Investigation and Analyses Report for the Logan River Watershed Project

Appendix D

Logan River Watershed

Cache County, Utah

The purpose of the Investigation and Analysis Appendix is to present information that supports the formulation, evaluation, and conclusions of the Watershed Plan and Environmental Impact Statement (EIS). Refer to the Administrative Record for the copies of the studies referred to in this Appendix.

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D.1.0 Introduction

This document summarizes the investigations and analysis completed for the planning and engineering of the stormwater and flood prevention, agricultural water management, and recreation activities in preparation for the Logan River Watershed Plan–Environmental Impact Statement (Plan-EIS). This information includes a summary of the design and criteria, analysis for agricultural water management, hydrologic and hydraulics, and flood protection, alternatives formulation and preferred alternative costs, economic evaluations, and economic benefits. Additional information relevant to each of the sections provided in this report is available in Appendices E2 E3, E4, and E5 and as part of the administrative record for the project.

The Logan River Watershed Project (Proposed Project) is located within the Logan River Watershed in portions of the City of Logan, North Logan City, Hyde Park City, Benson census-designated place (CDP), and unincorporated Cache County, Utah. The Proposed Project consists of three project purposes: agricultural water management, flood protection, and recreation. See Technical Memoranda (TM) -006 (TM-006) Agricultural Water Management Alternative Development in Appendix E3, prepared by Franson Civil Engineers Inc., and TM-019 Urban Flood Control and TM-020 Recreation Design Summary, prepared by J-U-B ENGINEERS, Inc. (J-U-B), in Appendix E5 for more details on the Proposed Project.

D.2.0 Agricultural Water Management

The Crockett Avenue Irrigation Company (CAIC) aims to improve agricultural water management within the service area. The project is essential to improve efficiency, water conservation, and maintenance, as well as enhance environmental conditions and beneficial water use in the form of instream flows. The rapidly growing population in the project area demonstrates a need to improve public safety by reducing Crockett Diversion and Crockett Canal risk of failure. See Appendix E3, TM-006 Agricultural Water Management Alternatives Development for more information. Project measure categories include diversion location, intake method, distribution method, water storage method, instream flows, hydropower, additional water rights, diversion removal, and Logan River flood management as described in Table 4-1 in the Plan-EIS and in TM-006.

D.3.0 Stormwater and Flood Prevention

The Logan Northern, Logan Northwest Field, and Logan/Hyde Park (Twin) canals have been used for irrigation and floodwater conveyance, along with other existing flood protection infrastructure, throughout Logan. The watershed currently manages flood waters using a system of existing canals that double as irrigation conveyance systems. However, population growth has replaced farmland with impermeable surfaces—increasing stormwater runoff—and the existing canals now lack capacity for larger storms. Recent flash floods have exposed deficiencies in the system.

The canal systems do not have the capacity to carry flood flows from storms with a return period of 10 years or greater, which results in the potential for frequent flooding of buildings, property, and agricultural land throughout the project area. The Proposed Project would make improvements or replace multiple pieces of infrastructure to provide flood control for the cities of Logan, North Logan, Hyde Park, Benson CDP, and parts of unincorporated Cache County, addressing flooding from large storm events. See Appendix E5, TM-019 Urban Flood Control for more information. Topics include purpose and need, historic conditions and flooding, floodwater protection policies, previous studies, flood water analysis, canal systems overview, and canal system model by alternatives in TM-019. See Table 4-1 in the Plan-EIS for the specific flood protection and flood damage measures considered for the Proposed Project.

D.4.0 Recreation

The recreation component of the Proposed Project consists of two ADA compliant shared paths: Canyon Road Trail and River Hollow Trail. Enhancement of recreational access points to terrestrial and river trail systems is ancillary to replacing an existing canal in a location where the canal water would be piped and to provide access to maintain key components of the pressure irrigation and flood prevention infrastructure. See Appendix E5, TM-020 Recreation Design Summary for more information. Topics include purpose and need, improved system—Canyon Road Trail and River Hollow Park Trail, design criteria, including American Disabilities Act and American Association of State Highway and Transportation Officials, and use projections in TM-020.

D.5.0 Design and Criteria

The Proposed Project would be designed to meet the NRCS and Utah state requirements and other applicable design requirements and standards, as shown in Table 5-1 by project purpose. See Appendix E3, TM-005 Agricultural Water Management Design Criteria, prepared by Franson Civil Engineers Inc. for more details on the design criteria for the Proposed Project. Other Utah or NRCS codes, as applicable, would also be followed along with the City of Logan, North Logan City, and Hyde Park City's Public Works standards for construction and stormwater management.

The design of the proposed pressure irrigation systems would meet the requirements of the NRCS and Utah State Code. Design requirements are identified in NRCS Practice Standards Codes 430 and 533, American Concrete Institute (ACI) Code 350, Hydraulic Institute (HI) Standards, Utah Rules R309-510, R317-3-9, R317-3-11, American Public Works Association (APWA) 2017 standards and specifications, and supplier requirements.

The Logan River Watershed includes Logan City, North Logan City, Hyde Park, Benson CDP, and unincorporated Cache County. Logan City and North Logan have design standards and construction specifications that are used throughout their jurisdictions. Hyde Park and Benson CDP have both adopted the standards of the Utah State Code. Cache County uses the Cache Valley design standards throughout the county. Additional design requirements are identified in NRCS Practice Standards, along with APWA 2017 standards and specifications. The roads within the project area that are maintained by the State include U.S. Highway (US)-91, State Road (SR)-252, and SR-218. Utah Department of Transportation (UDOT) design criteria for flood protection will use the UDOT Roadway Design Manual and UDOT Drainage Manual of Instruction as a basis for improvements.

Table 5-1. Design Criteria Used for Each Project Element

Number	Design Criteria & Practice Standards	Flood Control	Irrigation	Recreation (along Logan River or Trail)
1	Logan City Floodplain Development Permit Requirements	X	X	-
2	Federal Emergency Management Agency (FEMA) Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) Requirements	X	X	X
3	Cache Valley Storm Water Design Standards (2017)	X	X	X
4	Logan City Public Works Design Standards	X	X	X
5	Logan City Storm Water Design Criteria	X	X	-
6	Logan City Land Development Code	X	-	X
7	North Logan City Design Standards	X	X	X
8	Hyde Park City Design Standards	X	X	X
9	NRCS Irrigation Canal and Lateral (Code 320)	-	X	-
10	NRCS Clearing and Snagging (Code 326)	X	-	-
11	NRCS Critical Area Planting (Code 342)	X	X	X
12	NRCS Aquatic Organism Passage (Code 396)	X	X	X
13	NRCS Irrigation Pipeline (Code 430)	-	X	-
14	NRCS Access Control (Code 472)	X	X	-
15	NRCS Pumping Plant (Code 533)	-	X	-
16	NRCS Access Road (Code 560)	-	X	X
17	NRCS Stormwater Runoff Control (Code 570)	X	X	X
18	NRCS Trails and Walkways (Code 575)	-	-	X
19	NRCS Streambank and Shoreline Protection (Code 580)	X	-	X
20	NRCS Stream Crossing (Code 578)	X	-	-

