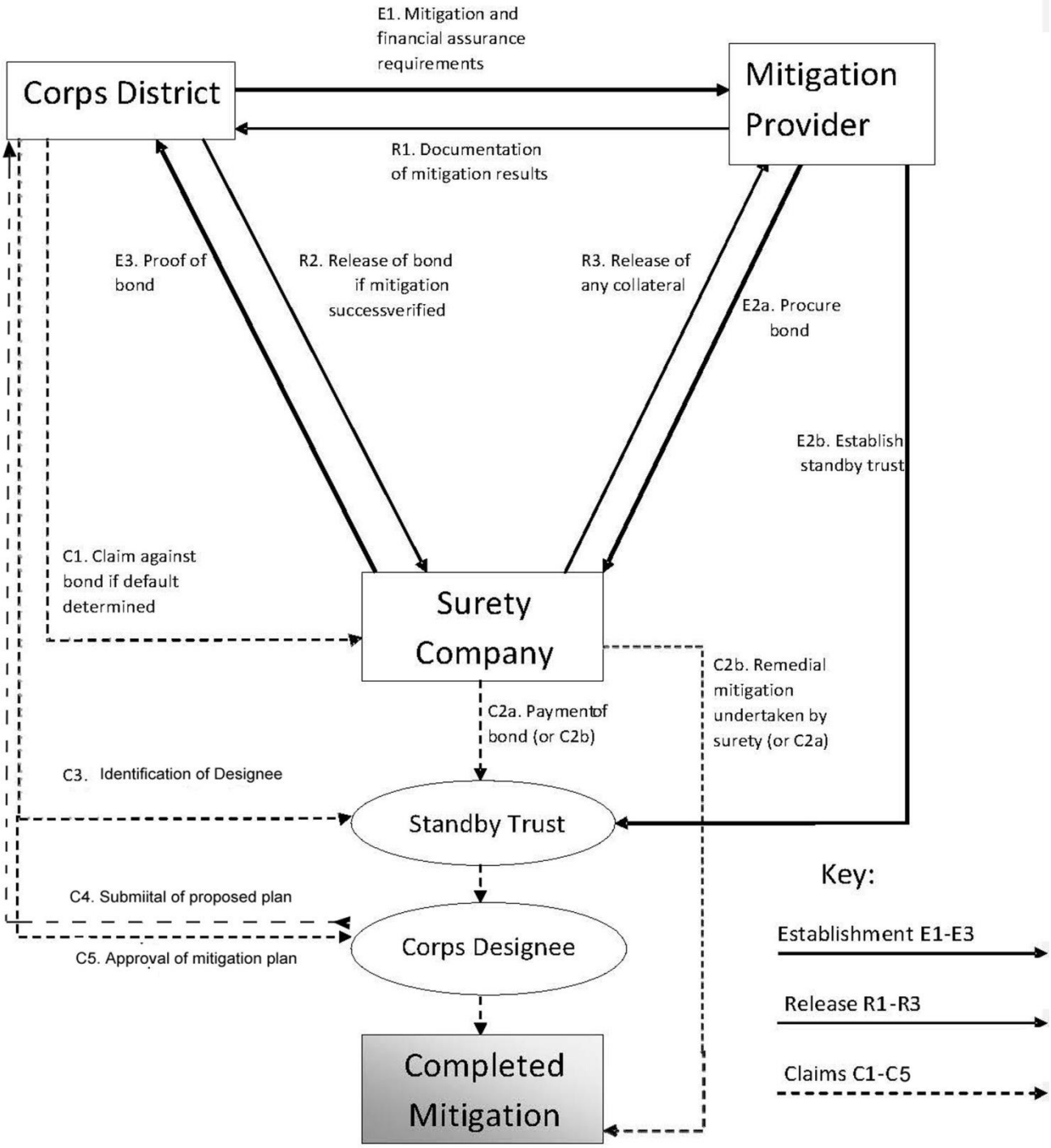


Figure 3 Cash in Escrow

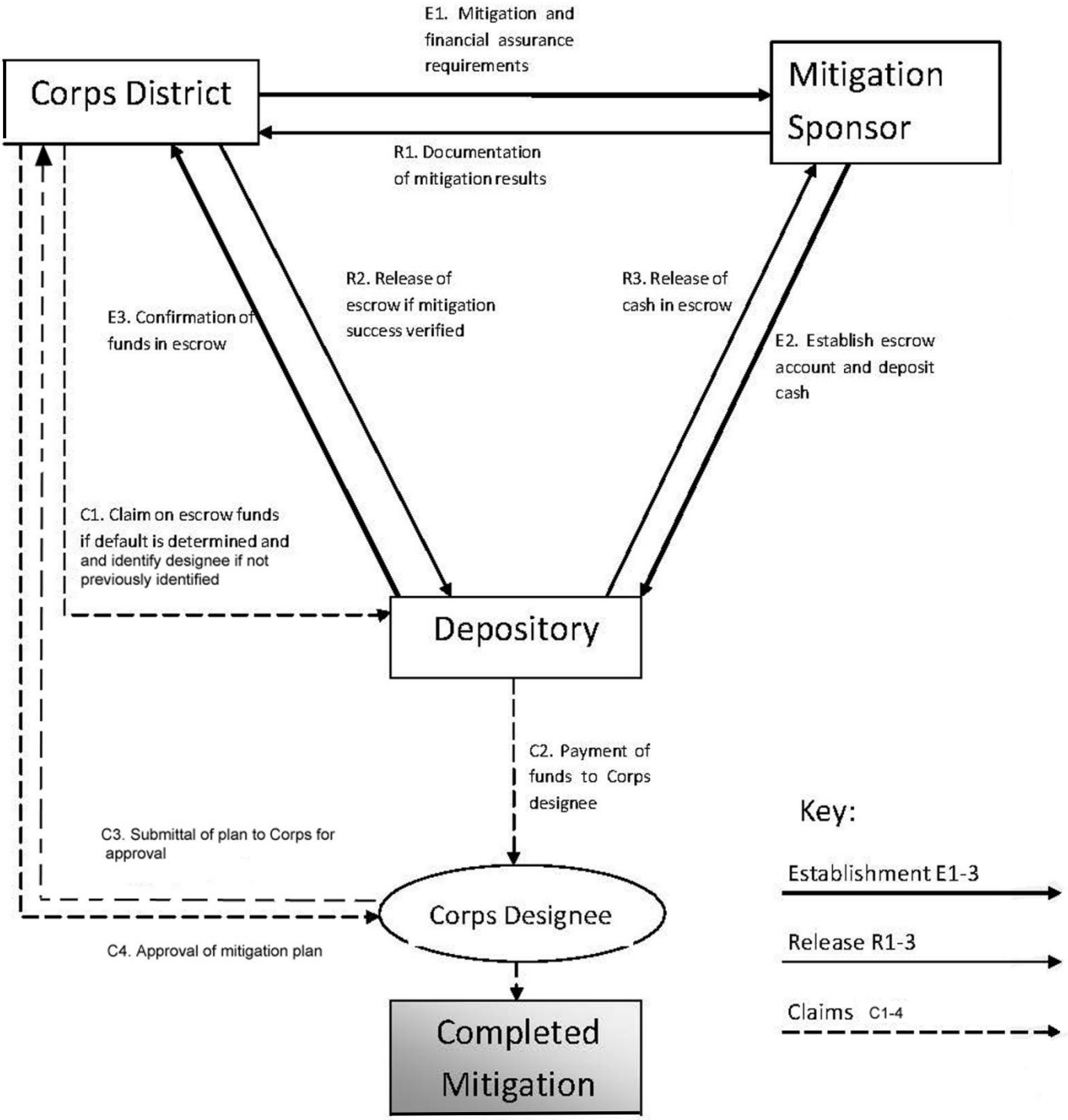
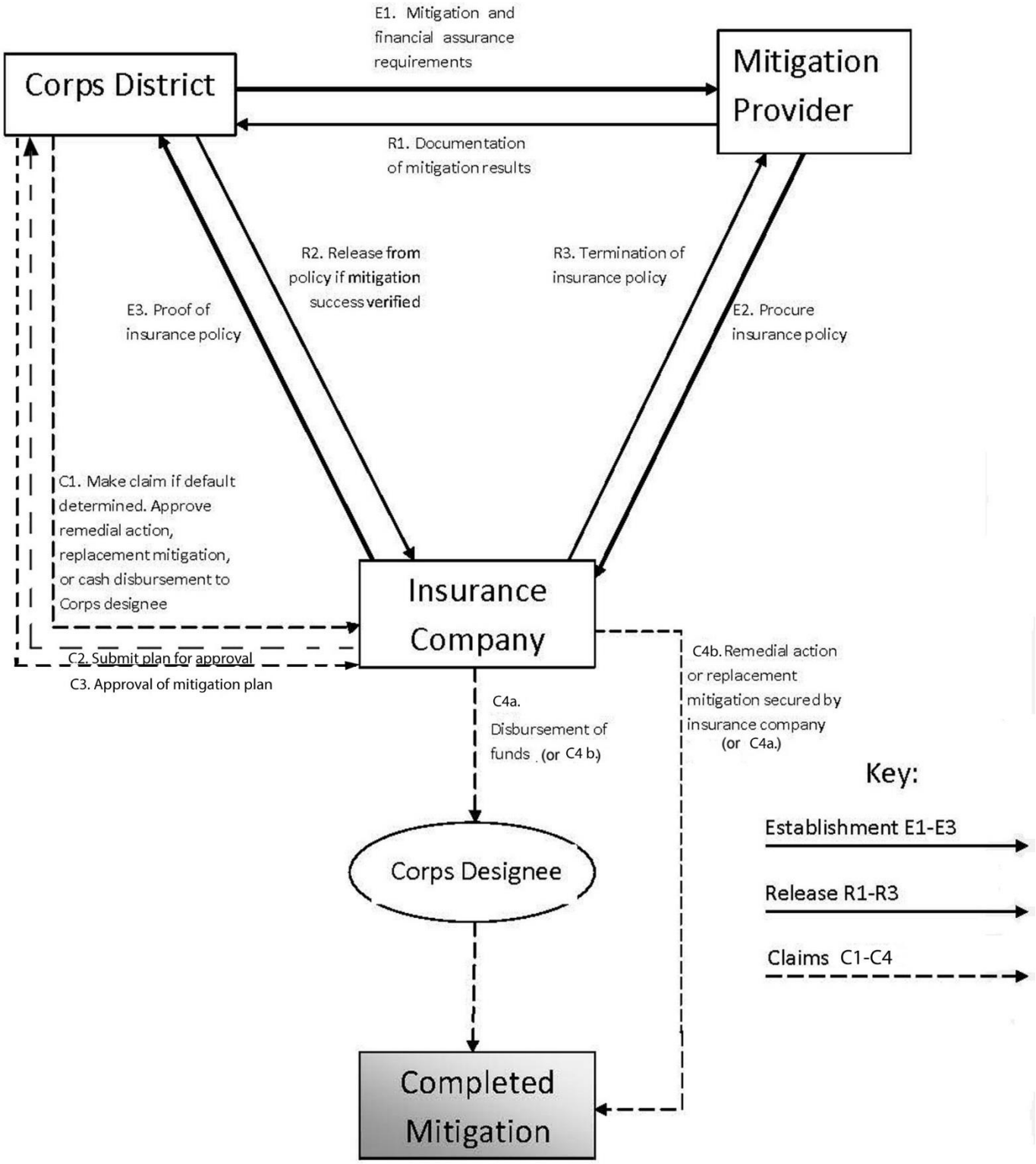


