2.0 Alternatives Analysis

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

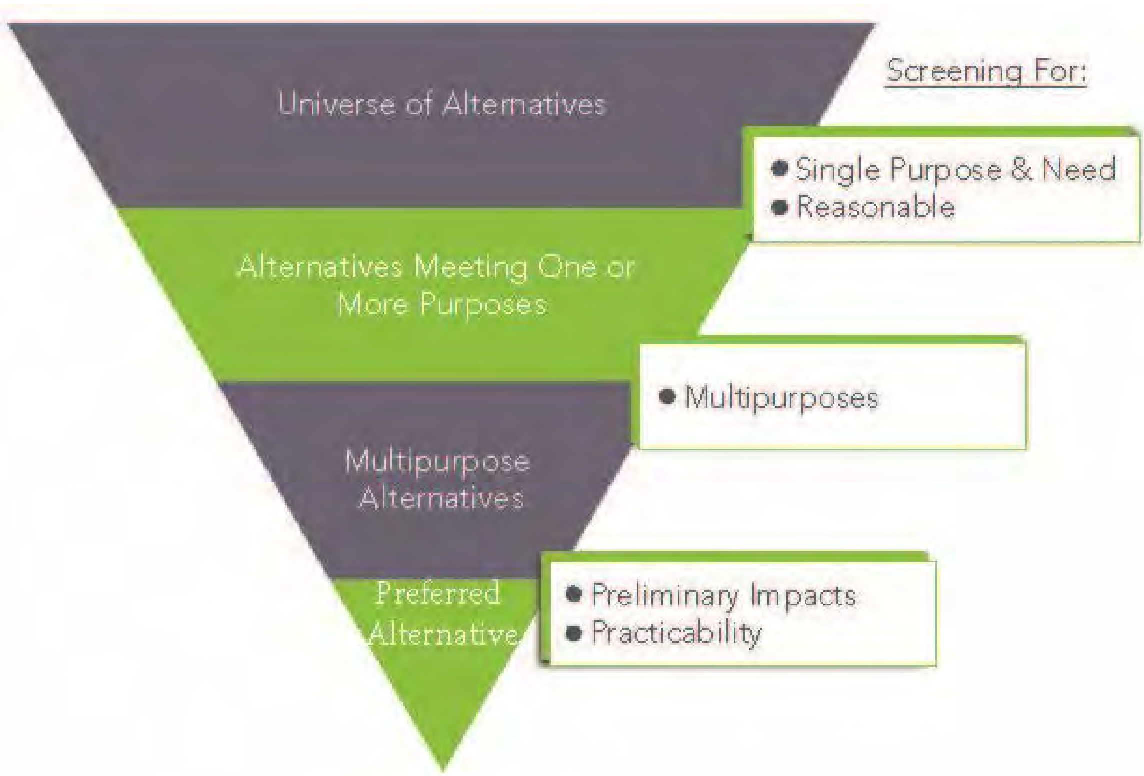
Each of the three project purposes includes the development of alternatives and screening criteria that allow the project proponent to meet the purpose and need for each individual project purpose. An alternative is eliminated from consideration if it does not meet an individual project purpose or cannot 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.

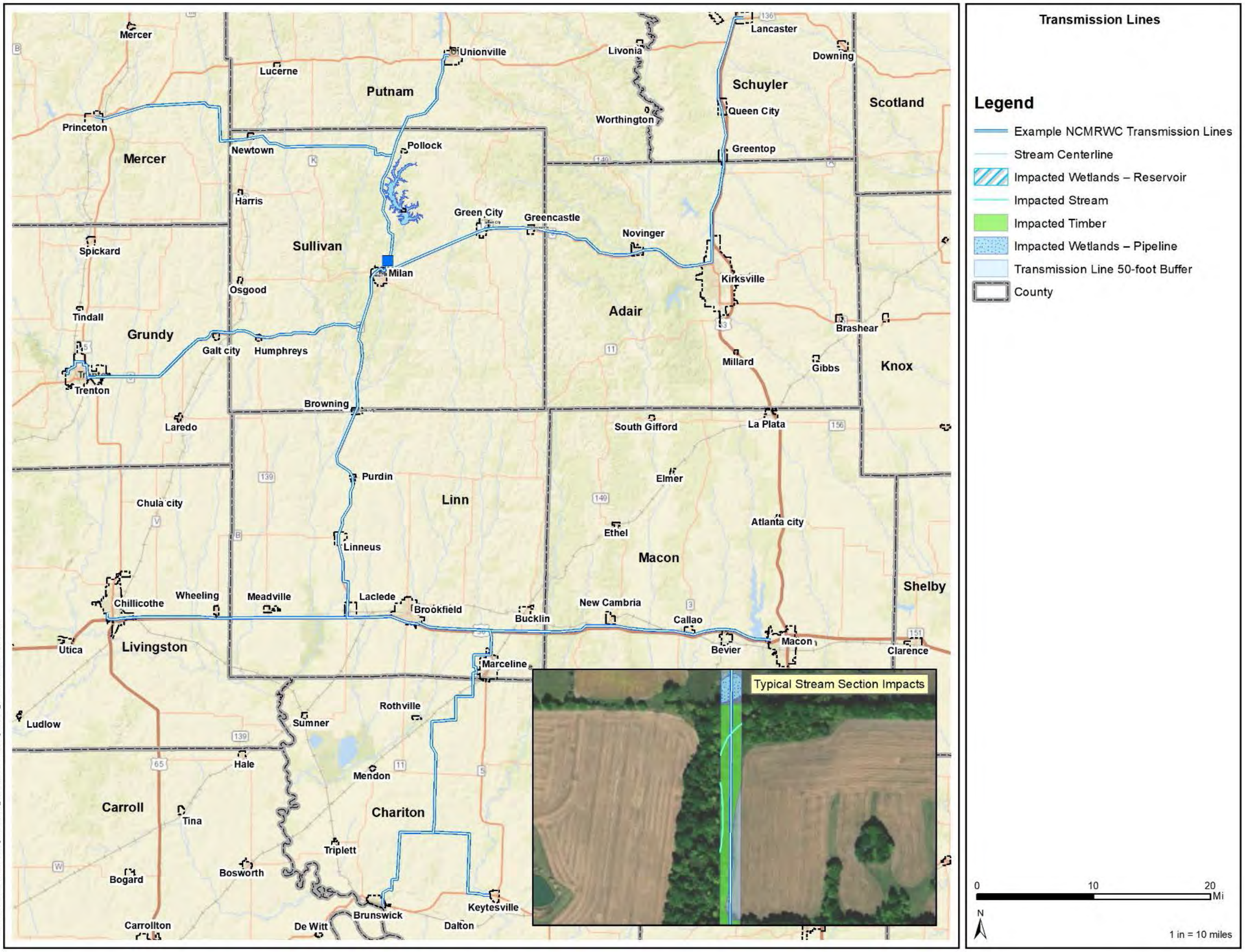


Figure 2.0-1. Water Transmission Lines.

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.

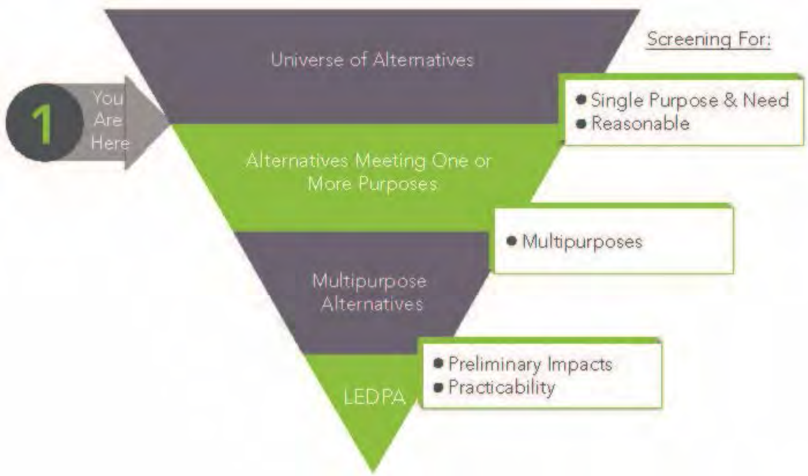
Alternative Naming Convention

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



This section screens the universe of alternatives for water supply.

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."

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.

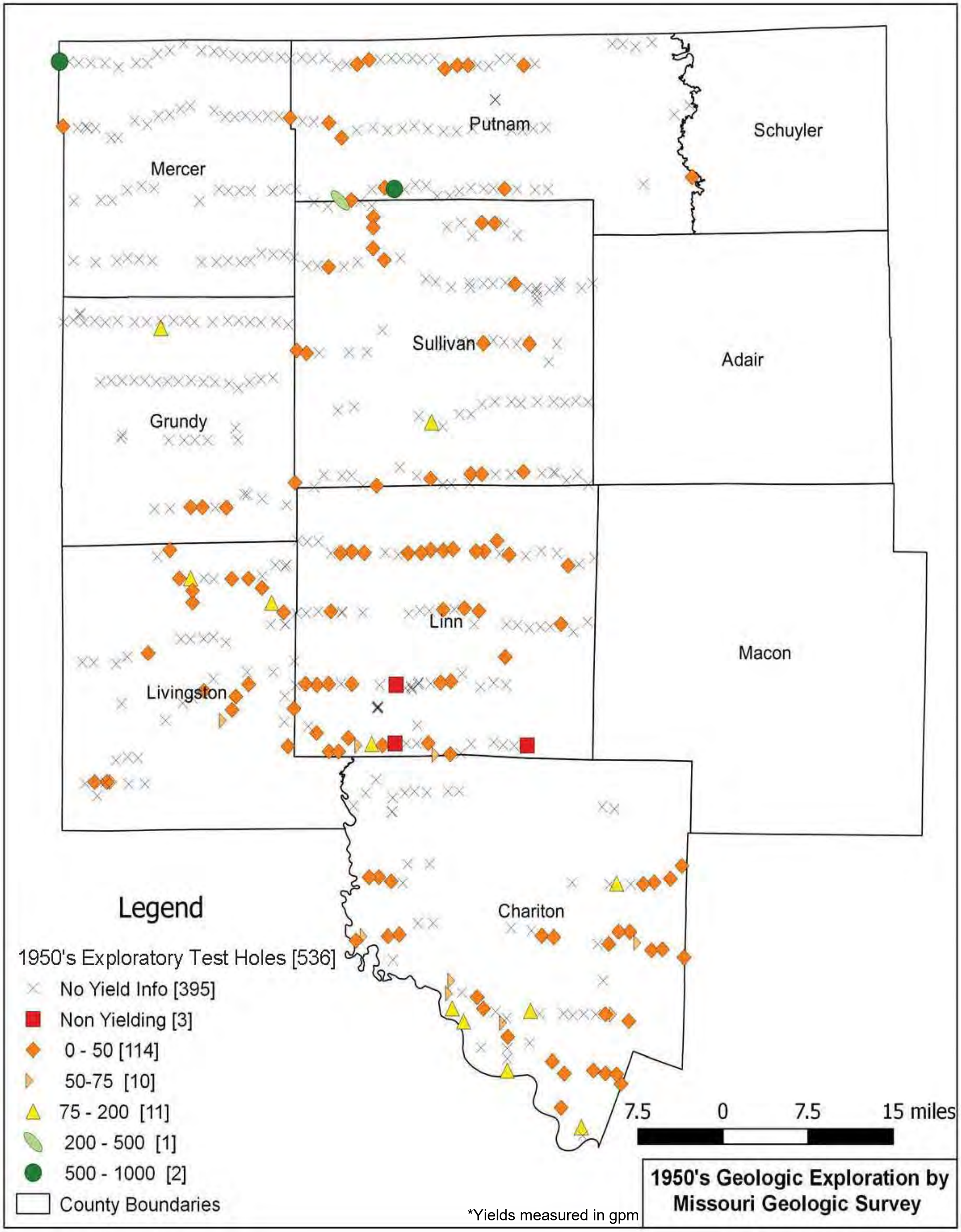


Figure 2.1.3-1. 1950s Geologic Exploration by Missouri Geologic Survey.

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.

