Integrated Feasibility Report and Environmental Assessment

Sheridan, Wyoming Section 1135 Ecosystem Restoration Study

Sheridan, Wyoming

Draft for Public Review

US Army Corps of Engineers®

Prepared by:
U.S. Army Corps of Engineers
Omaha District
1616 Capitol Avenue
Omaha, NE 68102-4901

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EXECUTIVE SUMMARY

This ecosystem restoration study is being carried out under Section 1135 of the Water Resources Development Act of 1986 (P.L. 99-662). Section 1135 authorizes the U.S. Army Corps of Engineers to partner with non-federal sponsors to restore degraded ecosystems through modification of existing flood risk management projects. The non-federal sponsor for this study is the city of Sheridan, Wyoming. In 2013 the city of Sheridan requested planning assistance through Section 1135 to restore and improve fish and wildlife habitat in the vicinity of an existing flood control project.

This study is needed to address degradation that has occurred within Big Goose Creek, Little Goose Creeks, and Goose Creek as a result of flood control infrastructure and urbanization in the city of Sheridan. The purpose of the Sheridan Section 1135 study is to evaluate alternatives to restore ecosystem function and capacity by improving the quality of aquatic, wetland, and riparian habitats along the Goose Creeks in Sheridan, Wyoming in the vicinity of the existing flood risk management project. The flood risk management project was built in 1966 through a partnership between the city of Sheridan and the U.S. Army Corps of Engineers. The project collectively encompasses about 4.25 linear miles of stream channel on Little Goose, Big Goose, and Goose Creeks. Major features of the flood risk management project consist of levees, channel alterations, a concrete chute, and a concrete drop structure. The flood risk management project provides flood protection for downtown and large residential and commercial areas along the creeks. A constraint for this study is that ecosystem restoration recommendations must not change the level of flood protection provided by the flood risk management project.

Flood control activities such as channel deepening, widening, realigning, and lining have altered the physical, biological, and chemical processes characteristic of a healthy stream transitioning away from the mountains. Historically, the Goose Creek watershed was a viable cold water fishery home to native cutthroat trout. Today, problems associated with the degraded in-stream aquatic environment include lack of channel sinuosity, loss of riffle pool complexes, lack of shading, poor depth diversity, poor refuge habitat for fish, and lack of aquatic vegetation. Migratory pathways for fish from Goose Creek to Little Goose Creek and Big Goose Creek have been significantly affected by construction of the concrete lined channel and drop structure, respectively. Problems associated with the poor riparian and wetland habitat adjacent to the creeks include lack of natural connection with the floodplain, lack of native herbaceous and woody vegetation, and lack of wetland hydrology.

Ecosystem restoration measures were developed collaboratively with input from the city of Sheridan, local and state resource agencies, and the U.S. Army Corps of Engineers. In-stream restoration measures consist of habitat structures to benefit the aquatic environment and fish habitat and stream modifications to allow for improved fish passage. Riparian restoration measures consist of wetland habitat restoration adjacent to the creeks. A variety of restoration measures were identified and screened before being developed into alternatives. A total of 46 alternatives, including No Action, were evaluated and compared and based on environmental benefits and costs a preferred plan was selected and recommended for implementation. This recommended plan consists of 11 in-stream restoration alternatives and six riparian restoration alternatives on Little Goose Creek, Big Goose Creek, and Goose Creek. The recommended ecosystem restoration plan calls for placement of rock habitat structures in the creeks, modification to the drop structure, and excavation, grading, and seeding, at a financial first cost of $6,620,000.

Stream restoration benefits include restoration of 14,881 feet of low quality existing stream channel to a higher quality and creation of 845 feet of stream channel through restoration of channel meanders. Wetland restoration benefits include restoration of 4.83 acres of palustrine emergent wetland habitat and 7.76 acres of scrub-shrub wetland habitat. The recommended plan also opens up a migratory pathway connection for fish by improving the gradient of the existing drop structure from having drops from one to three feet high to drops of 0.4 feet across the entire length of the structure. The recommended plan provides 17 net total average annual habitat units. The incremental average annual cost per unit of habitat is $52,549. This plan is recommended with full support from the non-federal sponsor. It also carries wide ranging support from local and state agencies and the public.