Figure 4 Casualty Insurance



Appendix B:

HQ USACE Office of Counsel Memo on Compensatory Mitigation Financial Assurances (2011)

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON DC 20314-1000

REPLY TO
ATTENTION OF

DEC 012011

CECC-E

MEMORANDUM FOR ALL DIVISION AND DISTRICT COUNSEL

RE: Financial Assurance Instruments for Compensatory Mitigation under the Corps Regulatory Program

1. The U.S. Army Corps of Engineers (Corps) often requires compensatory mitigation to offset environmental losses resulting from unavoidable impacts to waters of the United States authorized by Army permits under the Clean Water Act and Rivers and Harbors Act. See 33 CFR 332.3. In some instances, the District Engineer will determine that it is necessary to require financial assurances that are sufficient to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, as measured by applicable performance standards. The regulations that establish the requirement for financial assurances set forth a number of different financial assurance products that may be appropriate to satisfy this requirement, including "performance bonds, escrow accounts, casualty insurance, letters of credit, legislative appropriations for government sponsored projects, or other appropriate instruments." See 33 CFR 332.3(n)(2). It is permissible to use different financial assurances to cover different stages of mitigation construction so long that each financial assurance is of an adequate duration to ensure that the stage it covers was successful.

2. District Offices of Counsel should work with their Regulatory Division or Branch clients to review and negotiate the financial assurance instruments used to support mitigation projects. Counsel should work with the proponents of financial assurance products, whether it be a new form of assurance or a new issuer of a previously utilized assurance, in a timely manner in order to determine if they can negotiate acceptable terms. The different forms of financial assurance have different benefits and limitations, but all forms of financial assurance should be provided an equal opportunity for review and approval if terms can be negotiated that fulfill project-specific requirements. However, it is recognized that it may not always be possible to reach an agreement on terms that are acceptable to both the Corps and the financial assurance provider. The District Engineer retains authority to determine acceptable terms in each case.

3. Miscellaneous Receipts Statute (31 U.S.C. 3302(b)) Compliance

    a. Regardless of the form of financial assurance used, the financial assurance instrument must not provide that the Corps could be in actual or constructive receipt of the assurance funds. Even if the funds are held by a third party, the Corps is viewed as having constructively received those funds if the arrangement affords the Corps discretion to direct the use of those funds. For instance, assume that a financial assurance, settlement, or other arrangement

requires that funds be paid into an escrow account that is nominally managed by some third party (e.g., a bank). If the Corps retains discretion to directthe use of those funds, then the funds must be viewed as having been received by the United States, and as thus being subject to the deposit requirements of the Miscellaneous Receipts Statute.

b. The line is admittedly vague between (a) when the Corps is directing the use of funds held by a third party, in which case those funds must likely be deposited into the U.S. Treasury as miscellaneous receipts, and (b) when the Corps is simply giving its consent or approval to a proposed mitigation bank, permittee-responsible mitigation, or similar arrangement that is to be financed with funds provided under a financial assurance or similar arrangement. A useful, albeit informal, test for determining which end of the spectrum a proposed arrangement falls is as follows: is the Corps attempting to do indirectly through a third party that which it could not do itself? If so, then the Corps is likely exercising constructive control over the funds held by the third party, and this arrangement is likely improper.

c. One means for avoiding problems with constructive receipt is to incorporate contingencies into the financial assurance documents or mitigation banking instrument that address how the mitigation requirements should be met if it becomes necessary to draw upon the financial assurance. Under this model, the documents establishing the financial assurance product would reference the approved mitigation plan associated with the Department of the Army permit, mitigation banking instrument, or approved in-lieu fee project and identify entities, such as non-profits, state agencies, or private mitigation providers, that would be eligible under the terms of the financial assurance product to accept the financial assurance and complete the approved mitigation project. In the event that it would not be possible or practicable to undertake or complete the approved mitigation project, then the financial assurance product would set forth in a general way an alternative means of accomplishing the approved mitigation project's goals (e.g., replacement of lost habitat units of a certain quality and type) that should be pursued with the funds. The Corps can retain authority to review and approve the plans of the entity utilizing the funds to ensure that they are likely to achieve the goals. However, if the contingencies contemplated by the assurance change (such as the dissolution of the entity eligible to accept the financial assurance funds), the parties to the assurance will have to modify that agreement. By establishing these contingencies and goals when the financial assurance product is created, the Corps limits the extent of control it can exercise over the funds and makes it clear that the funds are to be used to fulfill the mitigation commitments of the mitigation bank or other mitigation provider. In other words, the Corps is not attempting to direct the use of these funds and

thus do indirectly that which it could not do itself; rather, the Corps is simply establishing a framework to ensure that legal commitments that result from the issuance of a Department of the Army permit or the approval of a mitigation banking or in-lieu fee program instrument are in fact honored.

d. Casualty insurance policies can avoid running afoul of the miscellaneous receipts rule by utilizing operative language that provides that the insurance company will complete or secure the required mitigation itself or pay the necessary funds to a third party to complete the mitigation. An example of such language follows: "In the event of the 'Named Insured's' failure during the 'policy period' to meet the 'performance standards' under the 'mitigation banking instrument' at the 'insured property,' the Company agrees to undertake and complete or secure through payment, whether directly or through a third party, the 'compensatory mitigation' for which the 'Named Insured' is legally responsible under the 'mitigation banking instrument,' provided the 'regulatory body' first makes a 'claim' to the Company in writing and during the 'policy period' seeking such 'compensatory mitigation.'"

4. Neither the Corps Regulatory Community of Practice nor the Office of the Chief Counsel endorses any particular type of financial assurance or any specific financial assurance product or company. However, a form of financial assurance that had not previously been widely available, casualty insurance, has recently been proposed for use in connection with a number of different mitigation projects. In order to assist Districts in negotiating and approving casualty insurance policies, we have provided guidance specific to casualty insurance below. However, in providing this guidance it is recognized that there is no single solution that can be uniformly applied in all cases, and every policy should be carefully reviewed and modified to fit the particular circumstances and requirements of the particular mitigation project. Further, it may not always be possible to negotiate policy terms that meet a District's requirements. The District Engineer retains authority to determine acceptable terms in each case.