Number	Design Criteria & Practice Standards	Flood Control	Irrigation	Recreation (along Logan River or Trail)
21	NRCS Open Channel (Code 582)	X	-	-
22	NRCS Channel Bed Stabilization (Code 584)	X	X	X
23	NRCS Structure for Water Control (Code 587)	X	X	-
24	NRCS Tree Shrub Establishment (Code 612)	X	-	-
25	Water and Sediment Control Basin (Code 638)	X	X	-
26	NRCS Wetland Restoration (Code 657)	-	X	-
27	NRCS Wetland Creation (Code 658)	-	X	-
29	NRCS National Engineering Handbook (NEH)	X	X	X
30	Utah Pollution Discharge Elimination System (UPDES) General Construction Permit	-	X	-
31	UDOT Drainage Standards and Specifications (UDOT Right-of-Way)	X	X	-
32	Utah Chapter of APWA Standards and Specifications (Current Adopted Edition)	X	X	-
33	Utah Division of Water Rights Dam Safety Rules	-	X	-
34	Utah Division of Water Rights Stream Alteration Permit Requirements	X	X	X
35	U.S. Army Corps of Engineers (USACE) Permit Requirements	X	X	X
36	Utah Division of Water Quality Construction Dewatering	X	X	X
37	Utah Division of Drinking Water R309–510—Water Demand for Outdoor Usage	-	X	-
38	Utah Division of Water Quality R-317 Standards	-	X	-
39	Utah Division of Wildlife Resources Fish Passage	X	-	X

D.6.0 Agricultural Water Management Analysis

The following TMs have been prepared to document the current conditions and the effects of agricultural water management activities within the Project Area. Table 6-1 displays the number, name, and key information contained in the TMs in Appendices E3, E4 and E5.

Table 6-1. Technical Memoranda by Number, Name, and Key Information Content

TM Number	Name	Key information Content
TM-001	*Project Area Existing Conditions*	Describes system facilities, with photos, provides figures of service areas and canals, list of data available for analysis, and description of Project Area soil conditions.
TM-002	*Watershed Hydrology and Lower Logan River Hydraulics*	Describes Logan River Watershed hydrologic characteristics and description of the river reaches below First Dam (with photos); provides a list of available historical data; discusses the Logan River Conservation Action Plan (CAP) priorities and current water quality conditions.
TM-003	*Logan River Water Rights*	Describes all water rights on the Logan River and groundwater rights in the Project Area.
TM-004	*Canal Transmission Losses*	Describes the seepage study and quantification of transmission losses and proposed water conservation.
TM-005	*Design Criteria*	Discusses design criteria to be used during the Design Phase of the project
TM-006	*Agricultural Alternative Definition*	Discusses agricultural water project measures and the development of the alternatives for analysis.
TM-007	*Crockett Diversion Structure Removal Hydraulics and Habitat*	Describes the 30% design of the Crockett Diversion replacement and/or removal and effects on recreation, water quality, floodplain management, fish passage, and aesthetics.
TM-008	*Agricultural Water Management Operational Scenarios*	Description of the proposed pressurize irrigation (PI) system operations under each alternative.
TM-009	*First Dam Interconnect*	Describes First Dam's current role and operation on the Logan River under the existing conditions and for the First Dam Alternative, and addresses questions from the dam owner and power generator—Utah State University (USU)—and the Utah Water Research Laboratory (UWRL) located directly downstream (with an intake structure at First Dam).
TM-010	*Lagoon to Reservoir Storage Conversion*	Describes the current condition of the Logan Sewer Treatment Lagoons and the action required to convert them to secondary irrigation water storage.
TM-011	*Logan River Water Quality Modeling*	Describes the development of a dynamic hydraulic routing and process-based temperature model for the affected sections of the Logan River using a very low

TM Number	Name	Key information Content
		flow summer period during 2022 for the existing conditions. Using the calibrated 2022 model, this TM describes the simulation of two different design alternatives—the First Dam and Crockett Diversion Alternatives—that would change the distribution of flows based on projected flows for each alternative throughout the study reach to quantify potential changes to temperatures and dissolved oxygen. The flows it models are equivalent to the flows that would occur in both the First Dam Alternative and the Crockett Diversion Alternative, analyzed in detail in the Plan-EIS, as well as the Alternative 1 (First Dam with Crockett Diversion Removal), not analyzed in detail.
TM-012	*Secondary Irrigation System Effects*	Describes the expected effects to the municipalities under each project alternative, including reduction in culinary demand and operational costs, reduction in treatment costs, and avoided infrastructure costs. Quantifies these costs/reductions based on the Crockett Master Plan.
TM-013	*Power Generation and Consumption Effects*	Discusses the pumping requirements under each alternative and the power generation under the First Dam alternative; quantifies power costs and power generation revenue under each alternative; and correlates power consumption to greenhouse gas emissions.
TM-014	*Agricultural Yield Effects*	Discusses crop yield effects and quantifies yield increase by canal company under each alternative.
TM-015	*Logan River Floodplain Effects*	Discusses floodplain effects along the Logan River under each alternative—quantifies number of homes and schools as well as length of road inundated in each scenario.
TM-016	*Capital/Construction Costs Estimates*	Quantifies intake, PI system, pump stations, water storage facility, hydropower, diversion reconstruction and removal, and flood control action construction costs anticipated under each alternative.
TM-017	*Operation and Maintenance (O&M) Costs*	Quantifies O&M for the PI system under each alternative.
TM-018	*Project Benefits and Cost Share*	Identifies and allocates project benefits and costs.
TM-019	*Flood Prevention*	Details flood control activities. Examines the hydrology and hydraulics of the canals and the

TM Number	Name	Key information Content
		contributing areas and the effects of the proposed floodwater prevention system.
TM-020	*Recreation*	Describes the design for the recreation activities.
TM-021	*Logan River CAP Alternative Evaluation*	Provides Logan River CAP evaluations for summer base flow, water quality (temperature and dissolved oxygen), and instream habitat for each alternative compared to existing conditions.

D.7.0 Hydrologic and Hydraulic Analysis

The Logan River is similar in characteristic to other intermountain rivers. It experiences high flows during the spring due to snowmelt and decreases to lower baseflows during summer months. It is highly appropriate for agricultural uses and supplemental municipal water supply. As a result of these diversions, flows reach very low levels in late summer, which is a concern to many groups as identified through public comments. The Logan River Watershed includes Logan City, North Logan City, Hyde Park, Benson CDP, and unincorporated Cache County and makes up the western portion of the Logan River Watershed, which has a drainage area of 224,019 acres.

Additional detailed project information about hydrology can be found in Appendix E3, TM-002 Hydraulics and Hydrology, prepared by Franson Civil Engineers, Inc., including the characteristics of the Logan River Watershed, annual precipitation patterns and water demands, description of the Logan River and reaches, historical data sources, summer base flow, flood conveyance, floodplain function, instream habitat, water quality, including Utah Division of Water Quality standards, representative flows by year, UWRL analysis, instream flow analysis, and groundwater inflow analysis.

D.8.0 Flood Protection Analysis

A 2015 Canal Drainage Study was performed as a joint study by Logan City, North Logan, and Hyde Park. The study analyzed the canals going north into the neighboring cities of North Logan and Hyde Park. The study evaluated potential spill locations along the canal alignments that would remove flood waters from the canals to help reduce the potential of overtopping flooding. The study recommended a bypass in North Logan in the area of 1800 North or 2200 North. Refer to the Storm Water Master Plan and Canal Drainage Study that were completed by J-U-B in for a more detailed report on the flood water modeling and analysis, as referenced in Appendix E5, TM-0019.

J-U-B analyzed the existing canal flows starting at 400 N in Logan and flows were added at roadway crossings into Hyde Park to determine flooding limits during various storm events. The system was then analyzed with the proposed canal and piping improvements with the same storm events.

The flood water analysis was performed using Innovyze software package InfoSWMM and a list of the input parameters can be found in those studies. The parameters include soil conditions, rainfall loss methods, storm events, rainfall distribution, and time of concentration. InfoSWMM uses EPASWMM for hydrologic and hydraulic routing. The InfoSWMM model was utilized for this evaluation to determine the inflow hydrographs of the canals for the 500-, 100-, 50-, 25-, 10-, 5-, and 2-year storm events. Appendix E5, TM-019 Flood Prevention, prepared by J-U-B, shows the existing impact of flooding under the 2-, 10-, 25-, 50-, 100-, and 500-year storm events.