U.S. Army Corps of Engineers policy allows for recreation features to be planned at ecosystem restoration projects. In accordance with Corps policy, recreation at ecosystem restoration projects should be compatible with these types of projects and enhance the visitation experience by taking advantage of natural values. Recreation features planned for this project include 2,200 feet of trails providing new access, two interpretive educational signs, and one bench near the proposed trails. These recreational features provide connectivity to existing recreational facilities in the community. These features will provide recreation benefits to this community of 17,000 with a benefit to cost ratio of approximately 10.8 to 1.

The estimated cost-shared total for project implementation is $6,620,000. Of the total cost, $936,000 is for land, easement, rights-of-way, relocation, and disposal costs, for which credit will be given to the sponsor. Of the total cost, the federal portion is approximately $4,879,500 and the non-federal portion is approximately $1,740,500. Of the total non-federal portion, approximately $804,500 will be provided in cash and $936,000 will be provided in land, easement, rights-of-way, relocation, and disposal costs. Estimated average annual cost for operations, maintenance, repair, replacement, and rehabilitation is $63,835 for ecosystem restoration and $8,165 for recreation.

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AA	Average Annual
AAHU	Average Annual Habitat Unit
APE	Area of Potential Effect
BCR	benefit to cost ratio
BGEPA	Bald and Golden Eagle Protection Act
BHNF	Bighorn National Forest
BLM	Bureau of Land Management
BP	Before Present
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CIAA	cumulative impact analysis area
CLOMR	Conditional Letter of Map Revision
CSRA	cost and schedule risk analysis
CWA	Clean Water Act
dB	decibels
dBA	decibels (A-weighted scale)
DO	dissolved oxygen
EGM	Economic Guidance Memorandum
EM	Engineering Manual
EO	Executive Order
EOPs	Environmental Operating Principles
EQ	Environmental Quality
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FRM	Flood Risk Management
FWCA	Fish and Wildlife Coordination Act
GIS	Geographic Information Systems
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic, and Radioactive Waste
HU	Habitat Unit
IDC	Interest During Construction
IWR	Institute for Water Resources
LERRD	lands, easements, rights of way, relocations and disposal areas
MBTA	Migratory Bird Treaty Act
msl	mean sea level
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NHPA	National Historic Preservation Act

NPS	National Park Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity units
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
NWP	Nationwide Permit
O&M	Operation and Maintenance
OHWM	Ordinary High Water Mark
OMRR&R	Operations, Maintenance, Repair, Replacement, and Rehabilitation
OSE	Other Social Effects
P&G	Principles and Guidelines
PAS	Planning Assistance to States
PCE	tetrachloroethene
PDT	Project Delivery Team
PEM	Palustrine Emergent
PGN	Planning Guidance Notebook
PLSS	Public Land Survey System
PPA	Project Partnership Agreement
PSS	Palustrine Scrub-Shrub
RED	Regional Economic Development
RMH	Rocky Mountain Herbarium
SCCD	Sheridan County Conservation District
SEO	State Engineer's Office
SGCN	Species of Greatest Conservation Need
SHPO	State Historic Preservation Office
TCE	trichloroethene
TMDL	total maximum daily load
UDV	unit day value
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WRDA	Water Resources Development Act
WYCRIS	Wyoming Cultural Resource Information System
WYCRO	Wyoming Cultural Records Office Web database
WYNDD	Wyoming Natural Diversity Database
WYPDES	Wyoming Pollutant Discharge Elimination System

1.0 INTRODUCTION

This report is an Integrated Feasibility Report and Environmental Assessment. It is a decision document for a federal action related to ecosystem restoration. It complies with the National Environmental Policy Act (NEPA). It satisfies the requirements of U.S. Army Corps of Engineers policies that guide water resource development studies, including the Planning Guidance Notebook (Engineering Regulation 1105-2-100) and Procedures for Implementing NEPA (Engineering Regulation 200-2-2).

Construction of a flood risk management (FRM) project by the U.S. Army Corps of Engineers (Corps) and city of Sheridan along the system of creeks in Sheridan has adversely impacted ecosystem processes which has resulted in degradation of the quality of aquatic stream habitat, floodplain habitats, and has significantly impaired migratory pathways for fish. This study is needed to improve degraded aquatic habitats for fish and wildlife, including trout fisheries, which will improve the quality of the environment for residents of Sheridan.

1.1 Study Authority

This ecosystem restoration study is being carried out under Section 1135 of the Water Resources Development Act (WRDA) of 1986 (P.L. 99-662), as amended. Section 1135 allows for modifications to existing Corps projects for improvement of the environment.