5. When negotiating casualty insurance policies, there will be a number of provisions that will be of greater significance to the Corps. The specific provisions that need particular attention have been identified below along with some recommendations.

   a. Policy Period – Ensure that the policy period aligns with the time required for achievement of the mitigation bank performance standards for at least the duration of the monitoring period, or provides for options for renewal of the policy if the monitoring period exceeds the initial term of the policy. (Note that insurance policies generally have a maximum of a ten year term.)

   b. Exclusions – Scrutinize the exclusions under the policy to ensure that there is adequate coverage to ensure the project will be successfully completed. An

"Act of God" exclusion will be a common feature of most policies. While this exclusion can be negotiated out of the policy (with a resulting higher rate for the insured), it will be important to look closely at what kind of coverage for natural disasters is necessary. In many cases, "natural disasters" such as flooding or fire might be desired events in the management and success of the mitigation bank. Most mitigation banking instruments will have provisions that address "Acts of God" that should be considered when determining whether modifications to the insurance policy's exclusion are needed. Fraud on the part of the insured should not be an exclusion and should not limit the insurance company's obligation to pay. It may be appropriate for exclusions to cover other properties, claims that would be covered by a standard comprehensive general insurance policy, legal fees associated with defending any disputes between the insured and the insurer, and other site-specific matters.

c. Bankruptcy- Ensure the policy is payable upon bankruptcy or insolvency of the insured and that the insured's failure to satisfy the deductable does not release the insurance company's obligation to pay up to the full policy limit if a claim is made.

d. Modification- Provide that any modification of the policy should be contingent upon the approval of the Corps.

e. Notice of Cancellation- Include the regulatory requirement that any cancellation of the policy requires notice to the Corps at least 120 days prior to the proposed cancellation/release date.

f. Change in Law- Address the effects of any changes in applicable law or regulation after commencement of the policy on the terms would have on the policy.

g. Choice of Law/Forum- If a choice of law provision exists in the policy, it should not be applicable to the Corps. The provision should be clear that the Federal Courts are the only appropriate venue for any litigation regarding the policy that involves the Corps.

h. Filing Claims- The insured should generally not be able to file a claim. Only the Corps, and in some instances state regulators, should be the only party that can file a claim.

i. Third Party Rights -The policy should explicitly recognize the Corps' third party rights.

j. Definitions- For any terms that the policy defines that are also defined in Corps regulations, such as "adaptive management plan," "performance standards," "mitigation banking instrument," and "compensatory mitigation," the policy's definitions should reference the Corps regulations and adopt consistent definitions.

6. There will be a few additional matters that are not part of a casualty insurance policy but which should be considered before deciding whether to accept an insurance policy as financial assurance.

a. State Law on the Effect of Fraud – Understand the effect that fraud on the part of the mitigation bank proponent would have on the validity of the policy under the applicable state law. Some states may have statutory provisions or common law that provides that if insurance was obtained fraudulently, the policy is rescinded.

b. Qualifications of the Insurance Company- Review the qualifications of the issuing insurance company to ensure generally that they have an adequate rating from a rating agency (e.g., A.M. Best, Fitch, Moody's, or Standard & Poor's) , are licensed in at least one state, and are not closely financially tied to the insured (generally, the insurance company should not be wholly owned subsidiary of the parent company seeking insurance).

7. The Corps Institute for Water Resources (IWR) has developed an information paper on financial assurance products titled "Implementing Financial Assurance for Mitigation Project Success." This paper provides helpful background information on the different forms of financial assurance products, how they work, and the limitations and advantages of each. This background may be helpful in gaining a better understanding of how the Corps interest in ensuring the success of a mitigation project needs to be protected when negotiating a specific financial assurance instrument. This information paper is available on IWR's website (http://www.iwr.usace.army.mil/docs/iwrreports/Financial_Assurance.pdf).

8. My point of contact for this issue is Max Wilson (202-761-8544).

/ Ptiillip Steffen
Assistant Chief Counsel for Environment

Enclosure:
IWR Fact Paper: Implementing Financial Assurance for Mitigation Project Success

Appendix C:

Links to Sample Financial Assurance Mechanisms

DISTRICT	TITLE	ON RIBITS	ON WEBSITE	LINK
New Orleans	Escrow Agreement - Construction & Establishment	Y		
St. Paul	MN Performance Bond Template	Y		
	WI Irrevocable Escrow Mitigation Construction Agreement		Y	http://www.mvp.usace.army.mil/Portals/57/docs/regulatory/Website%20Organization/Irrevocable%20Escrow%20Wetland%20Mitigation%20Bank%20Construction%20Agreement.doc
	WI Irrevocable Escrow Mitigation Bank Maintenance Agreement		Y	http://www.mvp.usace.army.mil/Portals/57/docs/regulatory/Website%20Organization/Irrevocable%20Escrow%20Wetland%20Mitigation%20Bank%20Maintenance%20Agreement.doc
	WI Template Bond Form - Bank Construction		Y	http://www.mvp.usace.army.mil/Portals/57/docs/regulatory/Website%20Organization/Bond%20Form-Construction-Wetland%20Mitigation%20Bank%20template.doc
	WI Template Bond Form Post-Construction Maintenance		Y	http://www.mvp.usace.army.mil/Portals/57/docs/regulatory/Website%20Organization/Bond%20Form-Maintenance-Wetland%20Mitigation%20Bank%20template.doc
Baltimore	Typical Compensatory Mitigation Cost Estimate Components		Y	http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/Mitigation/FA_CostEstimateComponents071510.pdf
	Sample Performance Bond		y	http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/Mitigation/Sample%20Performance%20Bond.pdf
Seattle	Template Standby Trust Agreement	Y		
Wilmington	Template Letter of Credit	Y		
Los Angeles	Performance Bond Template		Y	http://www.spl.usace.army.mil/Portals/17/docs/regulatory/Mitigation/UsefulLinks/PerformanceBondForm.doc

U.S. Army Engineer Institute for Water Resources

The Institute for Water Resources (IWR) is a Corps of Engineers Field Operating Activity located within the Washington DC National Capital Region (NCR), in Alexandria, Virginia and with satellite centers in New Orleans, LA; Denver, CO; Pittsburgh, PA; and Davis, CA. IWR was created in 1969 to analyze and anticipate changing water resources management conditions, and to develop planning methods and analytical tools to address economic, social, institutional, and environmental needs in water resources planning and policy. Since its inception, IWR has been a leader in the development of strategies and tools for planning and executing the Corps water resources planning and water management programs.

IWR strives to improve the performance of the Corps water resources program by examining water resources problems and offering practical solutions through a wide variety of technology transfer mechanisms. In addition to hosting and leading Corps participation in national forums, which include the production of white papers, reports, workshops, training courses, guidance and manuals of practice. IWR develops new planning, socio-economic, and risk-based decision-support methodologies, improves hydrologic engineering methods and software tools, and manages several Civil Works information systems including national waterborne commerce statistics. IWR serves as the Corps expertise center for integrated water resources planning and management, hydrologic engineering, collaborative planning and environmental conflict resolution, and waterborne commerce data and marine transportation systems.

The Institute's Hydrologic Engineering Center (HEC), located in Davis, CA, specializes in the development, documentation, training, and application of hydrologic engineering and models. IWR's Navigation and Civil Works Decision Support Center and Waterborne Commerce Statistical Center (WCSC) are in New Orleans, LA. These centers are the Corps data collection organizations for waterborne commerce, vessel characteristics, port facilities, dredging information, and information on navigation locks. The Risk Management Center (RMC), located in Denver, CO and Pittsburgh, PA, is a center of expertise that supports Civil Works by managing and assessing risks for dams and levees, supporting dam and levee safety activities across the Corps, and developing policies, methods, tools, and systems to enhance those activities.

Other enterprise centers at the Institute's NCR office include the International Center for Integrated Water Resources Management (ICIWaRM), which is an intergovernmental center established in partnership with various Universities and non-Government organizations, and a Conflict Resolution and Public Participation Center of Expertise, which includes a focus on both the processes associated with conflict resolution and the integration of public participation techniques with decision support and technical modeling. The Institute plays a prominent role within a number of the Corps technical Communities of Practice (CoP), including the Economics CoP. The Corps Chief Economist is resident at the Institute, along with a critical mass of economists, sociologists, and geographers specializing in water and natural resources investment decision support analysis and multi-criteria tradeoff techniques.

For further information on the Institute's activities associated with the Mitigation Rule, please contact Forrest Vanderbilt at 703-428-6288, forrest.b.vanderbilt@usace.army.mil. The Director of IWR is Mr. Robert A. Pietrowsky, who can be contacted at 703-428-8015, or via e-mail at: robert.a.pietrowsky@usace.army.mil. Additional information on IWR can be found at: *http://www.iwr.usace.army.mil/*. IWR's NCR mailing address is:

U.S. Army Institute for Water Resources 7701 Telegraph Road, 2nd Floor Casey Building
Alexandria, VA 22315-3868

US Army Corps
of Engineers®

www.iwr.usace.army.mil

Appendix J

Public Comments

Draft Supplemental Environmental Impact Statement
Substantive Comments and Responses

Public Comment

It appears that the DSEIS fails to address the impacts of residential shoreline development on the reservoir. Would there be shoreline buffers to protect water quality? Would there be septic tank setbacks to prevent pollution of the water supply reservoir? Would there be permitting of residential docks?

Response

There is no residential shoreline developed planned. The North Central Missouri Regional Water Commission (NCMRWC) owns all the land surrounding the shoreline and does not intend to develop any land it owns. Land outside the NCMRWC boundary may be developed by private landowners or developers; however, the NCMRWC land provides a buffer to any development. The Shore Line Protection Plan is reference in Section 3.8.4.3 and is included in Appendix G.