Reported runoff flows from the reference studies varied widely based on methodology and the temporal distribution. The required temporal distribution for Logan City for new developments is the SCS Type II distribution. This temporal distribution is highly conservative and for the size of the subcatchments, it resulted in unreasonably high peak runoff flood flows in the canals. For this reason, the NOAA temporal distribution, 2nd Quartile, 50% probability for the Semiarid Southwest was selected as the design temporal distribution. Canal and pipe proposed improvements were sized to convey the 25-year storm event.

The Flood Protection Component (Flood Project) of the Proposed Project includes flood mitigation that would divert flood flows from the canals into a pipe along 1800 north with an overflow at the Logan and Northern Canal that would flow west through a 48-inch pipe, an overflow at the Twins Canal that would flow into the pipeline and be upsized to a 54-inch pipe, and an overflow at the Northwest Field Canal that would flow into the pipeline and be upsized to a 72-inch pipe. The 72-inch pipe would outlet in the open channel on the west side of 2400 West and be conveyed north to the Swift Slough. A 24" pipe would be constructed between the Logan Northern Canal and Twins Canal along 2200 North to convey flood flows from the Logan Northern Canal to the Twin Canal which would convey those flows to 1800 North. It also includes lining the Logan and Northern canal from 1400 North to 1800 North and enclosing the Twin Canal in a box pipe starting at 400 North along the alignment of the canal.

Additional details about the analysis and model of the Flood Protection Project can be found in Appendix E5, TM-019 Flood Prevention, prepared by J-U-B.

D.9.0 Alternative Formulation

Several alternatives were investigated as part of the study, and the alternative formulation process is described thoroughly in the Plan-EIS. The robust and thorough alternative development process is described in Section 4.1 of the Plan-EIS. Multiple measures were evaluated in consideration of the development of the alternatives (see Table 4-1 in the Plan-EIS). The current version of the First Dam Alternative was developed in response to the numerous comments regarding maintaining the connectivity of the Little Logan to the Logan River and maintaining base flows, as documented in Sections 3.3.10 and 5.3.10 in the Plan-EIS. The First Dam Alternative would replace the Crockett Diversion to address the public's concerns about that connectivity. Appendix E3, TM-006, and Appendix E5, TM-019 and TM-020 provide additional detail of all agricultural water management, flood prevention, and recreation measures considered during the development of the alternatives for analysis.

The measures that the project team carried forward for analysis were then compared pairwise to determine which were mutually exclusive or unnecessarily redundant and which could be combined into alternatives. The project team again evaluated the combinations qualitatively to inform the formulation of the initial array of alternative plans detailed in the Plan-EIS. Table 4-2 in the Plan-EIS illustrates this pairwise compatibility for the management measures and how they were carried forward into alternatives' development.

The final array of alternatives is presented Section 4.4 of the Plan-EIS and includes the No

Action Alternative (Future without Federal Investment [FWOFI]), and two action alternatives, First Dam Alternative (Preferred Alternative) and Crockett Diversion Alternative.

D.10.0 Economic Analysis

The Proposed Project's Benefit-cost Analysis (BCA) Report is included in Appendix E2. Report findings are summarized here.

D.10.1 Federal Guidelines of National Economic Efficiency Analysis

The BCA conducted as part of the report uses federal water resource project and NRCS guidelines for the evaluation of benefits and costs of the no action and action alternatives, relying primarily on the Principles, Requirements and Guidelines (PR&G) (USDA 2017), the NRCS Natural Resources Economics Handbook (NRCS 1998), and the National Watershed Program Manual (NRCS 2015).

Following the PR&G, the analysis looked to maximize public benefits with appropriate consideration to costs, using quantified and unquantified information in the trade-off analysis, and benefits encompassing environmental, economic, and social goals, including consideration of both quantified and unquantified measures.

D.10.1.1 Ecosystem Services

Using an Ecosystem Services framework, the analysis gives economic, social, and environmental costs equal standing in the decision-making process, and helps to accomplish the federal objective of maximizing national economic efficiency, ensuring federal investments protect and restore ecosystem functions and values, and avoid irreversible effects (USDA 2017). Economic efficiency requires that resources are used in their highest valued use. Projects that create more benefits—including both monetary and non-monetary benefits—than costs use resources more efficiently than baseline conditions and therefore increase the national economic efficiency (NEE). The four-category ecosystem framework adopted in the PR&G, and used in this analysis, is shown in Table 10-1.

Table 10-1. Ecosystem Services Framework Used to Evaluate Benefits and Costs

Service Type	Examples
Provisioning	The supply of food, fuel, fiber, water, timber, and genetic resources
Regulating	The regulation of air, climate, natural hazards, water quality, pests, and disease
Cultural	Services that enhance cultural values, like aesthetics, recreation, tourism, and spiritual or religious values
Supporting	Nutrient cycling, soil formation, and primary production

Source: NRCS 2015, DM 9500-013.

Causal chains are models describing how changes to the structure of an ecosystem affect its functioning and the goods and services it provides to society (Olander et al. 2016). When used as part of a BCA, a causal chain assessment of ecosystem services impacts trace changes in ecosystem composition all the way through to effects on social outcomes and human well-being.

Figure 10-1 shows the causal chain describing how the action alternatives would create social benefits and costs in the Logan River Watershed. As Figure 10-1 shows, the action alternatives would change the ecological structure of the Logan River Watershed by installing and replacing works of improvement.

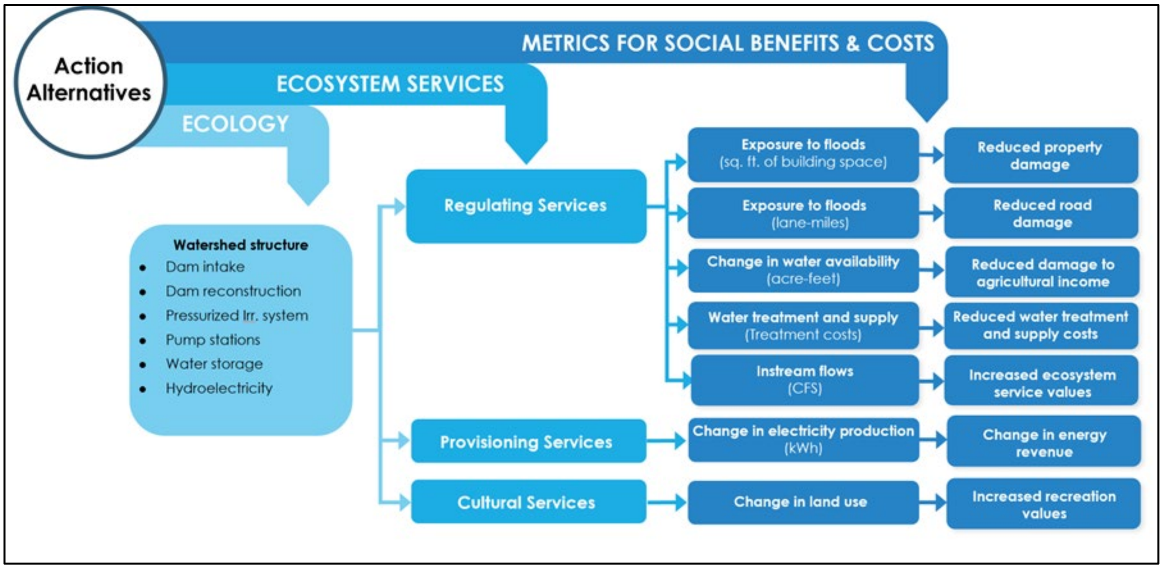

Figure 10-1. Description of Ecosystem Services Impacted by the Logan River Watershed Project Plan EIS and Anticipated Impacts on Ecosystem Services

The action alternatives would affect regulating, provisioning, and cultural ecosystem services in the watershed (Figure 10-1). The alternatives would enhance regulating services by reducing damage to agricultural incomes, buildings, contents, and infrastructure, while also helping manage water treatment and supply costs. Instream flows would improve along certain river reaches, helping to regulate the flow of the Logan River. Provisioning services would benefit through increased water availability for hydroelectric power generation, reduced power generation requirements, and reduced greenhouse gas emissions. Water would also be conserved as a result of the action alternatives. Recreation values would increase with new trails, benefiting cultural services by improving access to the Logan River and the Wasatch-Cache National Forest.