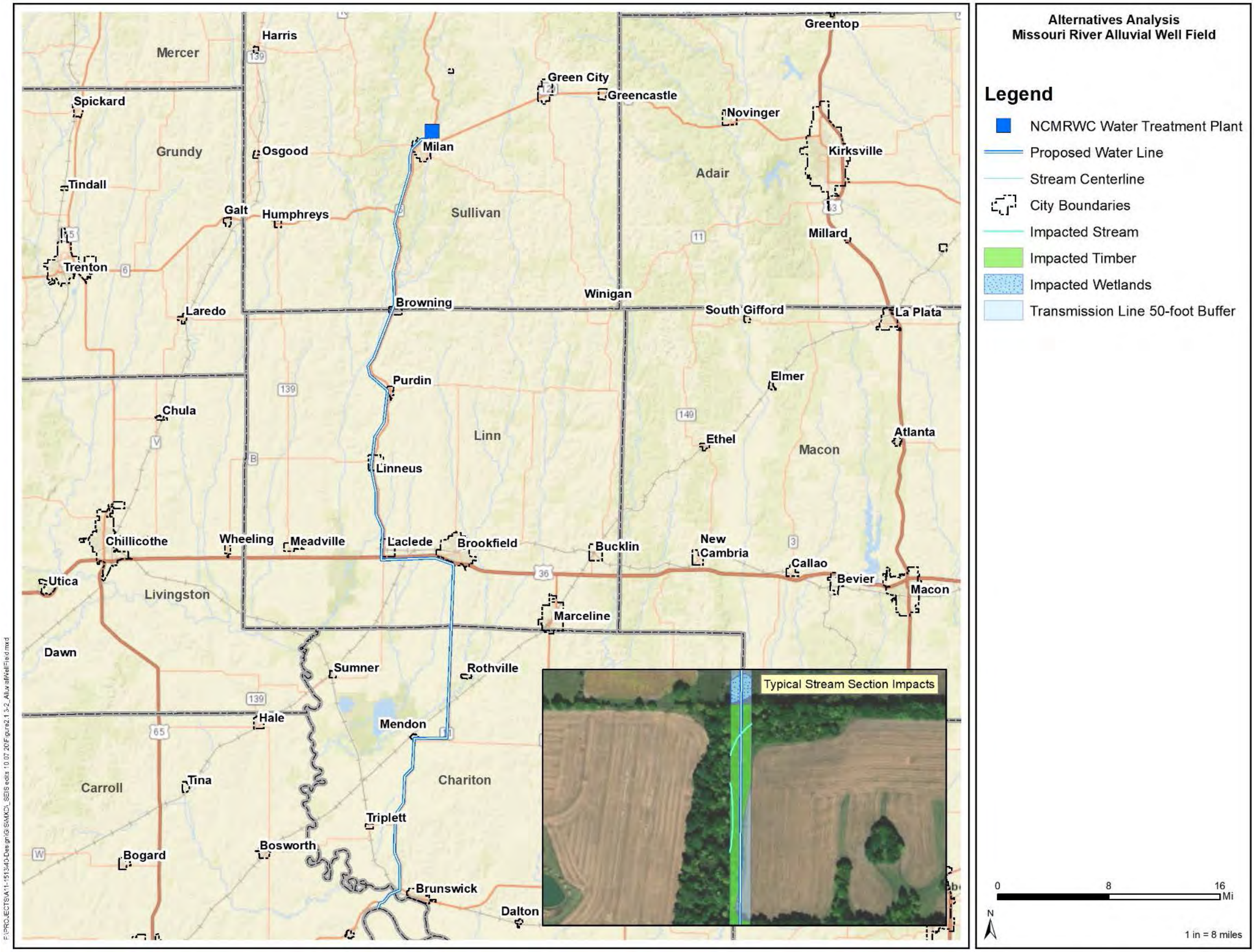


Figure 2.1.3-2. Missouri River Alluvial Well Field.

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.

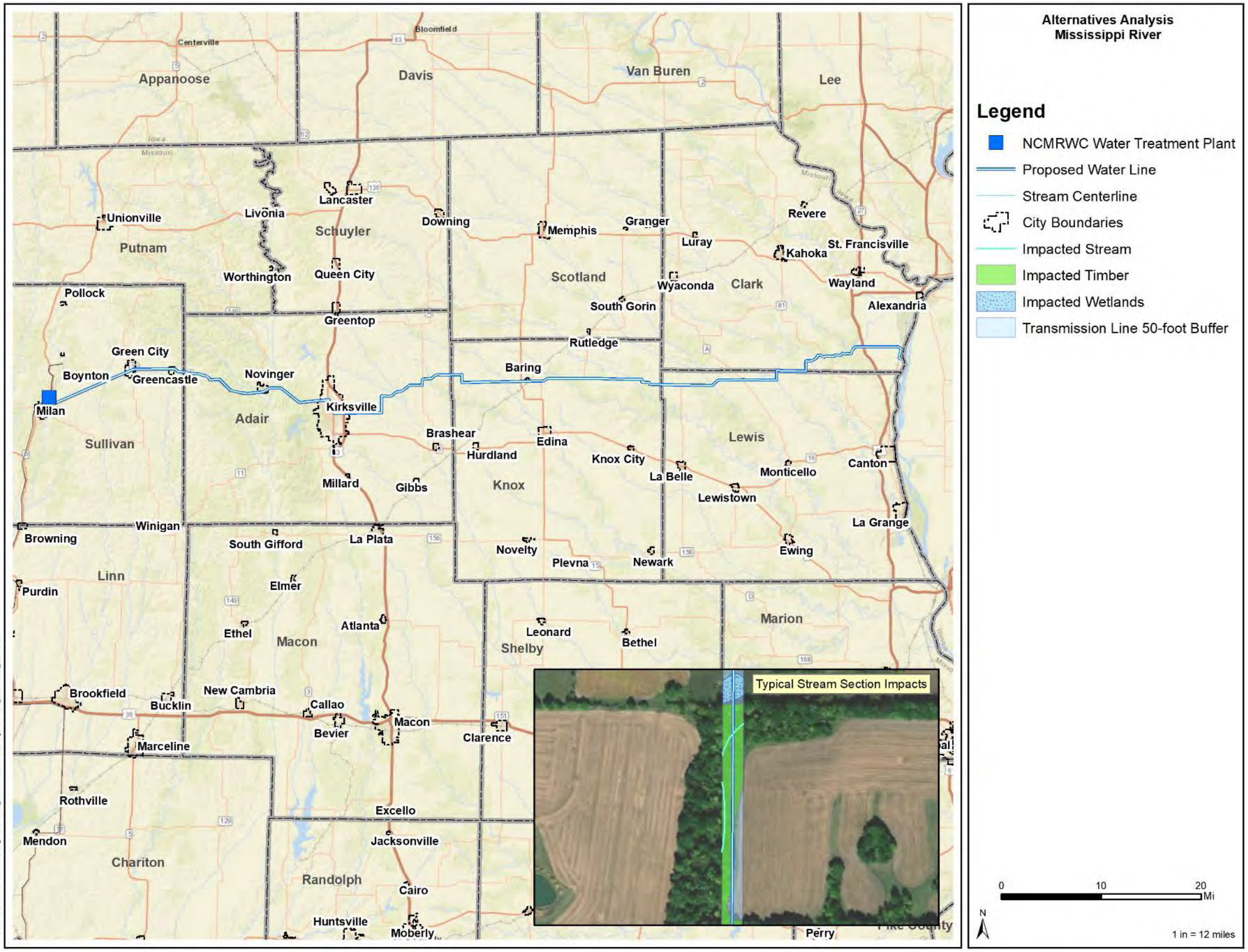


Figure 2.1.3-3. Mississippi River Alluvium Water Supply Alternative.

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.

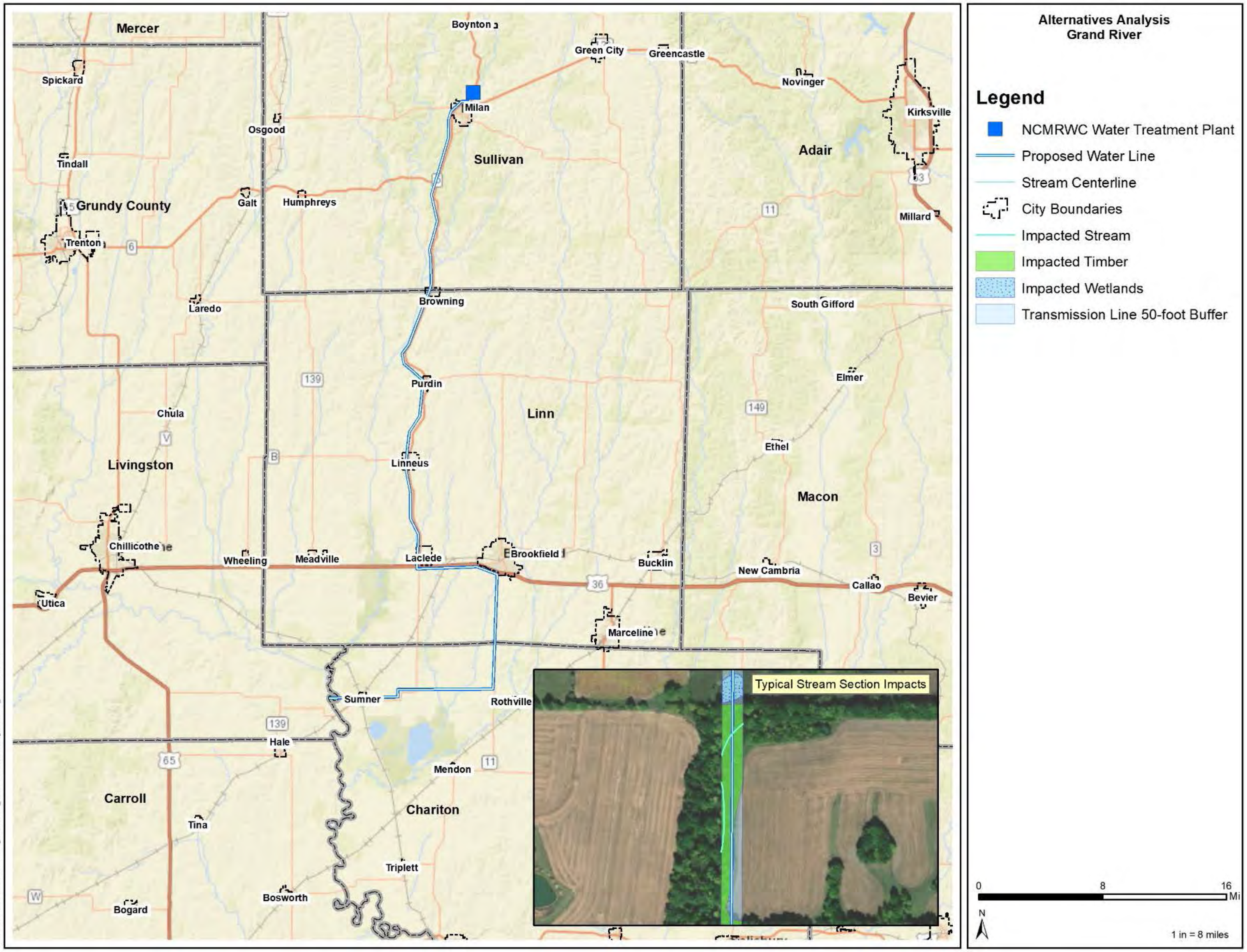


Figure 2.1.3-4. Grand River Alluvium Water Supply Alternative.

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.

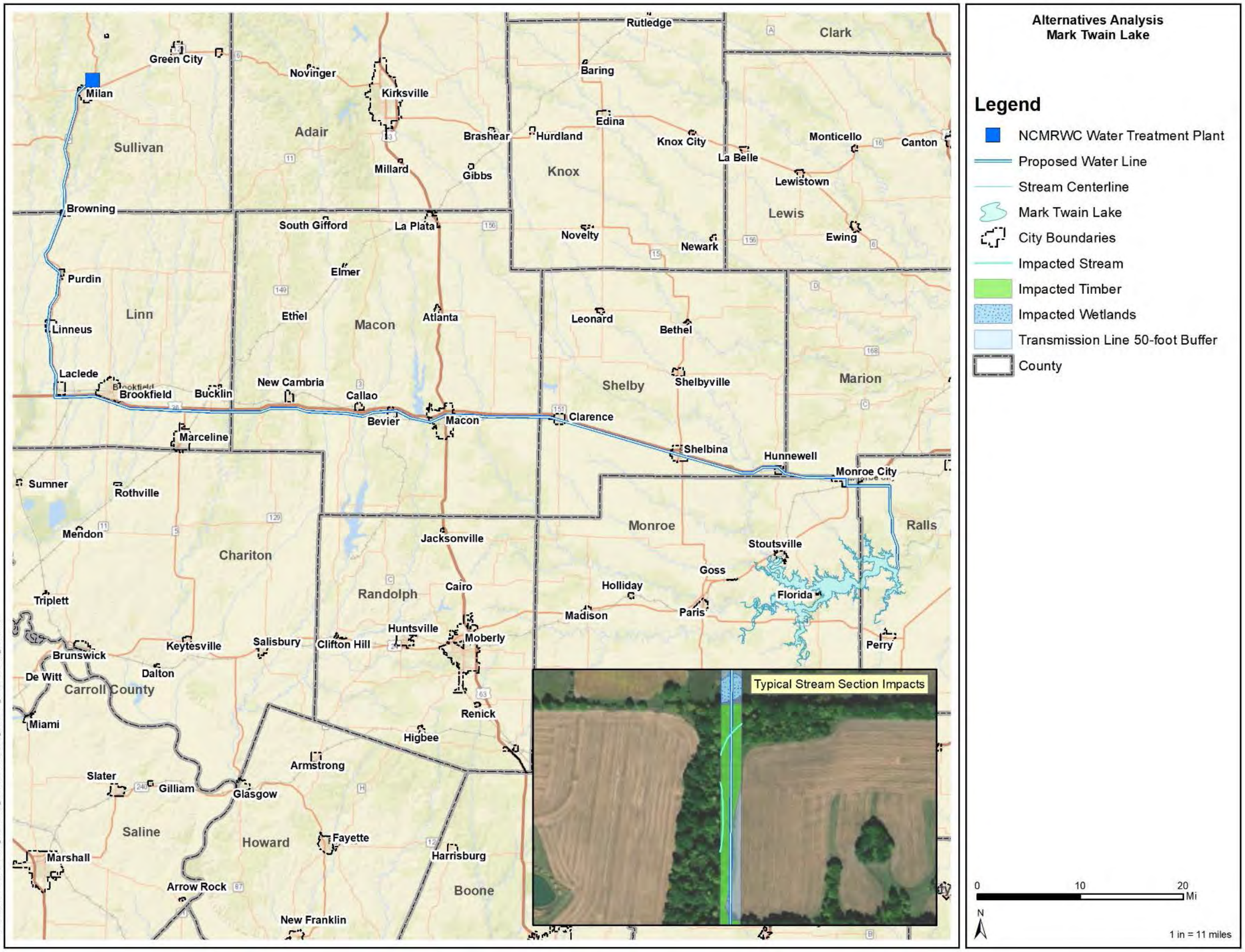


Figure 2.1.6-1 Mark Twain Lake Pipeline.