Draft Supplemental Environmental Impact Statement

Other Public Comments Received

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

OFFICE OF THE
REGIONAL ADMINISTRATOR

Mr. Chris Hamilton
Assistant State Conservationist (Water Resources)
Missouri NRCS State Office
601 Business Loop 70 West, Suite 250
Columbia, Missouri 65203-2585

Dear Mr. Hamilton,

In accordance with our responsibilities under Section 309 of the Clean Air Act and the National Environmental Policy Act, the U.S. Environmental Protection Agency has reviewed the Natural Resources Conservation Service's draft supplemental environmental impact statement (DSEIS) for the East Locust Creek Reservoir Revised Plan (CEQ No. 20200206).

The proposed action is to build a 2,328-acre multipurpose reservoir located northeast of Milan, Missouri, that would support water supply and water-based recreation for the 10-county region and reduce flood damage along a 22.5-mile reach of East Locust Creek from the toe of the dam to Locust Creek. The reservoir would provide seven million gallons per day of water supply and approximately 92,000 annual user-days of recreation. The lake size was adjusted from 2,235 acres in the 2006 final EIS to 2,328 acres in this DSEIS. The change in estimated normal pool size is because of the use of more accurate elevation data to estimate the normal pool size and elevation. The 2006 final EIS used photogrammetry measurements and the DSEIS was based on 2009 lidar measurements.

The project will require an individual Clean Water Act Section 404 permit, and the DSEIS has identified the proposed action, East Locust Creek Reservoir (RW1), as the preferred alternative. The EPA notes that the content of this correspondence is limited to the NEPA review and not intended to be review comments on the Section 404 permit. EPA has provided separate comments on the U.S. Army Corps of Engineers Public Notice (NWK-2004-255) Clean Water Act Section 404 individual permit related to this action.

We appreciate the opportunity to review the DSEIS. EPA acknowledges the early engagement and ongoing conversations with NRCS to discuss Agency feedback on the DSEIS. EPA does not have substantive comments pertaining to our review of the DSEIS.

We look forward to our continued participation with NRCS on this action. If you have questions regarding these comments, please contact Mr. Joshua Tapp, Program Manager, Office of Intergovernmental Affairs, at 913-551-7606 or tapp.joshua@epa.gov.

Sincerely,
JAMES GULLIFORD
Digitally signed by JAMES GULLIFORD
Date: 2020.12.04 12:54:51 -06'00'
James B. Gulliford

Printed on Recycled Paper

NCMRWC Public Hearing, November 10, 2020

Name: Jeff Carey

Representing: United Rentals – Fluid Solutions

Phone: 314-964-2152

Email: jcarey@ur.com

NCMRWC Public Hearing, November 10, 2020

Name: NANCY WATT

Representing: City of Milan

Phone: 660-265-4499

Email: chiefw@nemr.net

NCMRWC Public Hearing, November 10, 2020

Name: Steve Rhodes

Representing: SCPWSD #1

Phone: 660 292 1217

Email: rhodeshr@gmail.net

NCMRWC Public Hearing, November 10, 2020

Name: Chris May

Representing: Sullivan Co.

Phone: 660-265-5654

Email:

NCMRWC Public Hearing, November 10, 2020

Name: Melvin L. Scott

Representing: REC

Phone: 660 265 6423

Email: mls1936@windstream.net

NCMRWC Public Hearing, November 10, 2020

Name: Randy Huffman

Representing: Sullivan Co. Commission

Phone: 660-359-1063

Email:

NCMRWC Public Hearing, November 10, 2020

Name: Dennis Mead

Representing:

Phone: 660 265 6184

Email:

East Locust Creek Watershed Plan - Public Comment Period

The USDA-NRCS welcomes public ideas, comments, or concerns regarding a watershed plan about a proposed multi-purpose reservoir for the East Locust Creek Watershed. An Environmental Impact Statement for the East Locust Creek Watershed was prepared in 2006 but has been recently updated with new information in a Draft Supplemental Environmental Impact Statement (DSEIS).

You may locate the DSE IS on the internet at the following link: https://go.usa.gov/xGhWC.

Public input about the East Locust Creek DSEIS will be open until December 7, 2020. Comments may be provided:

a) in person to a USDA-NRCS representative during the open house event at the Milan Community Center, 205 North Market Street in Milan, MO from 3-7 p.m. on November 10, 2020

b) or in writing by mail or email to Chris Hamilton, Assistant State Conservationist, USDA Natural Resources Conservation Service, Parkade Center Suite 250, 601 Business Loop 70 West, Columbia, Missouri 65203-2585, or Chris.Hamilton@mo.usda.gov.

Substantive comments received will be addressed and incorporated into a subsequent Final Supplemental Environmental Impact Statement. The FSEIS will then be published on the Federal Register with another 30-day public comment period.

Provide statement below (optional) ----------

The East Locust Creek Watershed Plan for the E L C reservoir was very informative. The information posted around the room at the Milan Community Center, November 10, 2020 took you step by step to show all the planning that has taken place. The need for this project to be completed is vital for this 10 County region's survival. The future looks very bright with the completion.

Name: (print) Chris May

Address: 44434 Robin Rd. Humphreys, MO. 64646

Date: 11-10-20

Signature Chris May

East Locust Creek Watershed Plan - Public Comment Period

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Substantive comments received will be addressed and incorporated into a subsequent Final Supplemental Environmental Impact Statement. The FSEIS will then be published on the Federal Register with another 30-day public comment period.

Provide statement below (optional) ----------

A lot of work has been put into this. I hope it continues on pace. It will be very beneficial for the 10 county area. A water source that is desperately needed.

Name: (print) Randy Huffman Address: 20778 Hwy 139 GALT, MO. 64641

Date: 11/10/20

Signature Randy Huffman

Section 404 Permit

Agency Comments

From: WPSC.Water Quality Certification
To: Beyke, Sean M CIV USARMY CENWK (USA)
Cc: john_s_weber@fws.gov; USEPA Region 7; Thorne, David; Campbell-Allison, Jennifer; Miller, Stuart; Vitello, Matt; Hoggatt, Jennifer; Weller, Michael; Hunt, Rob; Irwin, Mike; Libbert, Danielle
Subject: [Non-DoD Source] North Central Missouri Regional Water Commission, NWK-2004-00255/CEK007390
Date: Monday, November 30, 2020 2:46:45 PM

The Missouri Department of Natural Resources' Water Protection Program has reviewed the Public Notice for NWK-2004-00255 in which the North Central Missouri Regional Water Commission (NCMRWC) is proposing to construct an earthen dam approximately 0.5 mile long by 600 ft wide by 78 ft tall within East Locust Creek for the creation of a 2,328-acre multipurpose reservoir. The project is proposed under the United States Department of Agriculture's (USDA) Natural Resources Conservation Service's (NRCS) Watershed Protection and Flood Prevention Act, Public Law 83-566 Program and is proposed to be constructed under agreement between the NCMRWC and the NRCS, the lead federal agency.

The dam would be constructed in three stages. Stages 1 and 2 would be the construction of the eastern and western sides of the dam adjacent to East Locust Creek. The third phase would involve constructing the center portion that blocks East Locust Creek and fills the reservoir. Seven borrow areas totaling 84 acres are proposed to provide fill for the dam. Five of the 7 borrow sites are within the reservoir's normal pool, and 2 of the borrow sites are located outside the reservoir's normal pool. The 2 borrow sites located outside the normal pool are a 25-acre site west of the dam and a 22-acre site northwest of the dam. These borrow sites were selected to avoid tree clearing, and the marina was selected on a borrow area to provide a secondary use. A concrete spillway would be constructed on the eastern end of the dam. It would extend 1,247 ft southwest to the East Locust Creek main channel and provide downstream flow in East Locust Creek. The spillway would be 55 ft wide at the dam and would taper down to 25 ft wide near its confluence with East Locust Creek.

To facilitate public access and recreational use, allow for construction access, and to minimize adverse transportation impacts, additional road improvements and realignments are proposed. This work would include the construction of several bridges and culvert crossings as well as the closure and abandonment of several roads, including a portion of State Highway N near Boynton. The timing of the mid-lake corridor portion of this proposed work would occur concurrent with or prior to the dam construction. The roadway projects would be partially funded by a Better Utilizing Investments to Leverage Development (BUILD) grant. The BUILD grant would be overseen by the Federal Highway Administration and administered by the Missouri Department of Transportation. Additional funding sources for the roadway projects include NCMRWC, NRCS, USDA Rural Development, and the state of Missouri.

Water supplied by the proposed action would be transferred by a raw water transmission pipeline to Milan, Missouri, the location of the existing NCMRWC water treatment plant. An approximately 24,700-ft raw water line would be constructed from a water intake near the dam and run to the water treatment plant. The raw water line would cause impacts to a width of approximately 40 ft and would run generally southwest along the existing, abandoned rail line until it reaches the water treatment plant north of Milan.