All ecosystem services shown in Figure 10-1 can be characterized, quantified, and/or monetized using publicly available data and established methods that link biophysical metrics to economic values. The specific methods used to quantify and value each service are detailed below.

D.10.2 Alternatives Evaluated

This analysis analyzed the effects of two action alternatives as compared to the FWOFI. Under the FWOFI, annual investments in operation, maintenance, and repair (OM&R) would be required for the system to continue operating safely. In particular, the Crockett Diversion would be reconstructed, and a portion of the Crockett Canal would be boxed to ensure operator safety and reduce slope failure risk. In the future, canals would be lined to reduce seepage. Canal lining would occur in phases.

Under the first action alternative, known as the First Dam Alternative, the major actions include relocation of the CAIC River diversion, creation of water storage and pump stations, installation of new hydropower turbines, installation of a new pressurized irrigation (PI) system, reconstruction of the Crockett Diversion, increased Logan River instream flows, maintenance of Little Logan base flows, improvements to floodwater overflow, and construction of recreation trails. Based on public comment and sponsorship preferences, the First Dam alternative was modified from its description in Appendix E3, TM-006 to include the Crockett Diversion reconstruction, rather than Crockett Diversion removal. The updated definition of the First Dam Alternative with the Crockett Diversion reconstruction is adopted here and throughout the remainder of the economic analysis.

The second action alternative, known as the Crockett Diversion Alternative, is similar in scope to First Dam Alternative, except that the current point of diversion for CAIC's water rights would not be moved to First Dam and the hydropower generators at the reservoir (lagoons) would not be installed. Consequently, a new trunkline between First Dam and the Crockett Avenue diversion would not be required, but more pumping would be required to operate the pressure irrigation system because of the reduced elevation of the diversion location compared to the First Dam Alternative. The majority of CAIC's water rights would continue to be supplied by diverting water at the current Crockett Diversion, in addition to the new point of diversion along the western end of the Logan River near N 3200 W, like the First Dam Alternative.

Besides these differences and associated actions as described above, the remainder of the PI improvements (i.e., constructing PI distribution system; converting lagoons to secondary irrigation water storage reservoir; constructing pump stations; removing Providence Pioneer dam; etc.) and all the flood control and recreational improvements would be the same in the two action alternatives.

Since a portion of the infrastructure proposed under the action alternatives is inter-dependent, individual works of improvement were analyzed in terms of their functional increments, where an increment is a series of inter-dependent projects that serve one or more purposes. Table 10-2 discusses the works of improvement included in each increment and the rationale for creating the increments themselves.

Table 10-2: Works of Improvement Proposed as Part of the Logan River Watershed Project, UT

Increments	First Dam Alternative Works of Improvement	Crockett Diversion Alternative Works of Improvement	Benefits and Benefit Allocation
Agricultural Water Distribution and Stormwater	First Dam Intake Pressurized Irrigation System	Crockett Pump Station Pressurized Irrigation System	The agricultural water distribution and storm water projects work together to create both agricultural water management and flood damage reduction benefits. The purpose of this joint set of projects is to remove irrigation water from open canals that flow through urban areas. By doing this action, the projects benefit agricultural producers by reducing seepage, creating storage, and pressurizing the irrigation system to make conveyance more efficient. As a result, 100 percent of reduced damage to agricultural incomes benefits are allocated to this increment. The pressurized pipe system increases freeboard in the Crockett Canal system, which reduces urban flood damage. Improvements to the Crockett Canal would also be made and they would be significantly more expensive if the canal improvements were a single-purpose project. About 90 percent of flood damage reduction benefits are allocated to this increment. The joint projects also reduce the need for the project sponsors to treat water and incur supply
	Stormwater	Stormwater	
	West River Pump Station	West River Pump Station	
	West Lagoon Pump Station	West Lagoon Pump Station	
	Storage Facility	Storage Facility	
	Cow Pasture Pump station	Cow Pasture Pump station	
	Hydropower Equipment	N/A	

Increments	First Dam Alternative Works of Improvement	Crockett Diversion Alternative Works of Improvement	Benefits and Benefit Allocation
			expenses. 100 percent of reduced water treatment and supply expenses are allocated to this increment. The hydroelectric equipment will create hydroelectricity on an ongoing basis. As a result, 100 percent of estimated hydroelectricity revenues are allocated to this increment.
Floodplain	Crockett Diversion Reconstruction	Crockett Diversion Reconstruction	The floodplain projects will help reduce flooding in the watershed and account for approximately 10 percent of the total flood damage reduction benefits quantified below.
	Removal of Providence Pioneer Diversion	Removal of Providence Pioneer Diversion	
	Flood Control Actions	Flood Control Actions	
Recreation	Recreation Trails	Recreation Trails	New pedestrian trails will provide additional recreational opportunities for community members and establish alternative travel routes among educational, recreational, and commercial facilities within the watershed. 100 percent of recreation benefits are allocated to this increment.

D.10.3 Evaluation Metrics

This section outlines the metrics that were used to quantify changes in ecosystem services. Reductions in building damage are measured in square feet and translated into dollar values. Road damage reductions are expressed in lane-miles. Changes in water treatment and supply and wastewater expenses are measured in acre-feet or gallons. Instream flows are evaluated by volume. Agricultural production changes are measured in tons or bushels and converted to revenue. Recreation value changes are discussed in terms of affected household counts and estimated willingness-to-pay.

Services were prioritized based on their expected contribution to the project's primary purposes of reducing flood damage and improving agricultural water use efficiency. As a result, the analysis prioritized evaluating the regulating and provisioning services shown in Figure 10-1.

Wherever possible, benefits and costs were calculated based on the expected effects of the action alternatives on the ecosystem services shown in Figure 10-1 as compared against the FWOFI or No Action Alternative. The BCA evaluated the costs of the action alternatives based on cost estimates from J-U-B, which included costs for permitting, engineering, construction, administration, and operations and maintenance of proposed improvements. These costs were compared against benefits received by reducing property damages, reducing damage to agricultural income, reducing water treatment and supply expenses, enhancing instream flows below First Dam, and increasing hydroelectricity production, as well as opportunities for recreation.

TMs were developed to quantify, and in some cases, value, the changes the action alternatives would have on the ecosystem services identified in Figure 10-1. To reduce redundancy, supporting information from the TMs—including maps, tables, and discussions—were incorporated into the BCA by reference. As a result, the BCA only includes information from the TMs necessary to explain and discuss how it was used to monetize benefits and costs. Readers interested in the details of how the effects were quantified should refer to the TMs in

Appendices E3, E4, and E5 for additional detail and discussion.

The effects of the action alternatives were evaluated over a 50-year evaluation period, which reflects the expected duration of significant benefits from the proposed improvements. Benefits are assumed to begin accruing in the first year following project completion and continue through the end of the 50-year evaluation period. Interest during the 5-year construction phase was calculated using the mid-life full expenditure method. Because all project components have design lives of 50 years, replacement costs were excluded from the analysis, as the evaluation period does not extend beyond the life of the improvements.