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.

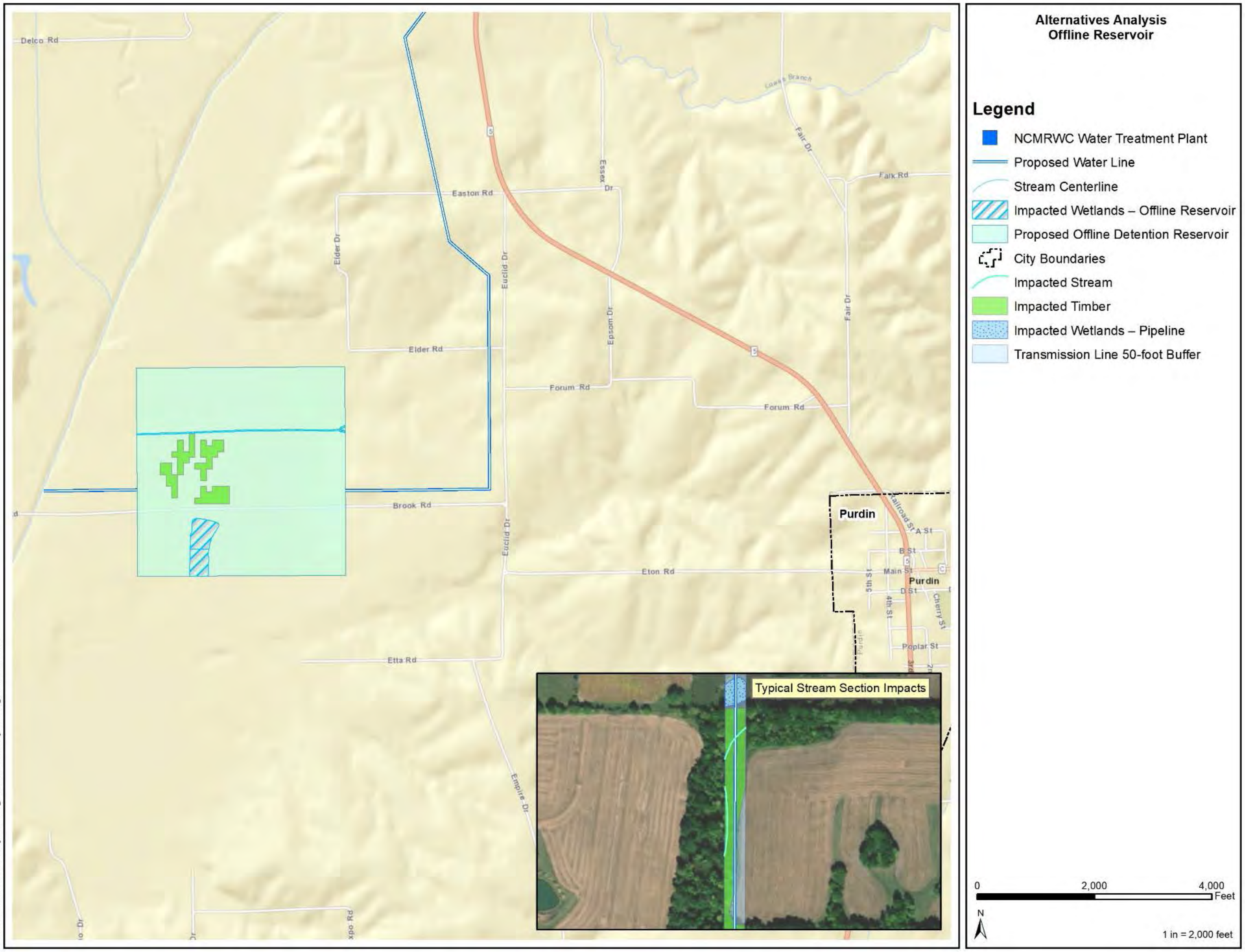


Figure 2.1.7-1. Offline Reservoir Water Supply Alternative.

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.

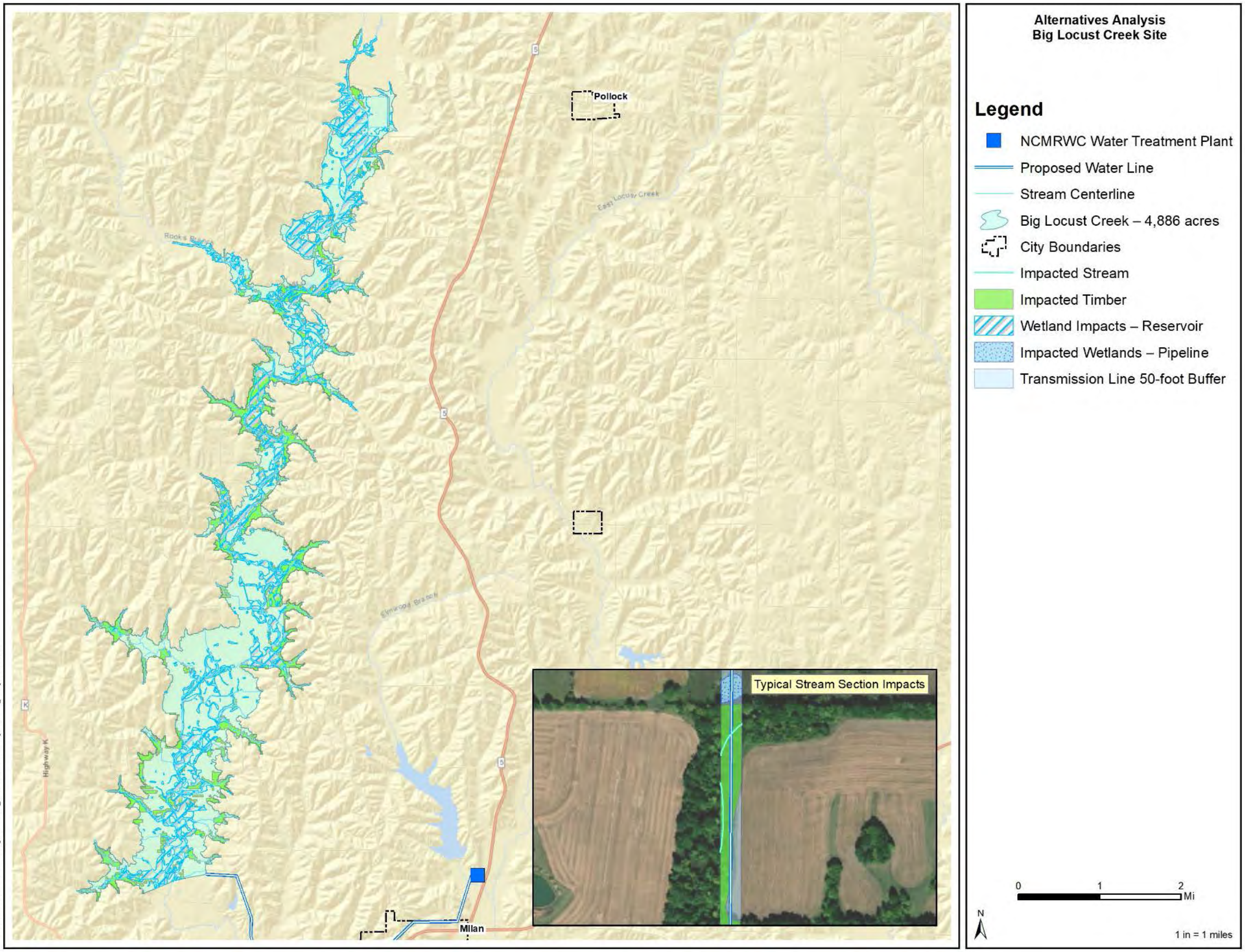


Figure 2.1.7-2 Alternative Lake Location Water Supply Alternative – Big Locust Creek Site.

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.

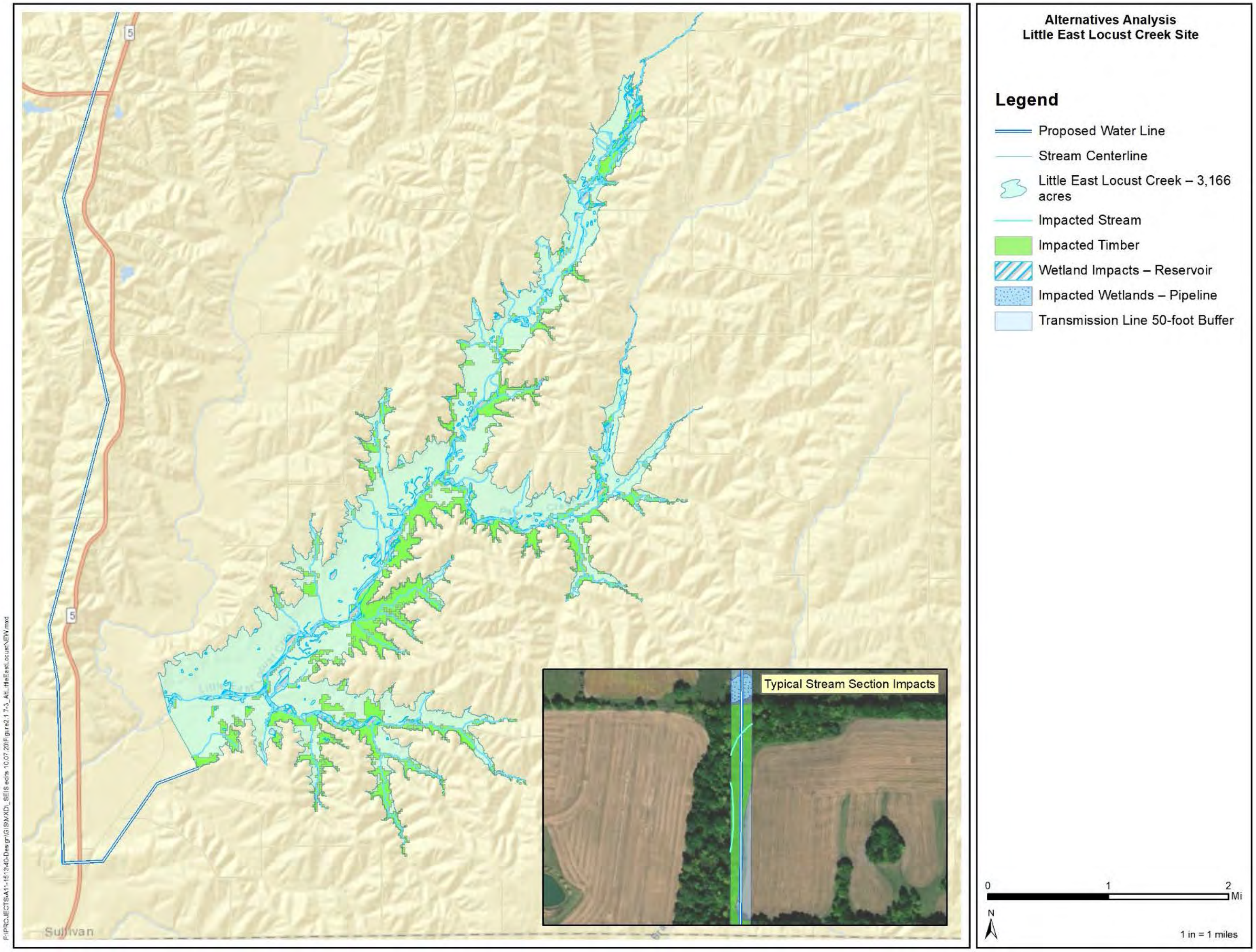


Figure 2.1.7-3. Alternative Lake Location Water Supply Alternative – Little East Locust Creek Site.