A total of 255,441 linear ft (LF) of streams and 375.1 acres of wetlands would be impacted by the proposed project, including 46,502 LF of perennial streams, 72,104 LF of intermittent streams, and 136,835 LF of ephemeral streams. Impacted wetlands include 280.17 acres of palustrine emergent, 9.79 acres of palustrine scrub-shrub, and 63.92 acres of palustrine forested wetlands as well as 21.22 acres of open water features. A total of 225 acres of wetlands, approximately 64 percent of the 354 wetland acres in the proposed normal pool, are impaired because they are currently or were previously farmed or comprised of over 50 percent reed canarygrass.

The proposed project is located in Locust Creek and wetlands adjacent to unnamed tributaries to East Locust Creek in Sections 1, 2, 11, 12, 13, 14, 24, 25, 26, and 35, Township 63 North, Range 20 West; Sections 5, 6, 7, 8, 17, and 18, Township 63 North, Range 19 West; Sections 12, 13, 23, 24, 25, 26, 35, and 36, Township 64 North, Range 20 West; and Sections 16, 17, 18, 19, 20, 21, 29, 30, 31, and 32, Township 64 North, Range 19 West, south of Pollock in Sullivan County, Missouri. Approximate geographic coordinates for the proposed earthen dam are 40.26617°N, 93.08223°W.

The Department requests a response to or acknowledgment of the following specific comments:

1. According to the Department's geospatial data, the project will impact multiple streams classified in Missouri Water Quality Standards' Missouri Use Designation Dataset [10 CSR 20-7.031(2)(E)] as well as many unclassified streams. East Locust Creek, the largest stream in the proposed impact area, has been assigned the following designated uses in Missouri Water Quality Standards: protection and propagation of fish, shellfish, and wildlife – warm water habitat; recreation in and on the water - whole body contact category A and secondary contact recreation; human health protection – fish consumption; irrigation; and livestock and wildlife protection [10 CSR 20-7.031(1)]. In addition, East Locust Creek is on the Department's CWA Section 303(d) list of impaired waters for *Escherichia coli* and low dissolved oxygen. The Missouri Water Quality Standards antidegradation requirement for maintenance and protection of these designated uses [10 CSR 20-7.031(3)] will still apply outside of the proposed project's limits.

   The Department's geospatial data is available upon request, and all published data is available on the Missouri Spatial Data Information Services website at msdis.missouri.edu/. Additional information to identify the project location, including stream reaches with listed impairments or special water designations, may be obtained from the Department's Water Protection Program by phone at 573-522-4502.

2. It is essential that any impacts to water ways are avoided or minimized to the extent possible. In-stream impoundments dramatically affect water quality and conflict with the Missouri Water Quality Standards general criterion requiring waters be free from physical, chemical, or hydrologic changes that would impair the natural biological community [10 CSR 20-7.031(4)(G)].

3. According to the U.S. Army Corps of Engineers (USACE) public notice, the applicant proposes to provide compensatory mitigation for unavoidable impacts with at least one large, watershed-approach mitigation site. The Department welcomes proposals regarding alternative methods for compensatory stream and wetland mitigation, including but not limited to alternative impact and benefit assessment methods. Any such alternative methods will be reviewed for approval by the Department for Clean Water Act Section 401 Water Quality Certification (WQC) purposes. The Department reviews proposed projects for compliance with the Missouri

antidegradation requirement for maintenance and protection of designated uses [10 CSR 20-7.031(3)] under Missouri Clean Water Law, which provides the Department authority to adopt remedial measures to prevent, control, or abate pollution [Chapter 644.026.1(9), RSMo] and approval authority for compensatory mitigation used in connection with any WQC [Chapter 644.026.1(26), RSMo].

4. To ensure compliance with the Missouri Water Quality Standards general criterion requiring waters be free from physical, chemical, or hydrologic changes that would impair the natural biological community [10 CSR 20-7.031(4)(G)], hydraulic design of the dam should seek to minimize adverse impacts by matching design outflows to natural inflows to the greatest extent practicable. Proposed efforts to maintain ecological flows, as well as other efforts to manage dissolved gases and temperature in release water, are beneficial to minimize additional impacts downstream of the proposed project. However, since such measures do not replace resources lost due to fill and impoundment impacts, they should not be considered as a form of compensatory stream or wetland mitigation.

5. State regulations regarding permitting and construction of dams must be followed. Dams over the height of 35 ft require approval through the Department's Dam and Reservoir Safety Program. Construction of the dam should be in accordance with the provisions of Chapter 236.400 to 236.500 of the Revised Statutes of Missouri and the rules and regulations of the Missouri Dam and Reservoir Safety Council.

6. Acquisition of a WQC should not be construed or interpreted to imply the requirements for other permits are replaced or superseded, including Clean Water Act Section 402 National Pollutant Discharge Elimination System Permits. Permits or any other requirements should remain in effect. Questions regarding permit requirements may be directed to the Department's Northeast Regional Office by phone at 660-385-8000.

7. Land disturbance activities disturbing one or more acres of total area for the entire project or less than one acre for sites that are part of a common promotional plan of development may require a stormwater permit. This will ensure compliance with CWA Section 402 National Pollutant Discharge Elimination System Permit requirements under Missouri Clean Water Law [Chapter 644.026.1, RSMo]. Instructions on how to apply for and receive the online land disturbance permit are located at www.dnr.mo.gov/env/wpp/epermit/help.htm. Questions regarding permit requirements may be directed to the Department's Land Disturbance phone line at 573-526-2082 or toll free at 855-789-3889.

8. The project proponent may wish to maintain or establish a forested perimeter around the lake to protect the water quality within the lake. A native, deep-rooted buffer would be beneficial to protect the lake's shoreline from wind and wave erosion while also filtering stormwater entering the lake from the watershed. This in turn would extend the life of the lake by reducing its sediment intake and storage while also improving the quality of water that is released from the lake into the waters downstream.

Response:

Comments 1 – 8 are acknowledged.

The following comments do not require a response but should be considered since they might be

included as or influence conditions of a WQC:

9. Streambed gradient should not be adversely impacted outside of proposed project areas. No project should accelerate bed or bank erosion. This will ensure compliance with the Missouri Water Quality Standards general criterion requiring waters to be free from physical, chemical, or hydrologic changes that would impair the natural biological community [10 CSR 20-7.031(4)(G)].

10. Only clean, nonpolluting fill should be used. The following materials are not suitable where contact with water is expected and should not be used due to their potential to cause violations of the general criteria of Missouri's Water Quality Standards [10 CSR 20-7.031(4)(A)-(H)]:
    a. Earthen fill, gravel, and broken concrete where the material does not meet the Suitable Material specifications stated in the "Missouri Nationwide Permit Regional Conditions" (https://usace.contentdm.oclc.org/digital/collection/p16021coll11/id/2662/) in locations where erosive flows are expected to occur on a regular basis, such as streambanks and/or lake shorelines.
    b. Fragmented asphalt.
    c. Concrete with exposed rebar.
    d. Tires, vehicles or vehicle bodies, and construction or demolition debris are solid waste and are excluded from placement in the waters of the state.
    e. Liquid concrete, including grouted riprap, if not placed in forms as part of an engineered structure.
    f. Any material containing chemicals that would result in violation of Missouri Water Quality Standards general criteria [10 CSR 20-7.031(4)] or specific criteria [10 CSR 20-7.031(5)].

11. Waste concrete or concrete rinsate should be disposed of in a manner that does not result in any discharge to the jurisdictional water ways. This will ensure compliance with the Missouri Water Quality Standards general criteria requiring waters be free from unsightly bottom deposits [10 CSR 20-7.031(4)(A)]; substances resulting in toxicity [10 CSR 20-7.031(4)(D)]; and physical, chemical, or hydrologic changes that would impair the natural biological community [10 CSR 20-7.031(4)(G)].

12. Missouri Water Quality Standards antidegradation requirements dictate all appropriate and reasonable Best Management Practices (BMPs) related to erosion and sediment control, project stabilization, and prevention of water quality degradation are applied and maintained [10 CSR 20-7.031(3)(B)]; for example, preserving vegetation, streambank stability, and basic drainage. BMPs should be properly installed prior to conducting authorized activities and maintained, repaired, and/or replaced as needed during all phases of the project to limit the amount of discharge of water contaminants to waters of the state. The project should not involve more than normal stormwater or incidental loading of sediment caused by project activities so as to comply with Missouri's general water quality criteria [10 CSR 20-7.031(4)(A)-(H)].

13. Care should be taken to keep machinery out of the water way as much as possible. If work in the water way is unavoidable, it should be performed during low-flow conditions and in a way that minimizes the duration and amount of any disturbance to banks, substrate, and vegetation to prevent increases in turbidity. This will ensure compliance with the Missouri Water Quality Standards antidegradation requirement for BMPs [10 CSR 20-7.031(3)(B)].

14. All efforts should be made to minimize exposure of unprotected soils. To the best of the

applicant's ability, project activity should be conducted at times of little or no rainfall to limit sediment movement and increased stream turbidity caused by heavy equipment. This will ensure compliance with the Missouri antidegradation requirement for BMPs [10 CSR 20-7.031(3)(B)].