Projected benefits and costs are based on a full employment economy and assume no change in relative prices during the period of analysis. Benefits and costs are discounted using the discount rate for federal projects of 3.0 percent for 2025. Results are reported in both net present values and average annualized values in 2025 dollars. The units of analysis in this study are the action alternatives. For this study, costs and benefits are estimated jointly for all works of improvement for the action alternatives. However, the incremental analysis analyzes the costs and benefits separately for inter-dependent works of improvement as shown in Table 10-3.

D.10.4 Benefits

D.10.4.1 Reduced Property Damage

Reduced property-related damages, including damage to structures and their contents, were estimated for the FWOFI and action alternatives. Data from the Cache County Assessor's Office was combined with Hydrology and Hydraulic (H&H) modeling to identify properties impacted by different depths of flooding for 10-, 25-, 50-, 100-, and 500-year flood events for the FWOFI and action alternatives. The County Assessor's data contained information about each impacted structure, including the structure's market value, the year it was built, its square footage, and its primary use.

The property data summarized below reflects the existing and proposed conditions for two increments that are designed to reduce flood damage: the Agricultural Water Distribution and Stormwater increment and the Floodplain increment. The reduced flood damage under each increment was estimated separately, but building data is combined here for purposes of discussion. Still, the Floodplain increment was found to account for about 10 percent of total flood reduction benefits while the Agricultural Water Distribution and Stormwater increment accounted for the remaining 90 percent.

The residential structures impacted by flooding in the watershed are an average of 30 years old, with the average home built in 1996. The oldest residential structure damaged by flooding was built in 1882 and the newest structure was built in 2023. The average market value of residential structures damaged in the watershed is approximately $469,000. While the residential structures impacted by flooding are primarily single-family homes, there are also several condominiums, apartment complexes, and assisted living complexes impacted by flooding in the watershed. These relatively high value building complexes increase the average value of residential structures damaged by flooding.

Like residential structures, commercial, industrial, and institutional buildings in the watershed are about 29 years old on average with an average market value of $3.6 million.

Among the commercial, industrial, and institutional structures impacted by flooding are two medical complexes: the Logan Regional Hospital, a $150 million complex of medical facilities, and the $20 million Cache Valley Hospital. In addition, a $16 million building that is part of the Utah State University system is also impacted by flooding in the watershed.

The total market value of structures at risk was calculated from the County Assessor's data and estimated to be approximately $984 million. The market value of each building was depreciated based on its age following a depreciation schedule. The depreciation rates were derived from the Swift Estimator and assume the buildings are in fair to good condition. Structures without valuations from the County Assessor and structures defined as sheds or agricultural outbuildings were excluded from the building count and property-related damage analysis.

The H&H modeling was used to estimate the number of structures that would be removed from flood risk under the action alternatives. The information from the proceeding analysis was used to calculate building damages and content loss under the FWOFI and action alternatives using depth-to-damage functions from the USACE and parameters from the FEMA's HAZUS model (FEMA 2021).

Depth-Damage Curves

Building and content damages under the FWOFI and action alternatives were derived using depth damage functions from the USACE. The depth damage functions relate flooding depth to a corresponding percentage reduction in building and content value. The analysis assumed that building contents represent 50 percent of building value for residential structures and 100 percent of building value for commercial and other structures, following assumptions used in the FEMA's HAZUS model (FEMA 2021).

Building Damage Reductions

The action alternatives would reduce flood damage by $96 to $132 million depending on the storm event frequency. In annualized terms, which account for the annual probability of each storm event, the action alternatives would create a combined nominal building and building-content damage reduction benefit of about $10.1 million per year.

D.10.4.2 Road Damage Reductions

TM-015 Logan River Floodplain Effects in Appendix E4 details the effects that the action alternatives will have on flood-impacted roads in the Logan River Watershed. Under the FWOFI, approximately 3,150 feet of roadways are impacted by flooding under the 100-year flood event. Under both action alternatives, flooding of roadways would be completely eliminated. Due to the limited extent of roadway flooding, the benefits of reducing flood damage on roadways are discussed qualitatively.

Reducing flooding on roadways will benefit people in the watershed in various ways. Removing roads from flood risk improves traffic flow by preventing delays caused by road closures or detours. It also improves safety, as flooded roads increase the risk of accidents. Reducing the prevalence of road flooding is particularly important for emergency responders, by helping ensure ambulances, fire trucks, and police can access affected areas quickly without interruption.

Reducing road flooding also benefits businesses as well as their customers and employees, helping to avoid costly disruptions that floods can cause. Additionally, preventing flood damage reduces road repair and maintenance costs for cities, counties, the state, and the federal government. Surrounding property values may also see an increase due to improved road access and safety.

D.10.4.3 Instream Flows

The action alternatives aim to improve instream flow in the Logan River by approximately 25 cubic-feet per-second (cfs) over a 15.1-mile reach. The alternatives lead to varying flow improvements along this reach. Under the FWOFI scenario, no changes would occur to existing flows.

Additional instream flows in the Little Logan and Logan River are an agricultural benefit that addresses agricultural sustainability problems. Current elevated water temperature and low dissolved oxygen levels in the Little Logan and the Logan River are contributing to poor water quality. Higher instream flows reduce water temperature and increase dissolved oxygen levels, which would improve water quality. Future agricultural operations may face regulatory pressure to reduce impacts on aquatic ecosystems. Enhancing instream flows can help meet environmental flow requirements, reducing the risk of regulatory penalties or restrictions on water use. Because much of the Logan River dry dams in the summer, pollinator populations are declining, and biodiversity is waning. Instream flows address the health of the Little Logan and Logan River ecosystems, and support declining pollinator populations and biodiversity, which are essential for sustainable agriculture. Additionally, many agricultural communities in the Logan River Watershed rely on ecosystem services provided by riparian zones, such as natural filtration and erosion control. Indirectly, projects that support instream flows often qualify for state and federal conservation funding, which can be used to support on-farm improvements like efficient irrigation. Participation in such programs can offset costs for producers and improve long-term water security.

The First Dam Alternative would increase flows over a section of the river between the Crockett Diversion and the Proposed West River Pump Station location, but it would reduce flows by about half in the reach between First Dam and the Crockett Diversion during summer months compared to the FWOFI scenario. The Crockett Diversion Alternative would provide identical increased instream flows between the Crockett Diversion and the Proposed West River Pump Station while having no effect on flows between First Dam and the Crockett Diversion.

To compare the instream flow changes across the proposed alternatives, the average flow rate for the entire 15.1-mile reach was estimated using a weighted average approach. This method considered the differing lengths of the river sections between First Dam and the Proposed West River Pump Station by developing a reach-length weighted average flow rate. This approach ensured that the contributions of each section were proportionally represented in the overall flow assessment. Reach-weighted average stream flows under the FWOFI are about 25 cfs between First Dam and the Proposed West River Pump Station, compared to 41 cfs for the First Dam Alternative and 40 cfs for the Crockett Diversion Alternative. In volumetric terms, the First Dam Alternative would send about 6,256 acre-feet of additional water down the Logan River compared to the FWOFI while the Crockett Diversion would send an additional 5,865 acre-feet down the 15.1-mile reach impacted by the project.

In Utah, as in most locales, the economic benefits of instream flows are generally categorized as non-market values, which are not directly reflected in market transactions, including ecological, recreational, cultural, and existence values.