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.

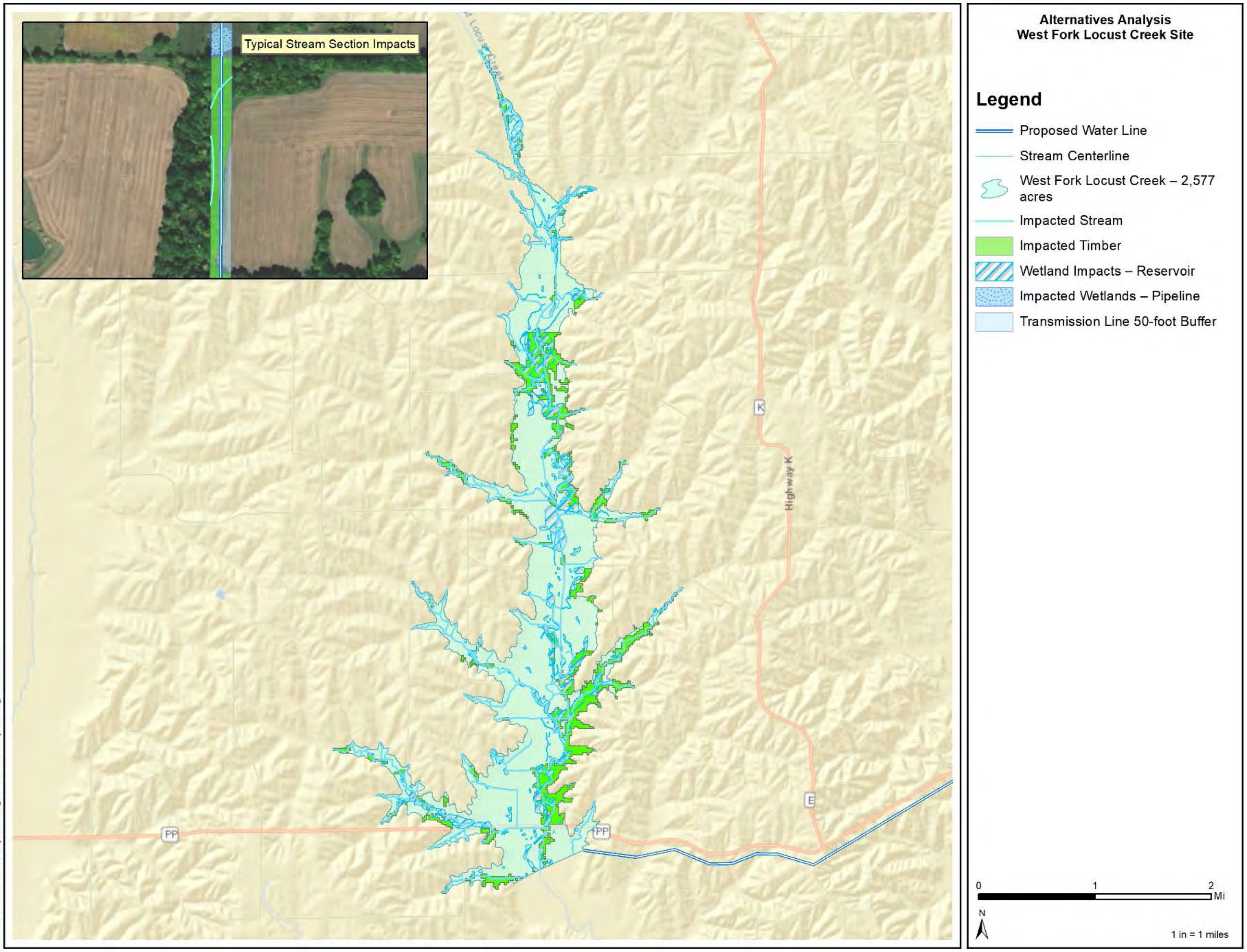


Figure 2.1.7-4. Alternative Lake Location Water Supply Alternative – West Fork Locust Creek Site.

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.

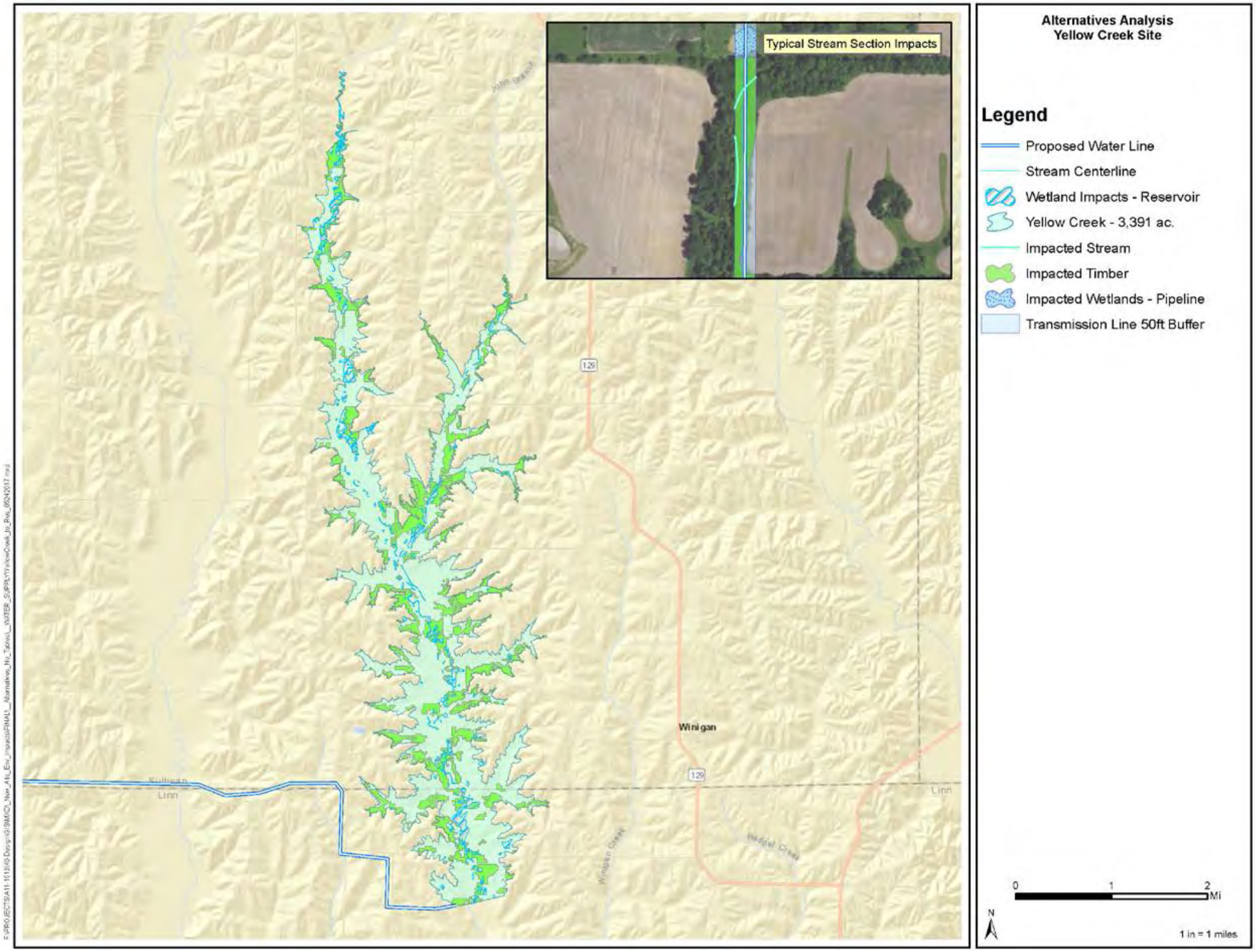


Figure 2.1.7-5. Alternative Lake Location Water Supply Alternative – Yellow Creek Reservoir.

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.

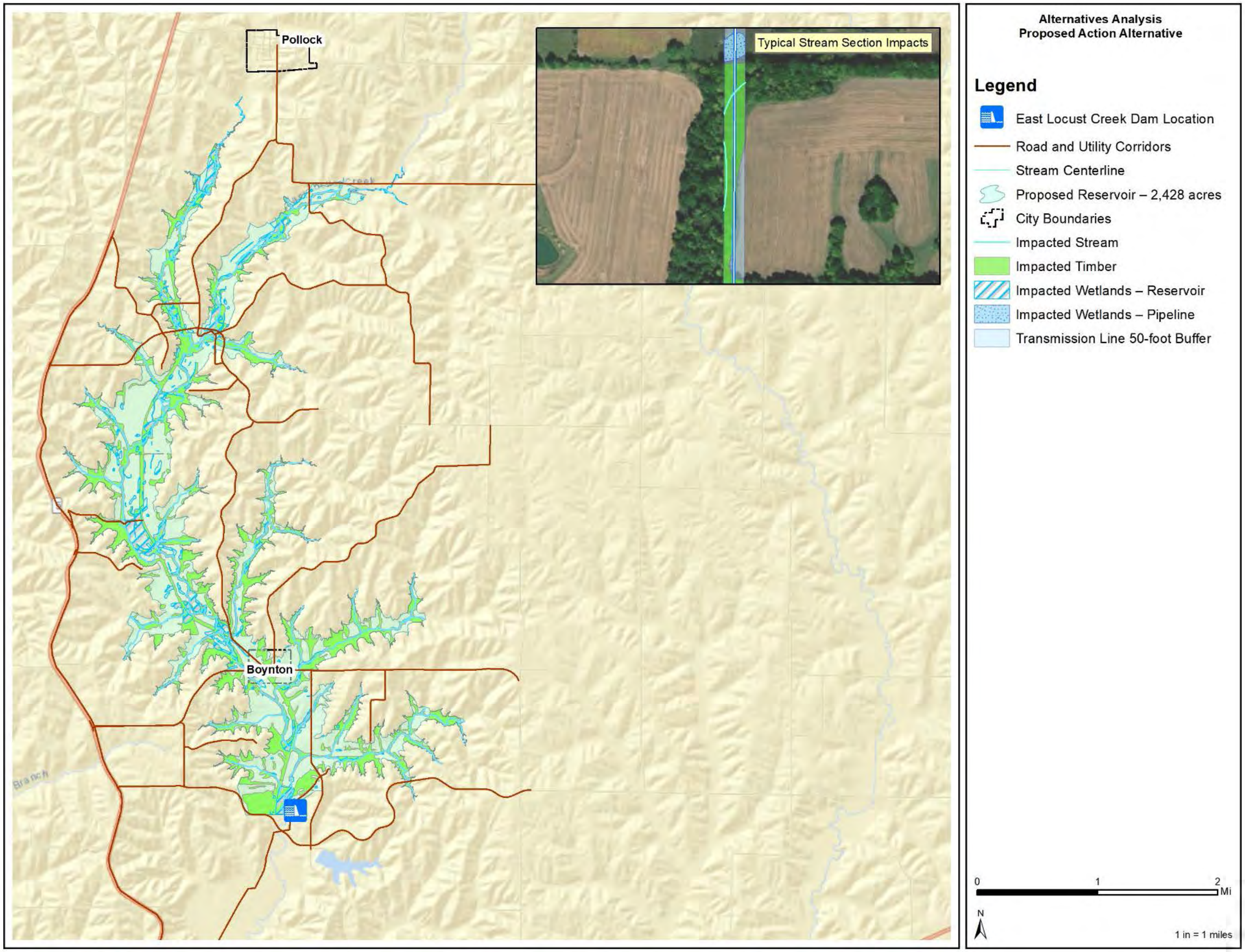


Figure 2.1.7-6. Water Supply Alternative – East Locust Creek Reservoir.

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 Participation	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

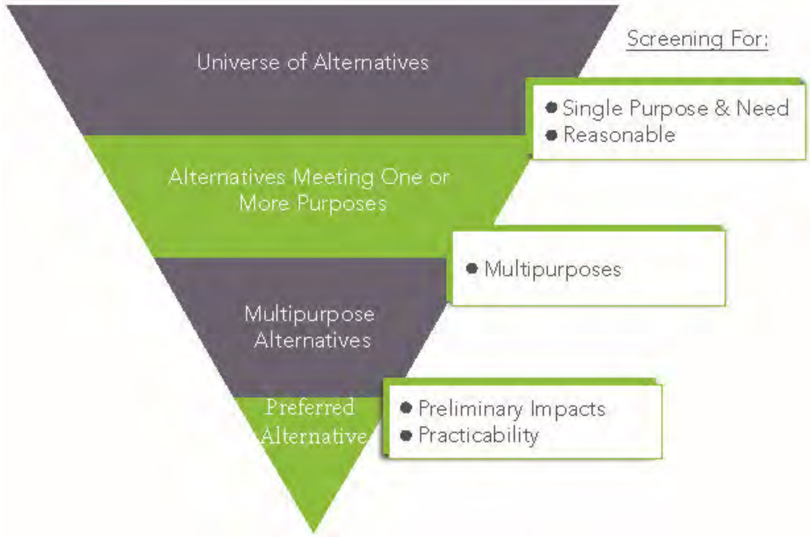
Existing Lakes

- 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.