15. Fuel, oil and other petroleum products, equipment, construction materials, and any solid waste should not be stored below the ordinary high water mark at any time or in the adjacent flood-prone areas beyond normal working hours. All precautions should be taken to avoid the release of wastes or fuel to streams and other adjacent waters as a result of this operation. This will ensure compliance with the Missouri Water Quality Standards antidegradation requirement for BMPs [10 CSR 20-7.031(3)(B)] and Missouri Water Quality Standards general criteria requiring waters be free from substances preventing beneficial uses [10 CSR 20-7.031(3)(A)]; substances causing unsightly color or turbidity [10 CSR 20-7.031(4)(C)]; and physical, chemical, or hydrologic changes that would impair the natural biological community [10 CSR 20-7.031(4)(G)].

16. Petroleum products spilled into any water or on the banks where the material may enter waters of the state should be cleaned up immediately and disposed of properly. Any such spills of petroleum should be reported as soon as possible, but no later than 24 hours after discovery to the Department's Environmental Emergency Response phone line at 573-634-2436 or website at http://dnr.mo.gov/env/esp/esp-eer.htm. This will ensure compliance with Missouri Environmental Improvement Authority [Chapter 260.015, RSMo] to provide for the conservation of state water resources by the prevention of pollution and proper methods of disposal and Missouri Water Quality Standards general criteria requiring waters be free from substances that prevent maintenance of beneficial uses; cause unsightly color, turbidity, or toxicity; and/or impair the natural biological community [10 CSR 20-7.031(4)(B)-(G)].

17. Clearing of vegetation and trees should be the minimum necessary to accomplish the activity except for the removal of invasive or noxious species and placement of ecologically beneficial practices. This will ensure compliance with the Missouri antidegradation requirement for BMPs [10 CSR 20-7.031(3)(B)].

18. The dam's face and disturbed areas should be restored to a stable condition to protect water quality as soon as possible. Seeding, mulching, and needed fertilization should be within three days of final contouring. To ensure erosion and deposition of soil in waters of the state are not occurring from this project, on-site inspections of these areas should be conducted as necessary to ensure successful revegetation and stabilization. This will ensure compliance with the Missouri antidegradation requirement for BMPs [10 CSR 20-7.031(3)(B)].

19. The Department encourages the use of native vegetation to protect impacted areas from future water quality concerns. Native vegetation has evolved with Missouri's geology, climate, and wildlife to occur within a region as a result of natural processes rather than human intervention. For areas where direct impacts to streams are to be avoided, the Department recommends a minimum riparian buffer strip width of 50 ft as measured from top of bank.

Thank you for the opportunity to comment on the proposed project. You may send responses to comments and other requested information electronically to the Stormwater and Certification Unit's general email account at wpsc401cert@dnr.mo.gov. If you have any questions, please contact Mike Irwin by phone at 573-522-1131, by email at mike.irwin@dnr.mo.gov, or by mail at Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, MO 65102-0176. Thank

you for working with the Department to protect our aquatic resources.

MI/pc

Missouri Department of Natural Resources
Water Protection Program
Operating Permits Section
P.O. Box 176
Jefferson City, MO 65102-0176
Phone (573) 522-4502 Fax (573) 522-9920
e-mail: wpsc401cert@dnr.mo.gov
web site: www.dnr.mo.gov/env/wpp/401

We'd like your feedback on the service you received from the Missouri Department of Natural Resources. Please consider taking a few minutes to complete the department's Customer Satisfaction Survey at https://www.surveymonkey.com/r/MoDNRsurvey. Thank you.

From:	Stuart Miller
To:	Beyke, Sean M CIV USARMY CENWK (USA)
Cc:	john_s_weber@fws.gov; David Thorne; Vitello, Matt; Hoggatt, Jennifer; Weller, Michael; Hunt, Rob; Irwin, Mike; Aaron Jeffries; Bryan Gragg; Danny Hartwig; Sherry Fischer
Subject:	[Non-DoD Source] RE: North Central Missouri Regional Water Commission, NWK-2004-00255/CEK007390
Date:	Wednesday, December 2, 2020 7:46:30 AM

Thank you for the opportunity to review and comment on the East Locust Creek Reservoir, Public Notice NWK-2004-00255. The Missouri Department of Conservation (Department) is the agency responsible for the fish, forest, and wildlife resources of Missouri. As such, the Department actively participates in the review of projects and proposals that may affect those resources. The Department's comments and recommendations are for your consideration and are offered to reduce impacts to the fish, forest, and wildlife resources in Missouri.

The proposed plans included in the public notice to avoid, minimize, and mitigate impacts to streams and wetlands suggest a need for more specificity as to how ecological benefits will be accomplished. As a federal, state, and local government project, there are numerous avenues in the future to coordinate mitigation of impacts. The Department encourages future coordination between agencies and interested parties.

If you have any questions, please contact me. My email address is stuart.miller@mdc.mo.gov or call (573) 522-4115 Extension 3378.

Response:

Acknowledged.

From:	Gaggero, Jaime
To:	Beyke, Sean M CIV USARMY CENWK (USA)
Cc:	mike.irwin@dnr.mo.gov; Vitello, Matt; John_S_Weber@fws.gov; Amy Rubingh; Robichaud, Jeffery; Huffman, Diane; Tapp, Joshua; Tilley, Amber; DuPree, Gabriel; Muehlberger, Christopher
Subject:	[Non-DoD Source] Clean Water Act Section 404 permit application for the East Locust Creek Reservoir Project
Date:	Wednesday, December 2, 2020 7:12:36 PM
Attachments:	image003.png
	ELC 404 comment letter_Final.pdf

Mr. Beyke,

Please accept the attached letter containing comments regarding the 404 permit application for East Locust Creek Reservoir currently on Public Notice, on behalf of EPA Region 7. We appreciate the opportunity to review and comment. EPA offers continued coordination in support of a permit that meets the project purpose and objectives. We are willing to participate in any meetings that would be beneficial to the Corps and the Applicant and would appreciate the opportunity to meet prior to a decision being rendered for the 404 permit. For future communication on this project, feel free to reach out to Gabriel Dupree or I.

Thank you -

Jaime Gaggero

Watersheds and Grants Branch Chief
U.S. Environmental Protection Agency R7
11201 Renner Blvd. Lenexa, KS 66219
913.551.7977

UNITED STATES ENVIRONMENTAL PROTECTION

AGENCY REGION 7
11201 RENNER
BOULEVARD
LENEXA, KS 66219

December 2, 2020

Sean Beyke
Regulatory Project Manager
U.S. Army Corps of Engineers
Missouri State Regulatory
Office 515 East High Street,
Suite 202 Jefferson City,
Missouri 65101

Subject: Clean Water Act Section 404 permit application for the East Locust Creek Reservoir Project, Sullivan County, Missouri

Mr. Beyke:

The U.S. Environmental Protection Agency (EPA) has reviewed North Central Missouri Regional Water Commission's (NCMRWC) proposal for the East Locust Creek Reservoir Project. The proposal includes a Clean Water Act Section 404 individual permit application submitted to the United States Army Corps of Engineers (Corps), and a Draft Supplemental Environmental Impact Statement (DSEIS) for the proposed East Locust Creek Watershed Revised Plan, prepared by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The project is proposed to be constructed under agreement between the NCMRWC and the NRCS, the lead federal agency.

This letter provides EPA comments pursuant to Section 404 of the Clean Water Act. EPA will provide comments pursuant to the National Environmental Policy Act in a separate letter to NRCS by December 7, 2020.

With respect to the requirements associated with the application for a 404 permit, EPA has two recommendations.

- First, EPA recognizes the DSEIS will be used as a source of information during the 404 permit review. EPA also recognizes the scope of alternatives analysis under 40 CFR 230.10(a) may be inclusive of alternatives that were not identified as the preferred alternative. In order to determine the least environmentally damaging practicable alternative per 404(b)(1) Guidelines requirements, a thorough understanding of the screening criteria for evaluating alternatives and the thresholds used will be necessary in

order to appropriately evaluate the full scope of practicable alternatives. For example, it would be prudent to understand why MA6 was eliminated and RW1 is the preferred alternative.

Response:

A description of the screening criteria method is described in Section 2.0 and states the following:

> *This alternatives analysis is intended to meet the requirements of both NEPA and Clean Water Act Section 404(b)(1) guidelines. Both require that a reasonable range of alternatives be considered. The NEPA alternatives analysis focuses on screening alternatives that are* ***reasonable and feasible*** *and meet the* ***purpose and need*** *for the project. The Clean Water Act Section 404(b)(1) process focuses on determining a practicable alternative that is the* ***least damaging to aquatic resources*** *while considering other significant adverse environmental consequences.* ***Practicable means*** *"****available and capable of being done after taking into consideration cost, technology, and logistics****" (40 CFR 230.3(g)). In terms of the LEDPA analysis, the least environmentally damaging alternative focuses primarily on aquatic resources and secondarily on a public interest review of other environmental resources. The alternatives discussed were developed jointly with the regulatory agencies to satisfy both NEPA and Clean Water Act Section 404(b)(1) requirements.*

Because there are three project purposes, each project purpose was independently evaluated for:

- **Considered reasonable and feasible**
- **Meets the project purpose and need**
- **Fewest environmental impacts**
- **Practicable - available and capable of being done when considering:**
    - **Cost (excluded until the multipurpose evaluation)**
    - **Technology**
    - **Logistics**

For a description of the screening criteria for each project purpose and why it was appropriate based on the above considerations, see the following section:

- **Water supply alternatives: Section 2.1 and Section 2.1.1.**
- **Flood damage reduction alternatives: Section 2.2 and Section 2.2.1.**
- **Water-based recreation alternatives Section 2.3 and Section 2.3.1.**

Multipurpose alternatives were combined in Section 2.4 and the process for how they were combined is described in Section 2.4. Below is an excerpt from Section 2.4

> *The NEPA and CWA require federal agencies consider all reasonable and practicable alternatives that meet project purposes. The multipurpose analysis evaluates the following:*
>
> *• Multipurpose alternatives that meet the screening criteria for each of the three project purposes.*
>
> *• Analysis of impacts to aquatic resources including streams and wetlands.*
>
> *• Analysis of whether the alternative is practicable. Practicability means the alternative is available and capable of being done, and it includes a consideration of cost, logistics, and technology regarding the project purposes.*

• As required by the Endangered Species Act, an analysis of impacts to rare species habitat.