These benefits are further divided into use and non-use values. Use values refer to direct economic benefits derived from the use of instream flows, such as improvements in public fisheries from better water quality. For the Logan River, use values would primarily stem from improvements in fisheries, resulting from higher dissolved oxygen levels and lower water temperatures. These improvements often correspond to the willingness of people to pay for enhanced fishing opportunities.

Non-use values, which reflect the value people place on instream flows without direct use, include existence values and bequest values. Existence values refer to the willingness to pay simply to know that instream flows are protected, regardless of direct interaction, while bequest values reflect the desire to ensure instream flows are available to future generations.

In the Western United States, it is increasingly common for government and non-profit entities to hold instream flow water rights to guarantee minimum stream flows that protect aquatic habitats, recreation, cultural values, and other ecosystem benefits. These rights can generate significant public benefits, though measuring the precise value of instream flows is challenging due to the variability in water values. For instance, an acre-foot of water used by a municipality may be worth $20,000 or more, while the same amount of water in rural areas with fewer competing uses might be valued at only $60. Furthermore, many water markets are not perfectly competitive, meaning values are highly location specific.

Utah’s water market for instream flows is relatively underdeveloped compared to some neighboring Western states. Transactions specifically aimed at securing instream flows are limited, in part due to Utah’s strict adherence to the "use it or lose it" doctrine, which traditionally discouraged non-consumptive uses like instream flows. However, legislative changes to Utah Code in 2008 allowed water rights to be temporarily leased or donated for instream purposes. Still, market activity remains sparse, with few transactions in water rights acquisitions or leases to support instream flows.

Efforts to quantify instream flow values began in the early 2000s, with studies using stated preferences (such as contingent valuation) and revealed preferences (based on water market transactions). One significant early study by Loomis et al. (2003) documented water market transactions in the western U.S. to secure instream flow rights for fisheries, recreation, and environmental purposes. The findings indicated that, in inflation-adjusted terms, water rights for instream flows transacted at about $1,640 per acre-foot, while lease rates averaged around $78 per acre-foot. The average water right lease value for instream flows was found to be about $83 per acre-foot in inflation-adjusted terms.

While the values from the study are informative for understanding the magnitude of water right values for instream flows, the inflated values may not be representative of contemporary values because the value of western water has likely risen faster than the general inflation rate. For example, share prices of Colorado Big Thompson project water, the largest trans-basin diversion project in the U.S., increased by 900% between 1990 and 2006, while the inflation rate during that time was 58% (see BCA in Appendix E2).

Several water transactions from the past few years illustrate the growing value of water for instream flow enhancements during periods of relatively low flows. For example, in 2016, water right holders in California negotiated water leases for pulse flows in the San Joaquin River at $378 per acre-foot to support endangered fish species. Similarly, in 2018, the Colorado Water Conservation Board paid $9.00 per acre-foot to lease water to protect endangered species in the

Colorado River. These agreements demonstrate that enhancing instream flows can be compensated at varying rates based on ecological goals, drought conditions, and regional water scarcity. On the Logan River, these transactions suggest that the value of instream flow changes could vary depending on similar factors, including local ecological benefits and water scarcity. In 2016, Trout Unlimited obtained its first instream flow lease for 1.49 cfs in the Weber River as part of a transaction to benefit fisheries along the river. However, no information about the monetary value of the transaction is available.

To estimate the change in instream flow values under the action alternatives, an average value of transactions for water right leases for environmental purposes within Western U.S. (2006–2019) was used. This average value of $328 per acre-foot was multiplied by the average volume of water that would flow along the 15.1-mile reach of the Logan River during the summer months under the action alternatives. The estimated value of instream flows is about $2.1 million for the First Dam Alternative and $1.9 million for the Crockett Diversion Alternative.

D.10.4.4 Reduction in Damages to Agricultural Income

TM-014 Agricultural Yield Effects in Appendix E4 describes the data used to estimate the change in farm output under the action alternatives. TM-014 describes cropping patterns, water demand, and precipitation, all of which vary temporally and spatially. It sets forth crop yield curves and quantifies expected yield increases in each canal company area under the FWOFI and action alternatives. The BCA incorporated this information by reference to reduce redundancies. Readers are invited to review TM-014 for supporting details.

Under the FWOFI or No Action Alternative, water-short conditions toward the end of the irrigation season limit yields, thereby damaging the incomes of farmers in the watershed. In contrast, the action alternatives include works of improvement that would allow conserved water to be applied during these late-season shortages, thereby reducing these damages compared to the FWOFI. The economic benefit of the damage reduction is measured as the increase in net income resulting from higher yields enabled by this additional water, less the marginal costs of production.

The BCA assumed water conserved with the works of improvement meant to improve agricultural water management under the action alternatives would be used to irrigate existing farmland, which is water-short during the tail-end of the irrigation season as described in TM-014. Under this assumption, farmers would face a marginal increase in production costs. Marginal production costs were estimated for barley, wheat, and alfalfa using crop enterprise budgets developed by the University of Idaho for south central Idaho, which is approximately 50 miles from the Logan River Watershed. The enterprise budgets were updated to 2025 dollars using the Consumer Price Index and expressed in dollars per bushel for barley and wheat, and dollars per ton for grass hay, which was used to approximate production costs for alfalfa. An average of the costs for wheat and barley were used to approximate the marginal production costs for corn.

The enterprise budgets from the University of Idaho express costs in terms of seed, fertilizer, pesticide, irrigation, labor, machinery, and custom services. The costs are further categorized by source of expense, including power, equipment operators, and fuel. These cost categories were reviewed to determine which portion of the costs would apply to the application of finishing water used to generate additional yield as part of the action alternatives. Costs related to irrigation, labor, machinery, and custom services were the only cost categories that would increase as a result of applying additional irrigation water to existing crops. These costs were itemized for each crop and standardized to report expenses in terms of bushels and tons.

In total, action alternatives are expected to increase the net value of crop revenue by about $1,140,500 per year in non-discounted terms.

D.10.4.5 Increased Electricity Production

TM-013 Power Generation and Consumption Effects in Appendix E4 discusses changes in hydroelectricity production under the First Dam Alternative. Under the First Dam Alternative, hydroelectricity production would be increased by installing a hydropower station at the West Lagoons to generate power from excess water. The existing hydropower turbine at First Dam, owned by USU, would be decommissioned to ensure sufficient pressure for the new system. The installation of the West Lagoons hydropower station would generate an additional 1.94 million kilowatt-hours (kW/hr) of electricity each year after accounting for the reduction of 740,000 kW/hr of hydroelectricity production that would occur as a result of removing the existing hydropower turbine at First Dam.

The net change in the value of electricity production under the First Dam Alternative would be 1,940,000 kW/hr. At $0.10 per kW/hr, the net change in value of electricity production for the First Dam Alternative would be $194,000. There would be no change in electricity production under the FWOFI or Crockett Diversion Alternative. In fact, under the Crockett Diversion Alternative, an additional 6,760,000 kW/hr of electricity would be required as a result of the proposed Crockett Pump Station.

D.10.4.6 Reduced Water Supply and Treatment Expenses

Constructing the PI system in the Crockett service area would produce substantial cost savings across three major infrastructure categories: pumping for culinary water, water treatment infrastructure and operations, and wastewater treatment infrastructure and operations. These savings are driven by reductions in outdoor culinary water use and decreased infiltration into sewer systems currently caused by seepage from open irrigation canals.

Energy rates, culinary water rates, and wastewater treatment rates were used to estimate these reduced costs. A similar approach was used in the Spring City Watershed Plan in Spring City, Utah to value reduced water treatment expenses. The culinary water and wastewater rates for the City of Logan were used to value the conserved culinary water. Culinary water rates reflect the material expenses of distributing water to customers. These expenses include capital, labor, energy, materials, and water supply. Some expenses are fixed while others are variable.