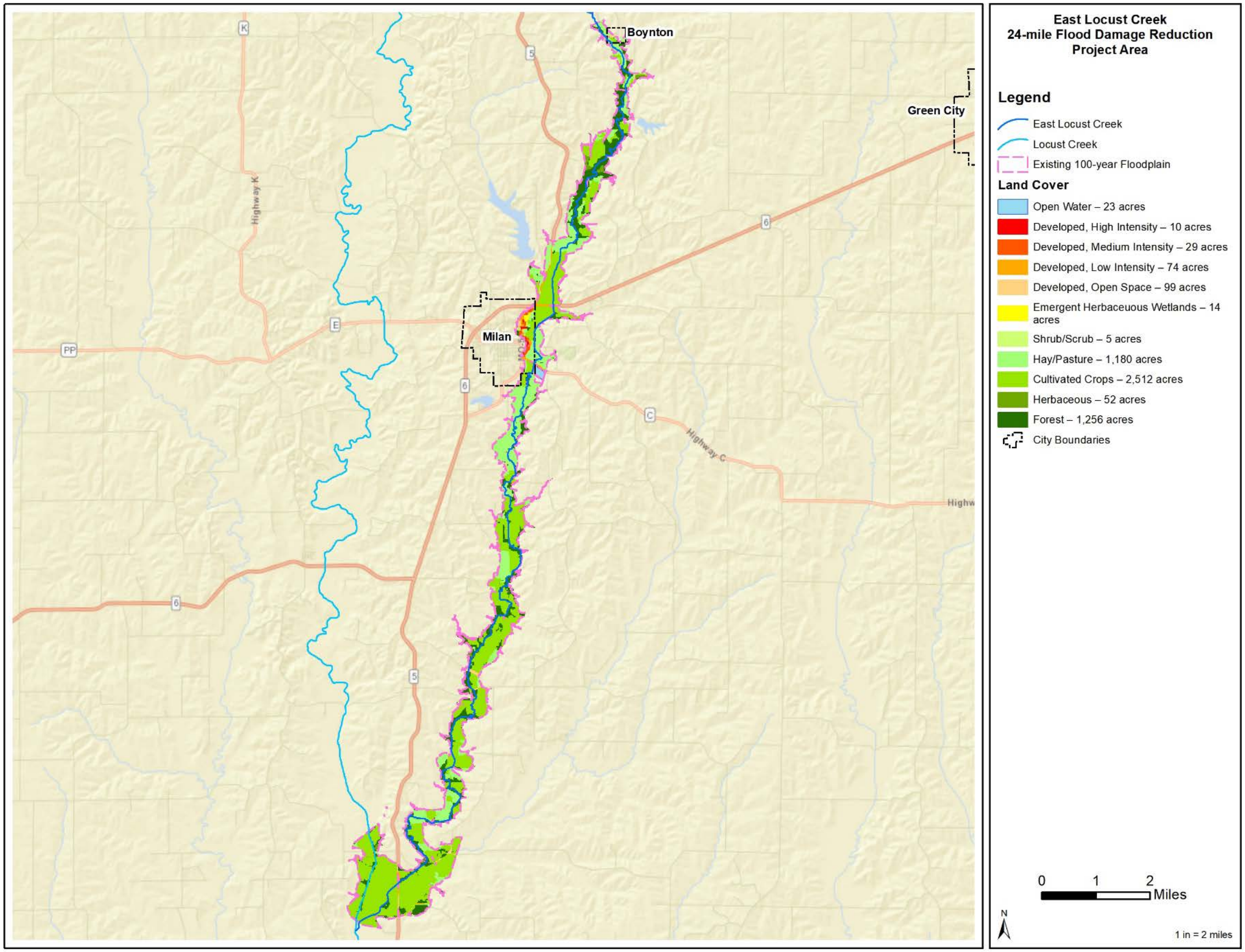


Figure 2.2-1. Flood Damage Reduction Area (URS Corporation 2014).

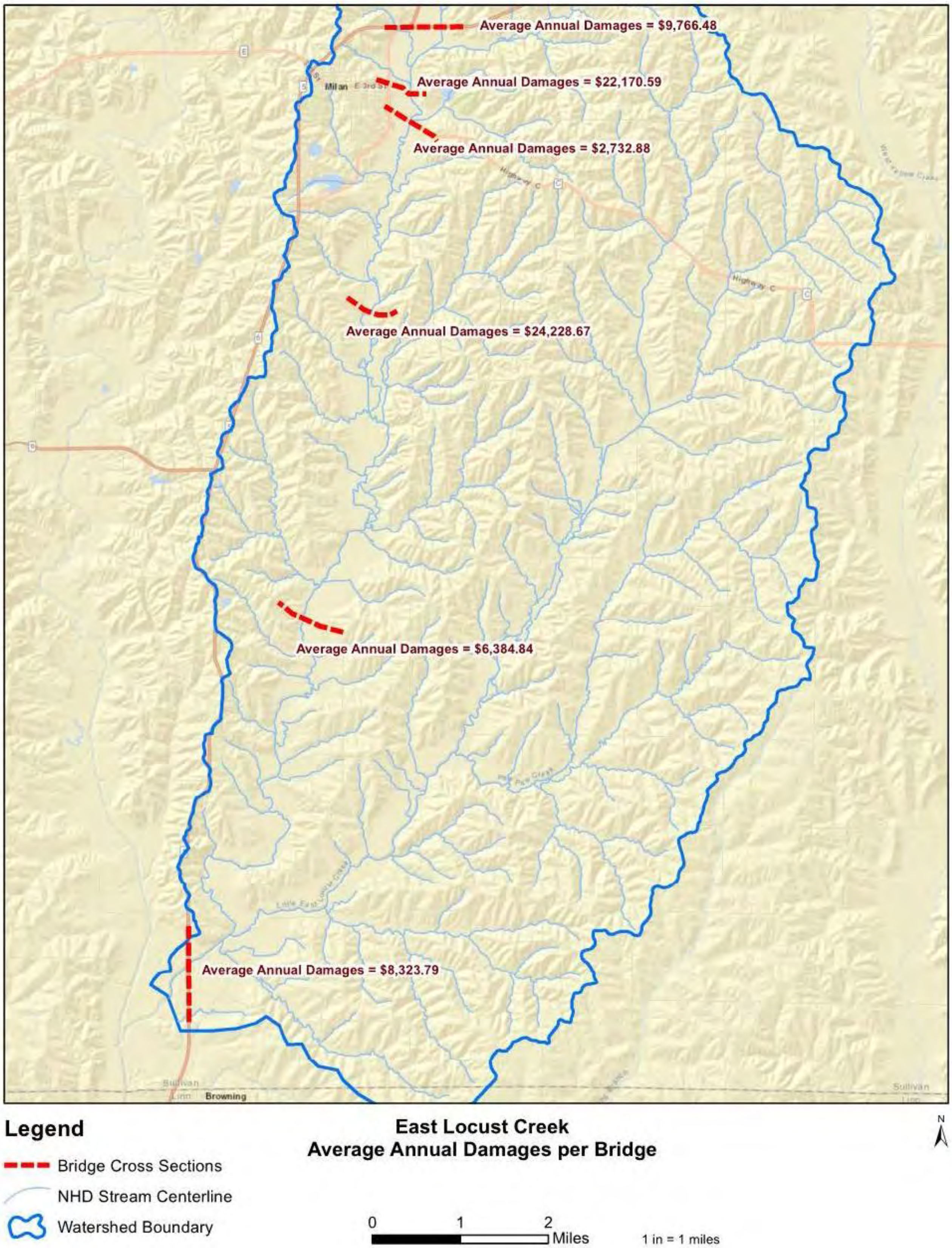


Figure 2.2-2. Location of and Average Annual Damage to Bridges within Flood Damage Reduction Area.

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.

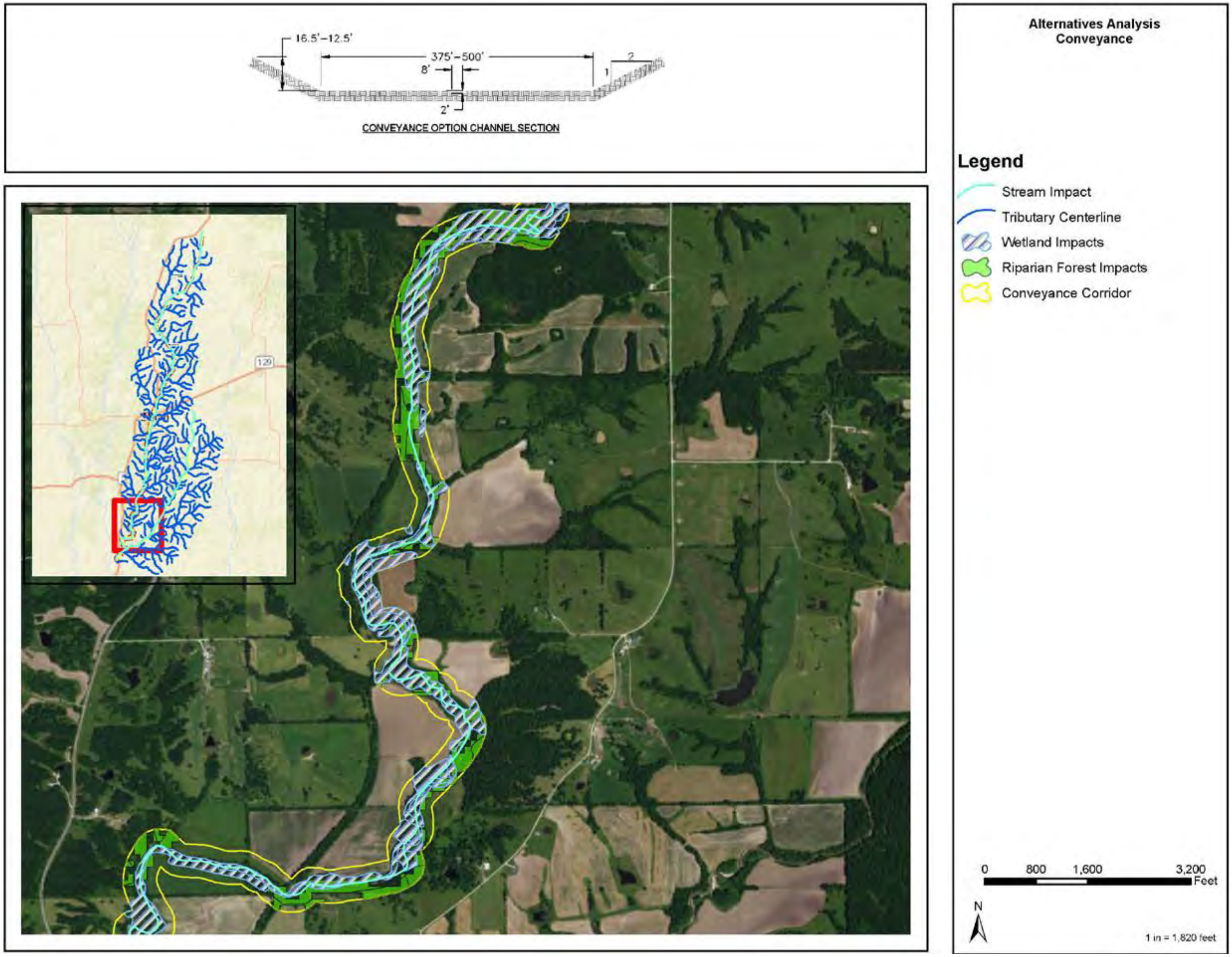


Figure 2.2.3-1. Stream Conveyance Conceptual Plan.

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.