In this case, forest is used because it is habitat for threatened and endangered bats. All possible multipurpose alternatives will be generated from individual alternatives that met the screening criteria for one or more of the project purposes. ***In this document, to determine the multipurpose Preferred Alternative, Section 2.4.1 will combine individual alternatives (if necessary), Section 2.4.2 will evaluate the multipurpose alternatives, and Section 2.4.3 will determine the multipurpose Preferred Alternative.***

As described in the DSEIS, the Preferred Alternative is evaluated in Section 2.4.2 and selected in 2.4.3. The evaluation (Section 2.4.2) includes environmental impacts <u>and</u> practicability. While the environmental evaluation portion of Section 2.4.2 shows MA6 as having the fewest environmental impacts, the practicability portion shows MA6 is not practicable because of costs and logistics. The FSEIS document was updated to make this distinction.

- Second, once all practicable avoidance and minimization of impacts has been achieved, the mitigation plan should address not only direct project impacts, but secondary impacts such as instream flow, loss of aquatic organism passage due to the earthen dam, and sediment transport. Furthermore, proposed mitigation should also include provisions for watershed cumulative impacts.

<u>Response:</u>

Acknowledged.

As the DSEIS, mitigation plan and 404 permit review are being finalized, EPA offers our continued coordination in support of developing a robust, defensible permit that meets the project purpose and objectives. We would be willing participate in any meetings that would be beneficial to the Corps and the Applicant and would appreciate the opportunity to meet prior to a decision being rendered for the 404 permit.

I want to reaffirm that EPA understands and supports the Applicant's desire and needs to develop its water resources in a responsible way that addresses the needs of the Applicant while safeguarding valuable aquatic resources. Thank you for the opportunity to review the 404 permit application and DSEIS. If you have questions regarding these comments, please feel free to write me or contact Mr. Gabriel DuPree, Missouri Coordinator, at (913) 551- 7751 or by email at dupree.gabriel@epa.gov.

Sincerely,

Jaime Gaggero
Chief, Watersheds & Grants Branch

cc (electronically):

Mr. John Weber, U.S. Fish and Wildlife Service, Columbia, Missouri
Mr. Matt Vitello, Missouri Department of Conservation
Mr. Mike Irwin, Missouri Department of Natural Resources, Water Protection Program
Ms. Amy Rubingh, Missouri Department of Natural Resources, State Historic Preservation Office

Section 404 Permit
Public Comments

From: Edward Heisel

To: Beyke, Sean M CIV USARMY CENWK (USA); chris.hamilton@mo.usda.gov; Herrington, Karen; Edward Heisel

Subject: [Non-DoD Source] Comments on NWK-2004-00255 (E. Locust Creek Reservoir)

Date: Wednesday, December 2, 2020 3:08:08 PM

Attachments: Ltr-2020-12-02-USACE.pdf

Dear Mr. Beyke,

Please see the attached comments on the above permit application.

Ted Heisel

314.401.6218

EDWARD J.
HEISEL

Attorney at Law

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December 2, 2020

VIA EMAIL (sean.m.beyke@usace.army.mil)

Sean Beyke
U.S. Army Corps of Engineers
515 E. High Street
Suite 202
Jefferson City, MO 65101

Re: NWK-2004-00255 (East Locust Creek Reservoir)

Dear Mr. Beyke:

I submit these comments on my own behalf as someone who is a regular user of Missouri's waterways and who has spent time exploring public lands and waters along Locust Creek downstream of the above referenced project area. It seems likely at this stage in the process that construction of the project is a fait accompli. Therefore, my comments focus on the required mitigation for impacts to jurisdictional waters and protected wildlife.

Mitigating Impacts to Waters

The public notice indicates that 255,441 feet of streams and 375.1 acres of wetlands would be destroyed by the project. This is a huge impact on waters protected by the federal Clean Water Act. It is the most significant impact on Missouri's water resources of any section 404 permitted project in recent memory.

A major failing of the project documents is that they include very little specificity with regard to how the very large stream and wetland impacts of this project will be mitigated. For streams, the SEIS (p.201) merely states that:

> Mitigation measures would be developed in coordination with resource agencies including the USACE, USFWS, MDNR, and MDC. Potential projects include removing barriers which impede the passage of aquatic organisms, streambank stabilization, levee setback, riparian enhancement and protection, floodplain expansion,

and addressing the impacts of channel avulsions affecting sensitive habitats along the lower portions of Locust and Yellow creeks.

For wetlands, the SEIS (pp.201-202) is similarly vague and non-committal, stating that:

> Unavoidable wetlands impacts would require compensatory mitigation following prescribed replacement to affected ratios. . . . Wetlands delineations and preliminary jurisdictional determinations are planned to be completed. . . . Appropriate mitigation sites would require adequate soils and hydrology to establish wetland vegetation. . . . Wetland mitigation sites and extent would be determined in coordination with USACE and MDNR. Wetland mitigation locations would focus on areas upstream and downstream of the Proposed Action. . . . Permittee-responsible mitigation will require monitoring to ensure the success of wetland mitigation areas.

These statements along with the "Preliminary Draft" mitigation planning document in SEIS Appendix I are insufficient compliance with applicable regulations and give the public very little to work with in terms of evaluating the adequacy of mitigation measures. This is essentially a "trust us, we'll get it done" approach. The Corps' permitting regulations state: "For Section 404 applications, mitigation shall be required to ensure that the project complies with the 404(b)(1) Guidelines." 33 C.F.R. § 320.4(r)(1)(ii). While every last detail of a mitigation plan does not have to be finalized at the point of permit issuance, such plans must be developed to a "reasonable degree" and must reflect a "genuine effort to develop a detailed mitigation plan." Bering Strait CRRD v. USACE, 524 F.3d 938 (9th Cir. 2008). The 2008 Mitigation Rule further states that: "Compensatory mitigation requirements must be commensurate with the amount and type of impact that is associated with a particular DA permit. Permit applicants are responsible for proposing an appropriate compensatory mitigation option to offset unavoidable impacts." The East Locust Creek reservoir project documents do not represent a "genuine effort to develop a detailed mitigation plan" and the Corps must require greater specificity before issuing a Section 404 permit.

Selected mitigation sites must be provided with long-term protection in the form of a conservation easement or other protective mechanism. 33 C.F.R. § 332.7(a). Among the details lacking in the Corps' public notice and the SEIS is any reference to how long-term site protection will take place. Similarly, the mitigation planning document in the SEIS suggests that stream mitigation will be permittee responsible without any discussion of why the preferred mitigation bank or in-lieu fee approaches were rejected. 33 C.F.R. § 332.3(b). In sum, there is little to no compliance with the 2008 Mitigation Rule demonstrated in the available project documents.

Carrying out mitigation projects on existing public conservation lands is inappropriate in that these lands are already protected and any needed restoration thereon should be undertaken from agency budgets. Allowing impacts of the project to be offset at Swan Lake NWR, for example, is merely substituting private mitigation dollars for public funds that should be allocated for this purpose. Any restoration activities that are already included in existing agency plans such as the Swan Lake CCP cannot be used to offset private mitigation needs. 33 C.F.R. § 332.3(a)(3).

The best way to offset impacts of this magnitude are to purchase land with degraded aquatic resources (e.g. marginal farmland), restore them, and – ideally – make them available for public use. The project developers should work with the Missouri Department of

Conservation to add lands to the nearby Locust Creek Conservation Area or the Fountain Grove Conservation Area. Alternatively, they could work with the U.S. Fish & Wildlife Service to add lands to the Swan Lake National Wildlife Refuge or the Big Muddy National Wildlife Refuge. Finally, they could work with the Missouri Department of Natural Resources to add lands to Pershing State Park. These are the types of projects that would operate at a scale needed to offset impacts of the new reservoir. Adding acreage to existing public land units will provide the maximum ecological benefit and the lowest long-term monitoring and maintenance costs.

Bat Habitat

The project will similarly impact a large amount of terrestrial forested habitat for the endangered Indiana bat, as well as many other wildlife species. The bat habitat mitigation measures discussed in the SEIS – like those for streams and wetlands – are generalized and non- committal. The USFWS Biological Opinion specifies that 1,236 acres of forested habitat must be protected with a conservation easement, but only a vague reference to discussions with one land trust about site protection mechanisms is mentioned in the SEIS. Additional detail must be provided to demonstrate that implementation of these mitigation measures will actually take place. As with the aquatic impacts, the best mitigation approach would be to donate these lands to an agency like the Department of Conservation such that a new conservation area can be created with the specific objective of offsetting impacts of the reservoir on terrestrial species, including the Indiana bat.