Conserving culinary water supply would reduce the variable expenses associated with treating and delivering water. To estimate the variable portion of culinary water treatment and delivery costs, the average cost of water was estimated using Logan's culinary water rates and assuming a monthly water usage profile of 20,000 gallons per month, which reflects approximately 10,000 gallons per month of indoor use and 10,000 gallons per month of outdoor use.

The City of Logan's water utility uses an increasing block-rate pricing structure, whereby the average cost of 1,000 gallons of water increases with monthly use. Like most water utilities, Logans' water utility recovers its fixed operating costs through a base charge, while the block rate structure applied to use recovers the variable portion of its costs. Averaging the price across the first and second tiers approximates the variable cost of providing culinary water to customers. Assuming an average monthly use of 20,000 gallons, the average variable cost of culinary water is $2.20 per thousand gallons under Logan's culinary water pricing structure.

To estimate the volume of treated culinary water currently used for outdoor irrigation, a per-connection demand approach was used, based on data from the Crockett Master Plan and Appendix E4, TM-012 Secondary Irrigation System Effects. Outdoor irrigation demand per equivalent residential connection (ERC) is estimated at 0.48 gallons per minute, reflecting seasonal use within the service area. Assuming 8 hours of irrigation per day over a 5-month irrigation season, the annual volume of outdoor use per ERC is approximately 34,560 gallons. This equates to roughly 0.106 acre-feet per year per ERC.

Using known ERC counts for North Logan (1,900 ERCs) and Hyde Park (648 ERCs), and a conservative estimate of 6,000 ERCs for Logan, the total amount of treated culinary water currently used for outdoor irrigation across the three cities is estimated at approximately 906 acre-feet per year, or 295.3 million gallons per year. At an average culinary treatment cost of $2.20 per 1,000 gallons, the reduced cost of treating this water equals approximately $650,000 per year.

Construction of the PI system would also reduce flows into the wastewater treatment system. Logan City's sanitary sewer network includes many clay pipes with open joints, particularly in areas with high groundwater tables. When irrigation water is conveyed via unlined canals, significant seepage infiltrates the soil and enters the sewer system through these joints, increasing flow volumes to the wastewater treatment plant.

Modeling conducted by Logan City indicates that approximately 53% of this infiltration volume originates in the Crockett service area. These seasonal flows result in increases of up to 3 million gallons per day (MGD) during peak irrigation season. Construction of a PI system would reduce most of this seepage by conveying water through closed, pressurized pipes, effectively removing the primary source of seasonal infiltration.

To estimate the cost implications of these flow reductions, the analysis assumes that wastewater treatment costs are approximately $3.00 per 1,000 gallons, based on Logan's current wastewater rate structure. A flow reduction of 3 MGD over the 5-month (150-day) irrigation season results in 450 million gallons of avoided wastewater treatment volume annually.

At $3.00 per 1,000 gallons, the cost savings are approximately $1,350,000 per year. Thus, the PI system could generate up to $1.35 million in annual wastewater treatment cost savings by reducing seasonal infiltration during the irrigation season. In total, the savings from the culinary water system and wastewater system are approximately $2 million per year.

D.10.4.7 Recreation Benefits

The piping of the PI system proposed as part of the action alternatives would provide a corridor for the construction of recreation trails as described in detail in TM-020 Recreation in Appendix E5. The recreation component of the Plan-EIS consists of completing two American Disabilities Act (ADA) compliant shared use paths located within Logan City (the City).

- **Canyon Road Trail**: The first shared use path is along the north side of Canyon Road between 200 East and 600 East.
- **River Hollow Trail**: The second path provides access to River Hollow Park from three locations (pedestrian routes along Sumac Drive, Riverside Drive, and Lauralin Drive).

New pedestrian trails would provide additional recreational opportunities for community members and establish alternative travel routes among educational, recreational, and commercial facilities within the City ancillary to providing access to maintain key components of the PI and flood prevention infrastructure within the Project Area. As the canals are converted to a buried pressurized system, recreational trails can be built within the existing irrigation corridors to provide safe transportation and recreation opportunities in the community to the nearby Forest Service lands, thereby completing a vital recreation corridor for Cache Valley residents to access the Wasatch-Cache National Forest in Logan Canyon.

While it is difficult to calculate an estimate of the economic benefit the watershed's residents would receive from the proposed trails—as the annual number of trail users is not known and is not available—it is possible to estimate the minimum value that residents would have to place on the projects to justify them from an economic perspective.

As discussed in more detail below, the average annualized cost of the trail and sidewalk projects is approximately $232,400. This means the benefit of the trail and sidewalk projects would outweigh the costs if each of the approximately 17,700 households in Logan received a benefit of about $13.13 per year from the proposed recreation trails. Adding new trail segments would benefit households by improving trail access, which has multiple benefits, including enhancing health and well-being, property values, and community connectivity. A brief review of the economic literature on trail values found that these values generally exceed those required to justify the trail investments proposed under the action alternatives of the Proposed Project.

A study from North Carolina found that people with access to trails were twice as likely to achieve the U.S. Surgeon General's recommended level of physical activity. Physical inactivity has been linked to a variety of health problems and their associated social costs, including heart disease, diabetes, and colon cancer. The Center for Disease Control estimates that inactivity costs the country approximately $117 billion per year in health care costs, or about $3,800 per inactive adult. If the trails proposed under the action alternatives lead to greater levels of physical activity for 61 people, the healthcare savings could more than offset the annualized cost of the trails.

A study of Arizona residents found that residents received about $8.3 billion per year of consumer surplus from non-motorized trail use, equating to a consumer surplus of about $100 per visit. The same study asked residents the importance of having trails nearby in deciding where to live, and more than 77 percent of respondents said trail proximity was somewhat or very important. A study of trail users at Table Rock State Park in South Carolina found that most users were willing to pay a fee of $4.76 per day to use hiking trails at the park. The study found about 62 percent of respondents were willing to pay a trail use fee. These results further demonstrate that the value of trail segments proposed under the action alternatives are likely to produce values beyond those required to justify their installation costs.

When the many benefits of trails and sidewalks are taken into consideration—including increased property values, reduced transportation costs, increased health benefits, increased community connectivity, and enhanced economic development—it seems reasonable to assume that households would each be willing to pay about $1.10 per month ($13.13 per year) for the trail improvements proposed as part of the action alternatives.

D.10.5 Costs

Project costs include all expenses incurred as part of the development, installation, operation, and maintenance of a project. Costs were estimated for each work of improvement included as part of the action alternatives.

Preliminary engineering work on design, permitting, construction, and operation and maintenance requirements for the structures included as part of the action alternatives was completed by J-U-B, who were hired by the project Sponsors to lead design and planning work on the Plan-EIS. Based on this work, J-U-B provided cost estimates for the installation of the structures included in the action alternatives as well as the FWOFI. The cost estimates for the action alternatives were allocated to particular cost categories, which included design and engineering, administration, and construction.

D.10.5.1 Installation Costs

Installation costs were estimated using the bottom-up approach. This method breaks projects and structures into lower-level components and then prices those components for their direct costs, including labor, materials, and professional services. In the case of the FWOFI, the cost estimates represent the ongoing operation and one-time maintenance and repair costs required to maintain the existing benefits of current water infrastructure systems. This conforms with NRCS guidance which recommends defining the baseline condition by considering the normal and necessary O&M required over the evaluation period to maintain current service standards.

The total one-time installation costs for the FWOFI are $5,050,000. The estimated installation costs for the First Dam Alternative are $308,633,000 and for the Crockett Diversion Alternative are $280,683,400.