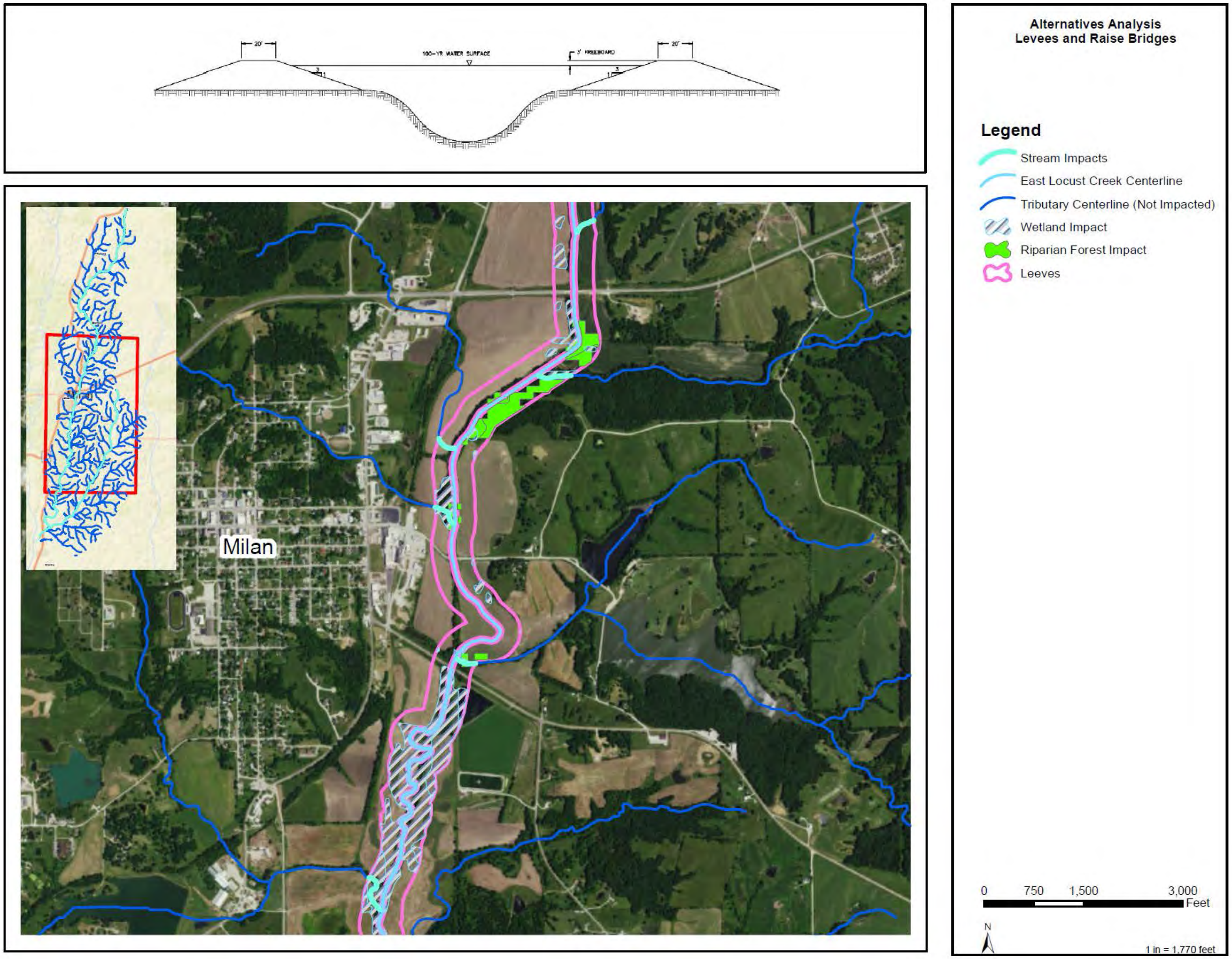


Figure 2.2.3-2. Construct Levees and Raise Bridges Conceptual Plan.

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.

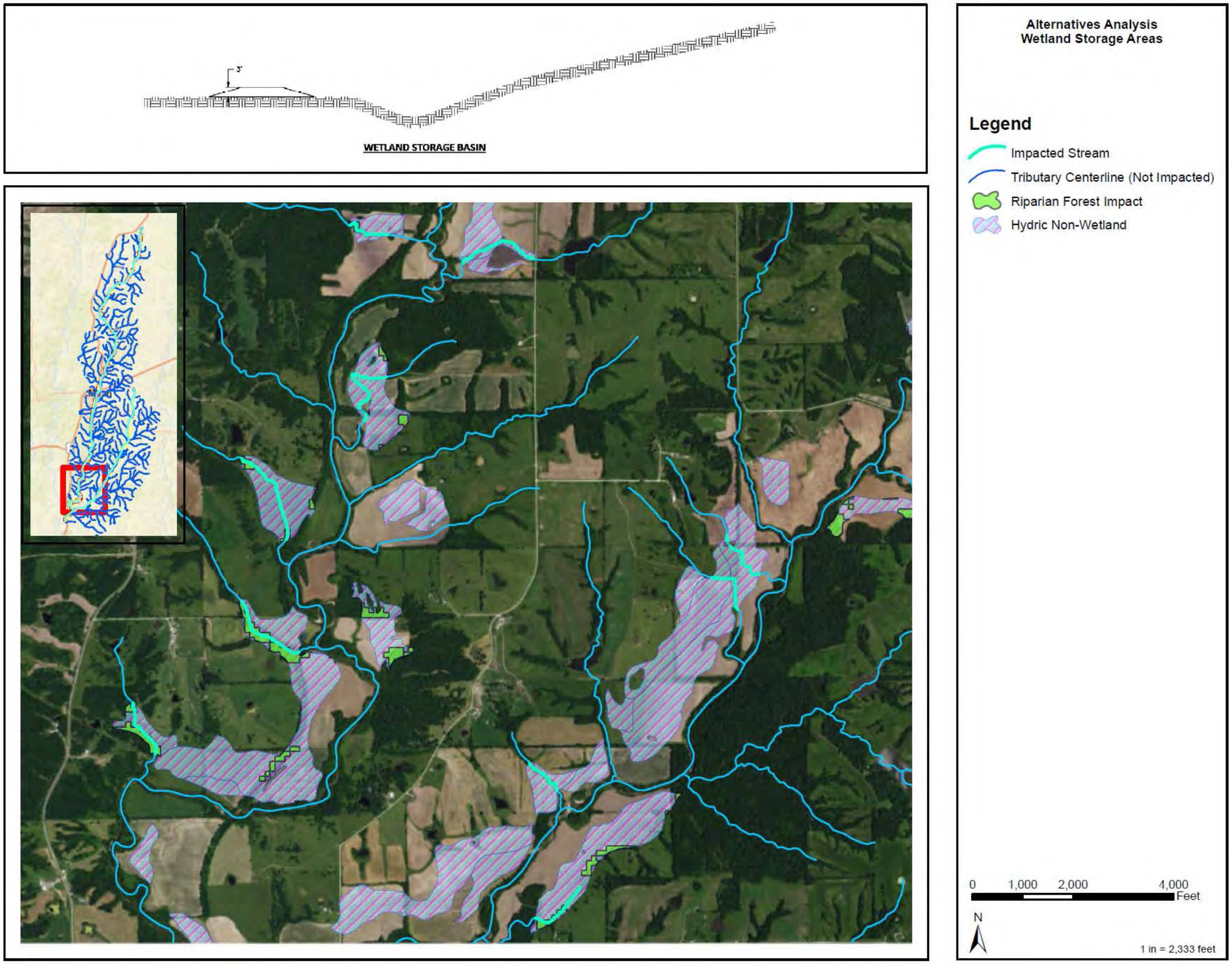


Figure 2.2.4-1. Wetland Storage Areas Conceptual Plan.

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.

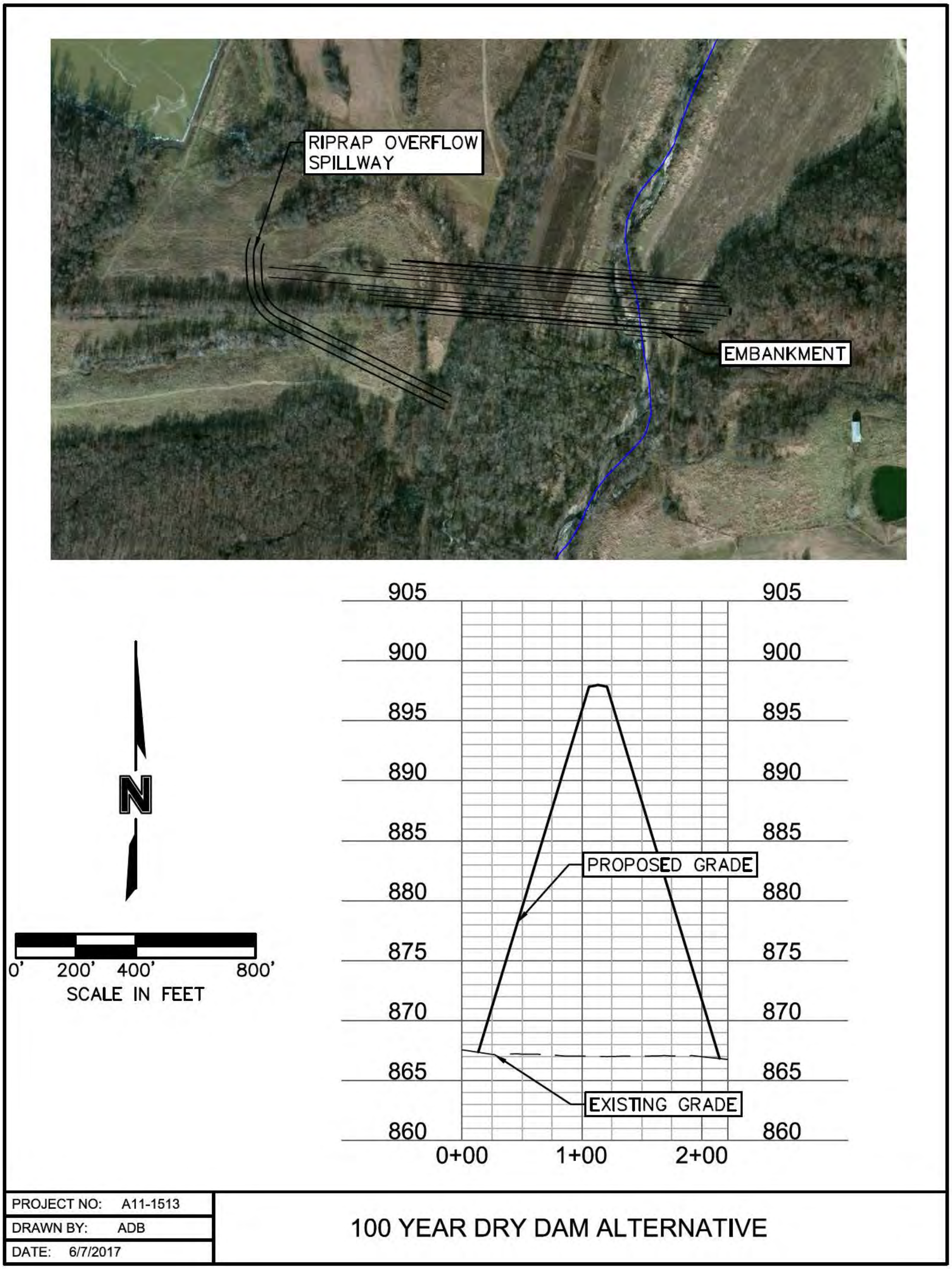


Figure 2.2.4-2. Large Dry Dam Conceptual Plan – 100-year Storage.

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.

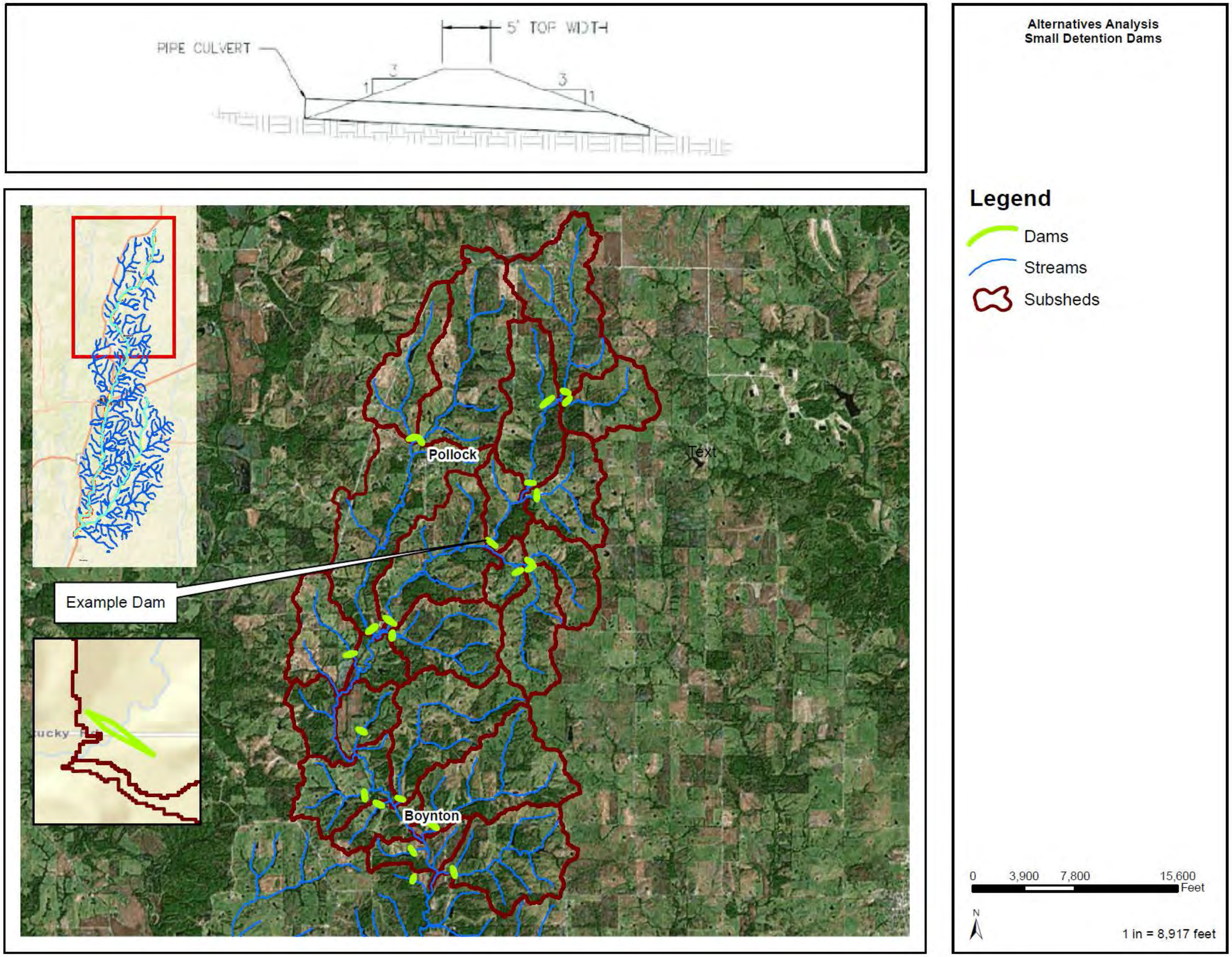


Figure 2.2.4-3. Small Detention Dams Conceptual Plan.