Thank you for considering these comments. Please add me to any notification lists for future updates on this project.

Very truly
yours,

Edward J.
Heisel

cc: Chris Hamilton, NRCS (Chris.Hamilton@mo.usda.gov)
Karen Herrington, USFWS
(Karen_Herrington@fws.gov)

Response:

Mitigation measures that meet the 404(b)(1) guidelines are being developed and will be approved by the USACE prior to acquiring a Section 404 permit and prior to wetland and stream impacts.

Appendix K
Record of Decision

Record of Decision
East Locust Creek Watershed Plan
Sullivan County, Missouri

AGENCY:
Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA).

SUMMARY:
NRCS is publishing this provisional Record of Decision (ROD) within the Final Environmental Impact Statement (FSEIS) for the East Locust Creek Watershed Plan (ELCWP) to select the preferred alternative to construct the multiple-purpose reservoir. The purpose of the FSEIS and the subsequent ROD is to detail the National Environmental Policy Act (NEPA) considerations made both during and after NRCS prepared the ELCWP and Environmental Impact Statement (EIS) in 2006. The FSEIS updates the original EIS with more recent relevant environmental information and expands the alternatives analysis beyond those previously considered. The FSEIS evaluates reasonable and practicable alternatives and their expected environmental impacts under the EIS provisions of the Council on Environmental Quality. After evaluating the new information, this ROD remains consistent with the conclusions made in the 2006 EIS.

PUBLIC PARTICIPATION:
NRCS invites you to provide input on this action. Public input regarding the ROD will be considered 30 days after publishing the FSEIS. Comments may be directed to Chris Hamilton, Assistant State Conservationist, Water Resources and Easements, at chris.hamilton@usda.gov or (573)-876-0901. Persons with disabilities who require alternative means for communication should contact the USDA Target Center at (202) 720-2600 (voice).

SUPPLEMENTARY INFORMATION:
Background:
The NRCS, in cooperation with the Project Sponsors (North Central Missouri Regional Water Commission, Locust Creek Watershed District, Putnam County Commission, Sullivan County Commission, Putnam County Soil and Water Conservation District, and the Sullivan County Soil and Water Conservation District) and cooperating federal agencies (the U.S. Army Corps of Engineers [USACE], Federal Highways Administration [FHWA], USDA Rural Development [USDA-RD]), has prepared a FSEIS for the ELCWP in Sullivan County, Missouri authorized pursuant to the Watershed and Protection and Flood Prevention Act, Public Law 83-566, (16 U.S.C. 1001-1008).

The East Locust Creek Watershed is approximately 79,500 acres and is in North Central Missouri. East Locust Creek is a tributary to Locust Creek, then the Grand River, and the Missouri River. North Central Missouri has, for decades, suffered under the threat of water shortage. The Sullivan and Putnam County Commissions and the Sullivan and Putnam County Soil and Water Conservation Districts initially applied for federal watershed planning assistance in the East

Locust Creek Watershed in 1974. NRCS completed the East Locust Creek Watershed Plan-Environmental Assessment (EA) in 1986. Recognizing that the large lake proposed in the 1986 EA could help meet the regional need for a dependable water supply, the Locust Creek Watershed Board in November 2000 requested an NRCS study to revise the 1986 Watershed Plan-EA and include a public water supply reservoir.

NRCS began planning activities following authorization in July 2003 and revised the ELCWP in March 2006. The East Locust Creek Revised Plan (ELCRP) recommended the construction of a multiple-purpose reservoir that would provide a water supply, water-based recreation, and flood prevention. NRCS announced a ROD to proceed with installation of a multiple-purpose reservoir in September 2006 stating, "No alternative or combination of alternatives will afford greater protection of the environmental values while accomplishing the other project goals and objectives." The Environmental Protection Agency concurred and did not object to the proposed action.

Following the 2006 ROD, the project was not installed because of insufficient federal and local funding. Since 2010, a ½ cent retail sales tax has generated required funds for the local funding match for project related expenses. The Project Sponsors began acquiring land assets for the project which were completed in 2017 without the use of condemnation.

A Notice of Intent to prepare a Draft Supplemental Environmental Impact Statement (DSEIS) for the ELCRWP was published in the Federal Register on December 8, 2014. The NRCS determined that additional analysis was required and the purposes of the NEPA would be furthered through the preparation of a SEIS. The USACE, FHWA, and USDA-RD were cooperating federal agencies in the preparation of a DSEIS. The DSEIS was completed on October 23, 2020 and considered all reasonable and practicable alternatives to meet the purpose and need for the federal action. The DSEIS has assessed the potential social, economic, and environmental impacts of the project, and addressed federal, state, and local regulatory requirements. The DSEIS analyzed the direct, indirect, and cumulative effects of the proposed action.

Proposed Action:
The proposed federal action as presented in the 2006 EIS includes a 2,235-acre multiple-purpose reservoir on East Locust Creek, a water intake structure, a raw water line, fish and wildlife habitat enhancement, utility relocation, and recreational facilities. The lake size was adjusted in the FSEIS from 2,235 acres to 2,328 acres to reflect more accurate elevation data. The 2006 EIS used photogrammetry measurements and the FSEIS was based on 2009 Light Detection and Ranging (LiDAR) measurements. The purpose of the proposed federal action is to:

- Provide a dependable, affordable long-term water supply to meet the water demand for the 10-county region of north-central Missouri, including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties.

- Reduce flooding damages on 22.5 miles of East Locust Creek above the confluence with Locust Creek.
- Provide water-based recreation to meet the unmet demand for the 10-county recreation management area including Adair, Chariton, Grundy, Linn, Livingston, Macon, Mercer, Putnam, Schuyler, and Sullivan counties.

The installation of the proposed action will result in temporary and permanent impacts to jurisdictional waters of the U.S. requiring a Clean Water Act (CWA) Section 404 permit. The USACE has not issued a Section 404 permit for this project. Potential impacts of all reasonable and practicable alternatives have been updated and analyzed in the FSEIS in compliance with Section 404(b)(1) of the CWA.

Alternatives:
The FSEIS evaluated environmental impacts of alternatives that were identified as reasonable and practicable:

(1) Creation of a multiple-purpose reservoir;
(2) A combination of independent purpose alternatives to meet the overall project purposes and needs; and
(3) The no-action alternative.

The FSEIS identified the National Economic Development alternative, which is the alternative with the greatest net economic benefit consistent with protecting the Nation's environment and documents the estimated direct, indirect and cumulative impacts of the proposed action and alternatives on the environment. The FSEIS recommends a multiple-purpose reservoir and are consistent with the findings of the 2006 EIS.

Scoping:
In developing the ELCRWP, numerous scoping meetings were held to gather public input and keep the community informed on the status of project planning activities. Periodic news articles, fact sheets were published through the years to update local citizens. The 2010 tax issue for the project passed by an 81% vote in favor. A public open house was held from 3:00 p.m. to 7:00 p.m. in conjunction with USACE on November 10, 2020, at the Milan Community Center in Milan, Missouri to answer questions and solicit comments on the DSEIS. NRCS has responded to all substantive comments received in this FSEIS (see Appendix J).

Other Environmental Review and Coordination Requirements:
The USACE, USDA-RD, and the FHWA are cooperating federal agencies assisting in the preparation of the FSEIS. The NRCS, as the lead Federal agency, will continue to coordinate with other agencies and entities throughout the NEPA process including: Putnam and Sullivan County Commissions, Putnam and Sullivan Soil and Water Conservation Districts, Missouri Department of Natural Resources (MDNR), Missouri Department of Conservation, U.S. Fish and

Wildlife Service, and the Environmental Protection Agency. The FSEIS addresses project compliance with applicable laws and regulations, including NEPA, CWA, Endangered Species Act, and the National Historic Preservation Act. The FSEIS also includes an administrative action proposal to exchange an Agricultural Conservation Easement Program easement which will be inundated by the permanent pool (Appendix F).

Permits or Licenses Required:
The proposed federal action requires a CWA Section 404 permit from the USACE. The project also requires certification by the State of Missouri, MDNR, under Section 401 of the CWA, that the project would not violate State water quality standards. A land disturbance permit issued by the MDNR under Section 402 of the CWA (National Pollutant Discharge Elimination System Permit) is required. Construction and Safety Permits issued by the Missouri Dam and Reservoir Safety Program will also be needed.

DECISION:
Having concluded that all practical means have been considered according to laws and policy, and that the need for a regional water supply is extraordinary, the NRCS has decided to implement the ELCRWP preferred alternative which includes construction of a 2,328-acre multiple-purpose reservoir. The ELCRWP will serve the overall public interest while avoiding impacts to the extent possible and minimizing and mitigating for impacts that are unavoidable.

_____ Date _____

Scott Edwards
Missouri State Conservationist, USDA-NRCS
Responsible Federal Official
Columbia, MO