D.10.5.2 Other Direct Costs and Adverse Effects

According to the PR&G, other direct costs and adverse effects include uncompensated losses caused by the installation, OM&R of a project or group of projects. These other direct costs and adverse impacts can include costs caused by downstream flood damages cause by channel modifications, levies, dikes, and other structures, erosion of land along streambanks created by dams that prevent sediment export downstream, and through lost use value of the land where flood mitigation structures are cited (DM 9500-13).

The action alternatives have one category of other direct costs: OM&R costs. Once the improvements are installed, overheads for OM&R would be required for the improvements to continue generating the benefits for which they were designed. J-U-B estimated OM&R costs, which are discussed in detail in Appendix E5, TM-017 Operation and Maintenance Costs. Estimated annual OM&R costs for the First Dam Alternative are $1,910,000 and for the Crockett Diversion Alternative are $2,320,000.

D.10.5.3 Lags of Benefits and Costs

The benefits and costs of the action alternatives occur at different points in time. The installation of improvements is anticipated to occur over a five-year period after which the benefits of improvements are anticipated to accrue over the following 50 years. To account for the difference in timing of benefits and costs, lagging techniques were used to calculate benefits and costs in comparable terms.

The annualized installation costs were calculated by first estimating the interest during construction using the mid-life full expenditure method to account for the opportunity cost of capital. The total of installation and interest costs were annualized over a 50-year period by dividing them by the present value of an annuity of one assuming a 3.0 percent discount rate, yielding the average annual cost over the evaluation period.

O&M costs of works of improvement were assumed to begin following the five-year installation period. The annual value of O&M costs was discounted at a rate of 3.0 percent, projected over a 50-year evaluation period, and summed. The sum of the discounted stream of O&M costs were divided by the present value of annuity based on the 50-year evaluation period and a discount rate of 3.0 percent to calculate the average annualized value.

Project benefits, including a reduction in flood and farm income damages, were assumed to begin after the five-year installation period to be as conservative as possible. Benefits were discounted at a rate of 3.0 percent over a 50-year evaluation period and the sum of the discounted benefit values were divided by the present value of annuity based on the 50-year evaluation period and a discount rate of 3.0 percent to calculate the average annualized values.

D.10.5.4 Cost Allocations of Multi-purpose Projects—Separable Costs Remaining Benefits Analysis

Under the First Dam and Crockett Diversion Alternatives, two works of improvement are structurally connected despite serving two distinct purposes: the First Dam intake and PI system were designed to improve agricultural water management, but the two works of improvement also convey water that would otherwise increase flood risk along the Crockett Canal that conveys water through urban areas. The First Dam intake and PI system also reduce the cost of improving the canal for flood damage reduction purposes.

Costs of interconnected works of improvement must be fairly allocated between the project sponsors and the NRCS based on their contribution to each project purpose. The Separable Cost-Remaining Benefit (SCRB) method is widely used in watershed projects to allocate the cost of multi-purpose projects between project purposes (Economics Handbook, Part 611.0601). The method effectively allocates costs among multiple project purposes, such as flood damage reduction, agricultural water management, recreation, and other project purposes.

SCRB achieves this cost allocation by first identifying the costs specifically required to achieve each individual project purpose (the "separable costs") and then distributing any remaining joint costs according to the proportional benefits each purpose receives. This method ensures that each stakeholder pays a fair share based on the benefits derived, encouraging efficiency and fairness. The SCRB analysis of the interconnected works of improvement for agricultural water management and flood damage reduction in the action alternatives as shown in Table 10-3. All values used in the SCRB analysis are reported in average annualized equivalents:

Table 10-3: Separable-Cost-Remaining Benefit for Interconnected Works of Improvement in the Logan River Watershed Project, UT ($ 2025, Annualized Dollars)

Average Annualized Values	Flood Damage Reduction[1]	Agricultural Water Management[1]	Total[1]
Average Annual Benefits	$10,134,900	$1,140,500	-
Single Purpose Alternative Cost	$5,528,600	$6,028,200	-
Limited Benefit/Cost	$5,528,600	$1,140,500	-
Separable Costs	$3,982,800	$4,482,400	-
Remaining Benefits	$1,545,800	-$3,341,900	-
Percent of Total	100%	0%	-
Joint Costs	-	-	$1,545,800
Allocated Joint Costs	$1,545,800	$0	-
Total Cost Allocation	$5,528,600	$4,482,400	$10,011,000
Total Cost Allocation ($ 2025)	$137,606,300	$111,565,300	$249,171,600

[1]Price base: 2025 dollars; amortized over 50 years at a discount rate of 3.0 percent.

This total cost was also used to allocate the costs of the CAIC's canal improvements and PI system between the NRCS and project sponsors.

D.10.5.5 Current Economic Costs

Average annual costs of flood damage to structures and water scarcity-related losses to farm income under the FWOFI were estimated to provide a benchmark for comparison with the action alternatives.

The average annualized damages and cost for the FWOFI is $533,900 per year to simply maintain the current benefits of the system. In addition, approximately $16,146,200 in flood damage to structures and their contents and $944,300 in damage to agricultural income occur under the FWOFI. Approximately 3,150 feet of damage to roadways associated with the 100-year flood events would persist.

D.10.6 Economic and Structural Tables

The results of the BCA for the action alternatives are compared against the FWOFI or No Action Alternative and serve as the best estimate of the additional economic value that would be created under the action alternatives. Results are presented using the Economic and Structural Tables (NWPM Part 506) in Section 6.11 in the Plan-EIS for the First Dam Alternative and in the Benefit-Cost Analysis in Appendix E2 for the Crockett Diversion Alternative as shown below.

- National Watershed Program Manual Economic Table 1—Estimated Alternative Installation Cost
- National Watershed Program Manual Economic Table 2—Estimated Preferred Alternative Cost Distribution
- National Watershed Program Manual Economic Table 4—Estimated Average Annualized Costs by Increment
- National Watershed Program Manual Economic Table 5a—Estimated Average Annualized Benefits and Reduced Damages by Increment
- National Watershed Program Manual Economic Table 6—Comparison of Average Annualized Costs, Reduced Damages and Benefits

In total, the First Dam Alternative will create average annualized benefits of $15,754,700 per year compared to average annualized costs of $14,860,700, for a benefit-cost ratio of 1.1 and Crockett Diversion Alternative will create average annualized benefits of $15,431,500 per year compared to average annualized costs of $13,579,100 for a benefit-cost ratio of 1.1.

D.10.7 Tradeoffs and Other Considerations

The BCA for the project does not fully account for inherent trade-offs between the action alternatives, particularly in terms of long-term operational costs and sustainability. While the NRCS BCA guidance requires costs to be carried forward in constant relative terms, this approach inadvertently favors the Crockett Diversion Alternative, which has a lower initial construction cost but higher operational demands due to its reliance on extensive pumping. In contrast, the First Dam Alternative uses the natural hydrologic head at First Dam to move water, avoiding significant pumping costs. If the BCA had accounted for rising electricity costs over time, the long-term O&M expenses for Crockett Diversion would have been substantially higher, likely changing the outcome of the analysis. The project Sponsors anticipate this difference and as a result, the Sponsors favor the First Dam Alternative.

Lower operating costs not only make a project more sustainable over time—critical given the challenges of securing ongoing funding for public infrastructure—but also enhance its appeal to potential subscribers by reducing their share of O&M costs. Furthermore, while higher electricity costs diminish the net benefits of the Crockett Diversion Alternative, they actually increase the benefits of the First Dam Alternative due to its hydropower generation component. By offsetting some O&M costs with revenue from hydropower, First Dam becomes a more attractive and financially resilient option. A BCA that monetizes these trade-offs more comprehensively would likely lead to a different analysis of alternatives, better reflecting their true costs and benefits over the project's lifecycle.

D.11.0 Sources

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