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:

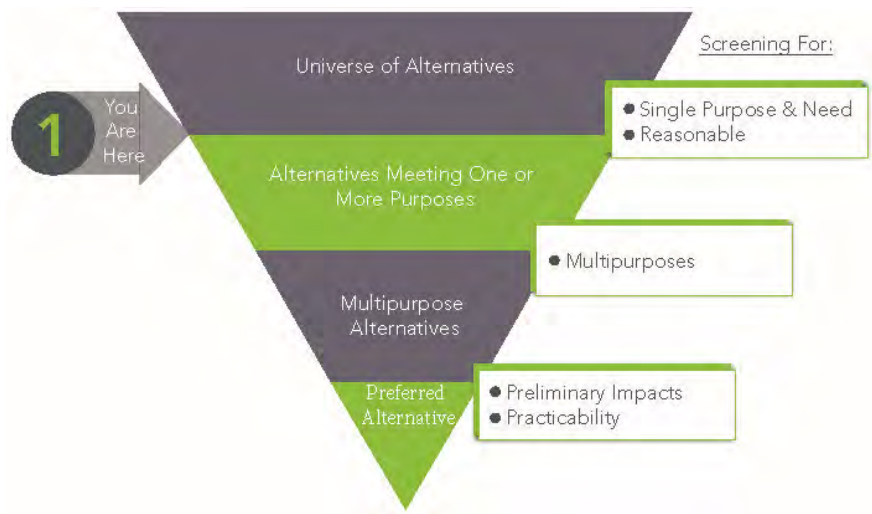
- Conveyance
- Levees and Raise Bridges
- Small Detention Dams

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



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

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."

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.

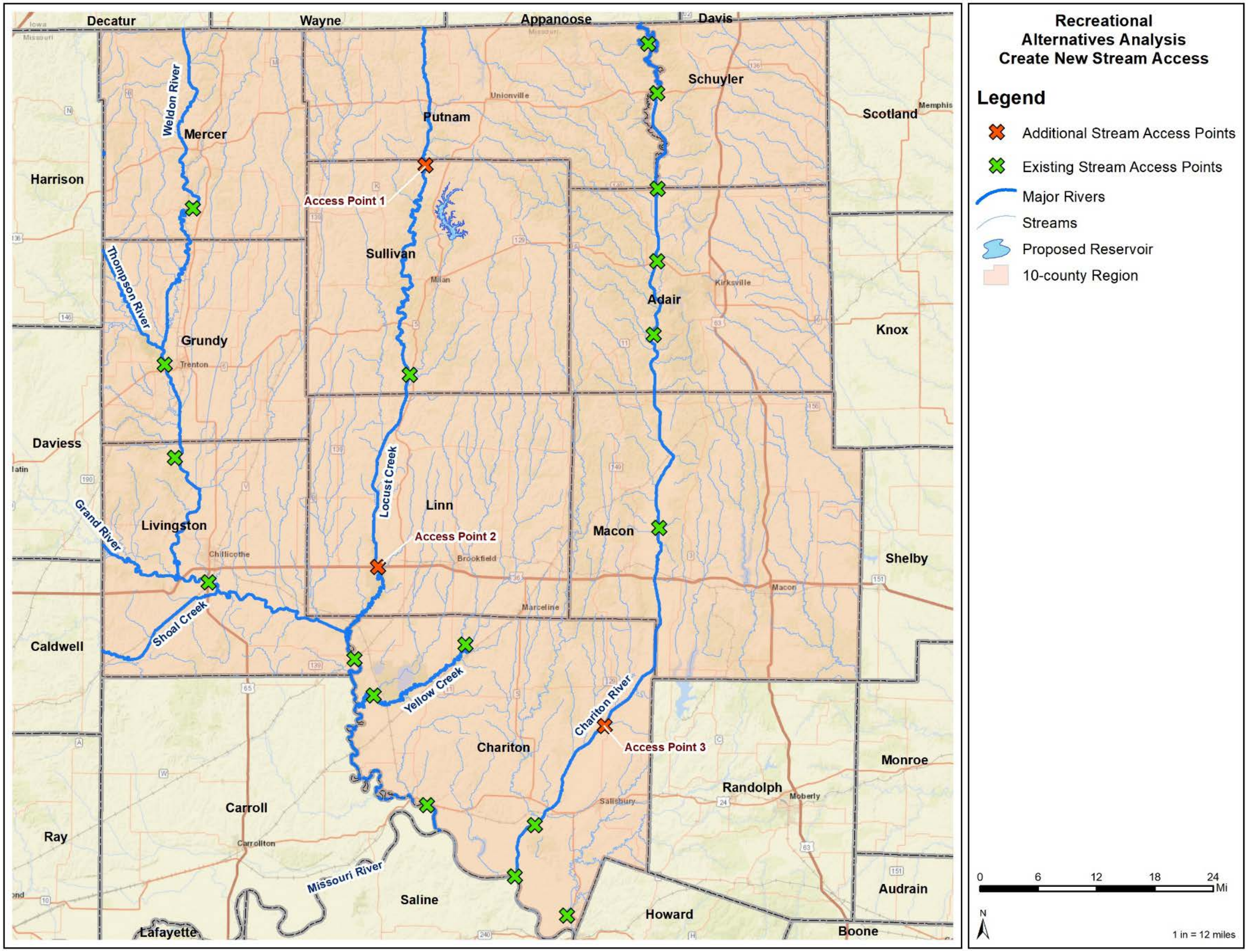


Figure 2.3.2-1. Water-based Recreation – Create New Stream Access Alternative.

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.

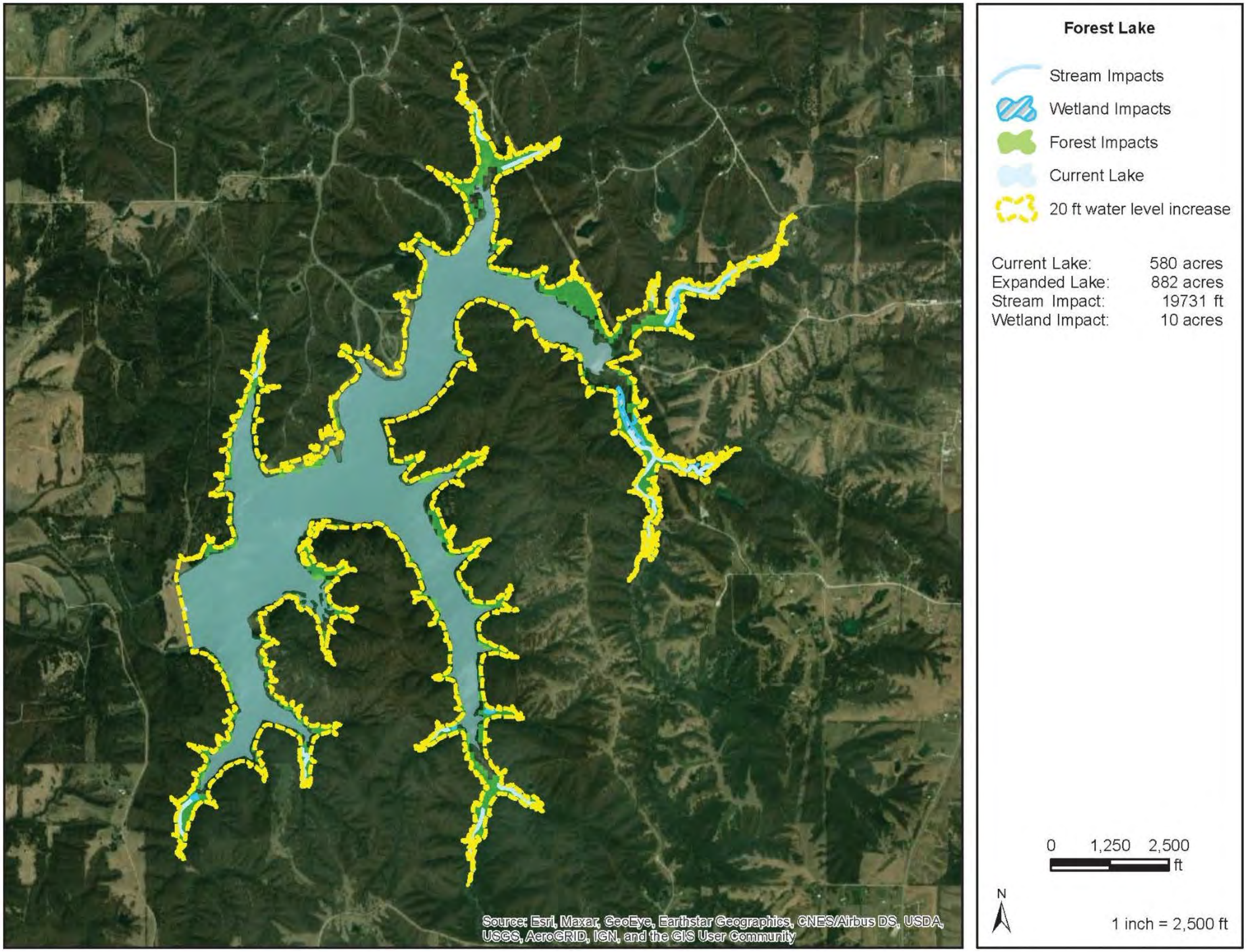


Figure 2.3.2-2. Water-based Recreation – Forest Lake (Thousand Hills) Expansion.

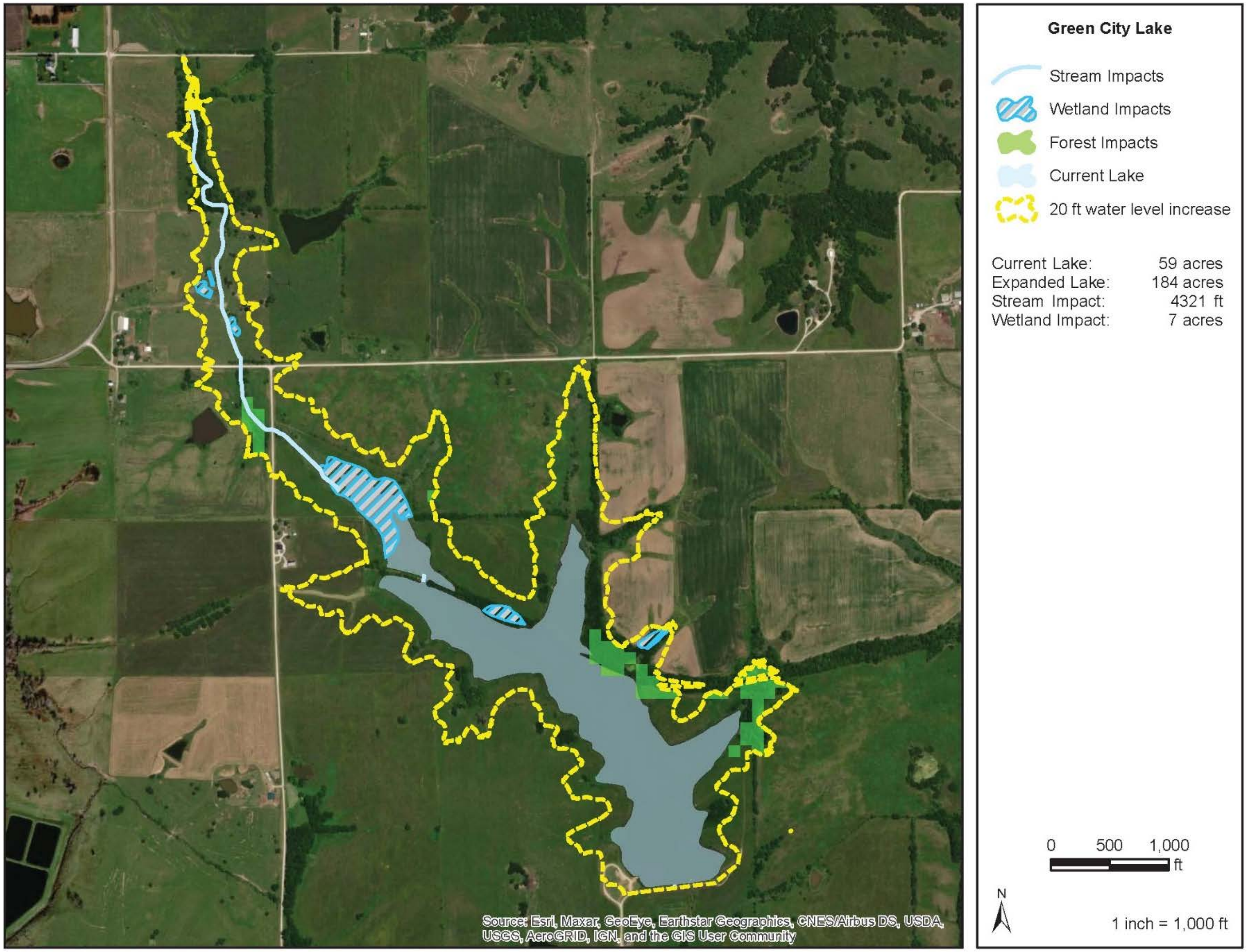


Figure 2.3.2-3. Water-based Recreation – Green City Lake Expansion.

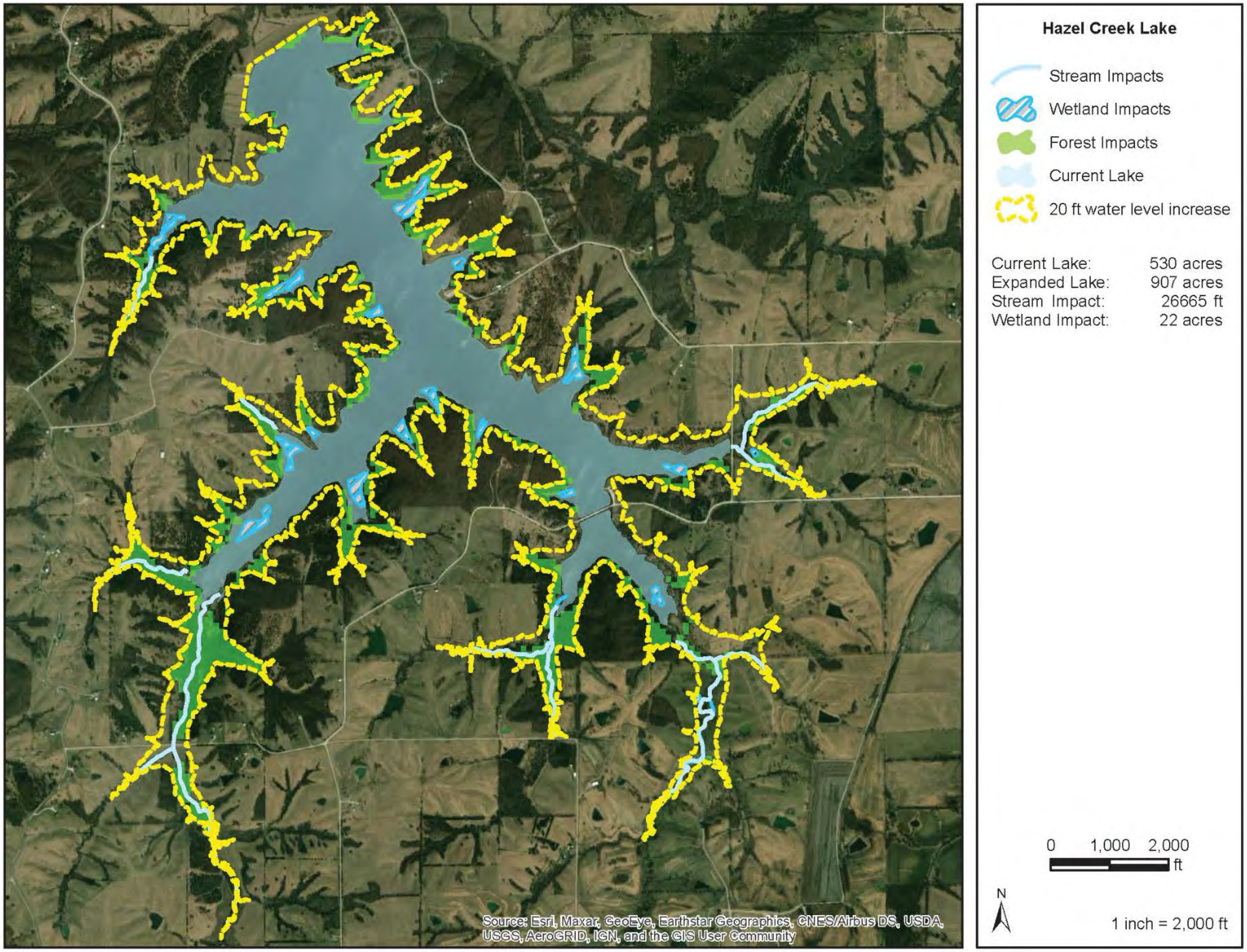


Figure 2.3.2-4. Water-based Recreation – Hazel Creek Lake Expansion.

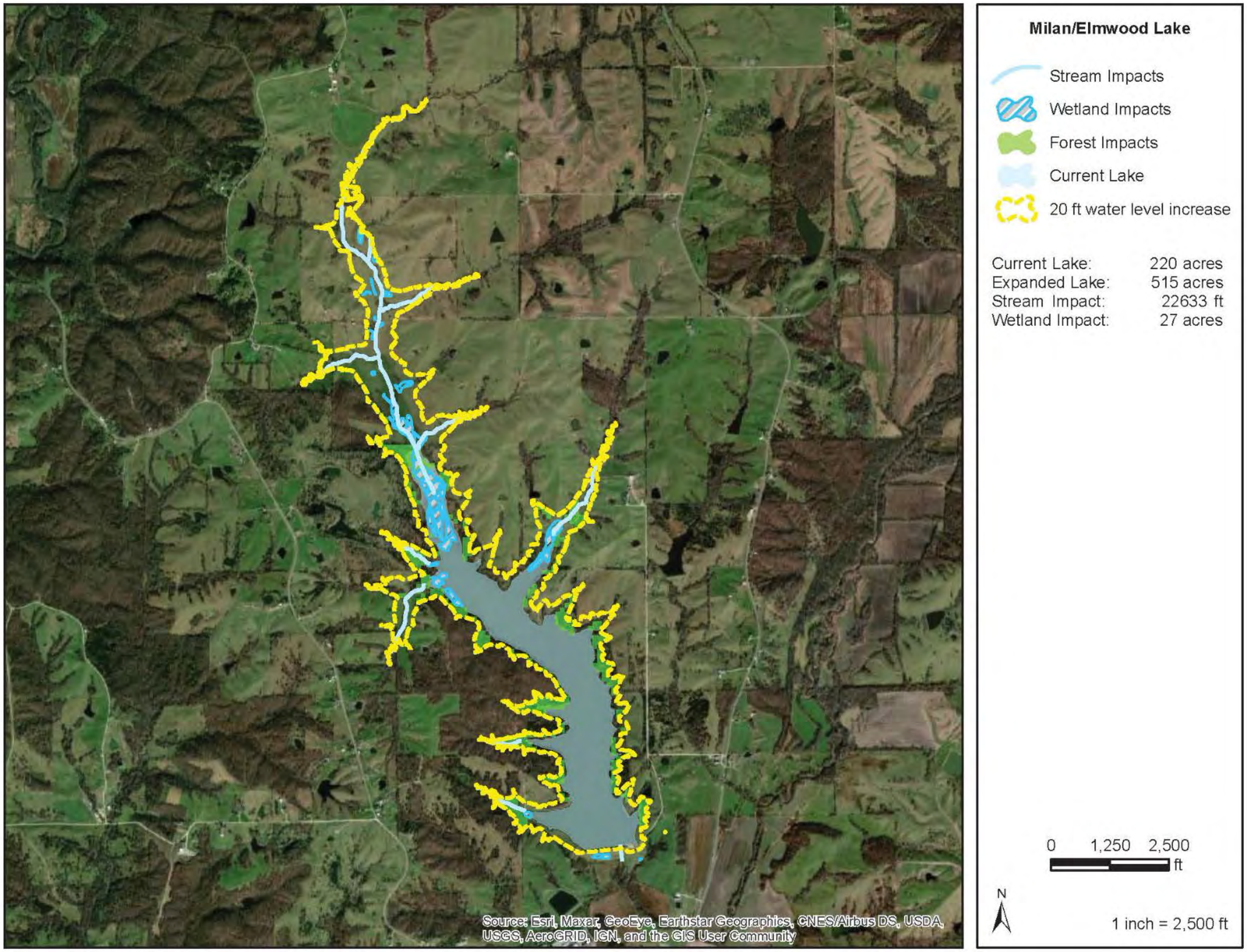


Figure 2.3.2-5. Water-based Recreation – Elmwood Lake Expansion.

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.

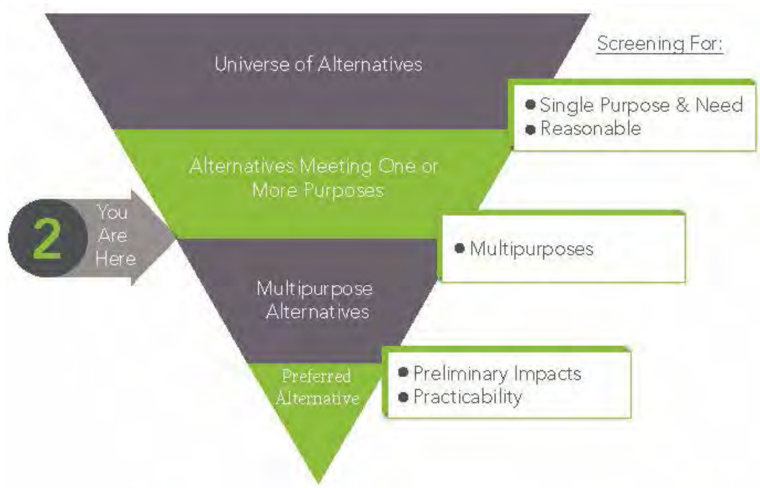
The multipurpose analysis evaluates the following:

- 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: Water Supply	Meets Project Purpose of: Flood Damage Reduction	Meets Project Purpose of: Recreation	Project Costs[1] ($)	Connected Actions Costs[1] ($)	Environmental Impacts: NHD Stream[2] (miles)	Environmental Impacts: MSC Stream[3] (miles)	Environmental Impacts: Temp NHD[2] (miles)	Environmental Impacts: Temp. MSC[3] (miles)	Environmental Impacts: Wetland[4] (acres)	Environmental Impacts: Temporary[4] Wetland (acres)	Environmental Impacts: 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

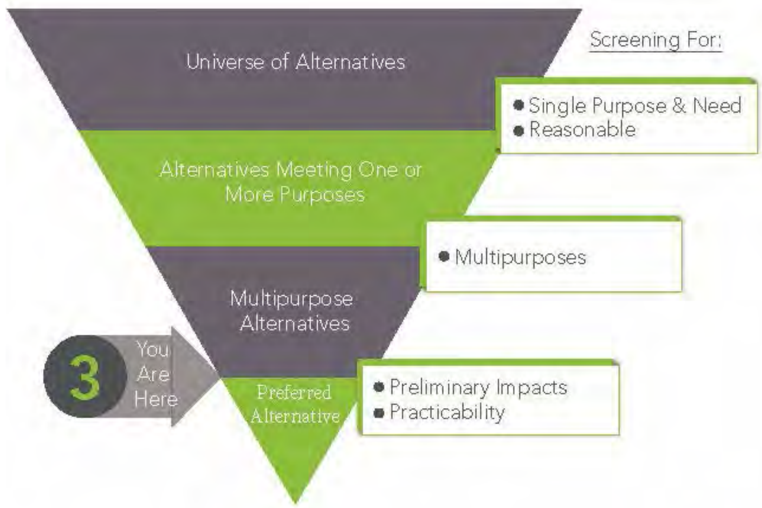
For this Preferred Alternative analysis, life cycle costs of different alternatives are an important consideration. An alternative with life cycle costs that are substantially more than another may not be considered to be practicable.

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.