1.2 Study Scope and Scope of this Report

Study Scope

Corps ecosystem restoration projects should utilize engineering and other technical solutions to water and related land resources problems, with emphasis on improving degraded ecosystem function and structure. Ecosystem restoration and protection initiatives should be conceived in the context of broader watershed or regional water resources management programs and objectives, which may involve contributive actions by other federal and non-federal agencies and other stakeholders.

The general scope of this study includes all investigations and analysis required to prepare an integrated feasibility report and environmental assessment. This includes evaluating alternatives and identifying the National Ecosystem Restoration (NER) plan, any other reasonable alternatives, and recommending a plan. Also included is coordination with the sponsors and other stakeholders and public outreach to ensure that the study adequately considers and reflects local concerns and input.

Formulating an ecosystem restoration plan is the primary goal of the feasibility study. A primary plan formulation task includes guiding the team to iterate through the six-step plan formulation process:

1. Specify problems and opportunities.
2. Inventory and forecast conditions and define the without project future condition.
3. Formulate alternative plans.
4. Evaluate the effects of alternative plans.
5. Compare alternative plans.
6. Select the recommended plan and prepare for the next project phase.

Scope of this Report

This Integrated Feasibility Report and Environmental Assessment incorporates the Corps planning process found in Engineering Regulation 1110-2-100 with the requirements of NEPA and its implementing regulations, 40 Code of Federal Regulations (CFR) SS 1508 and 33 CFR Part 230. This report documents the decision making process, recommends a plan, and documents whether actions

proposed by the Corps constitute a "...major federal action significantly affecting the quality of the human environment..." [NEPA, Section 102(c)] and whether an impact statement (EIS) is required.

1.3 Study Sponsor

Section 1135 allows for non-federal sponsors to cost-share the study and design and implementation phases and partner with the Corps in the planning process. Studies costs are shared 50 percent federal and 50 percent non-federal and design and implementation costs are shared 75 percent federal and 25 percent non-federal. The non-federal sponsor for the Section 1135 study is city of Sheridan. The city of Sheridan submitted a letter requesting to cost-share a feasibility study to the Corps in April 2013 and signed a Feasibility Cost-Sharing Agreement with the Corps on 24 September, 2014. Specific interests of the sponsor in this project include increasing and restoring channel habitat, reestablishing some connectivity with upstream and downstream reaches of the creeks, removal of the concrete chute, and restoring natural function back to the channel. The sponsor is an active participant in the study process.

1.4 Project Location

The project is located in the city of Sheridan, Wyoming in the north central portion of the state. The city is situated in the historic floodplain of Goose Creek and its two largest tributaries, Little Goose Creek and Big Goose Creek. A project location map is shown in Figure 1.

1.5 Background

The features within the existing FRM project are shown in Figures 2 and 2A – 2D. The project was planned and built by the Corps in sponsorship with the city of Sheridan. The project was authorized for construction by the Flood Control Act of 1950 (Public Law 516). Construction of the project was completed in two stages. Stage 1 was started in August 1961 and involved construction of levees, channel alterations, drainage structures, a concrete chute, a concrete drop structure, and sheet piling. This stage was completed in August 1963 and turned over to the city of Sheridan in December 1963. Stage 2 began in June 1965 and consisted of construction and channel straightening on Little Goose Creek upstream from Stage 1 construction. Construction of Stage 2 was completed in 1966. A modification to the existing drop structure on Big Goose Creek was completed in August 1995. The drop structure was modified for safety reasons by replacing a single large drop with multiple smaller drops ranging in height from about one to three feet.

Today, the FRM project is operated and maintained by the city of Sheridan in accordance with the operation and maintenance manual. The area where potential restoration projects could occur under this Section 1135 study is described below in Section 1.6 and the area where prior restoration projects have occurred through local efforts by the city is described in Section 1.7.

1.6 Section 1135 Project Area

The project area is the area where potential projects could be implemented. The study area for this study encompasses the entire Goose Creek watershed from the city, upstream to the headwaters. The watershed is assessed to the extent necessary to inform the development of problems and opportunities, and to inform the environmental existing and future without project conditions.

The Section 1135 Project Area encompasses the extent of the FRM project. The project area includes the extents of existing FRM features and a lateral distance of approximately 500 feet on either side of the creek, as depicted by the red line in Figures 2A – 2D. The distance is based on the assumption that ecosystem problems and restoration opportunities are expected to be situated in close proximity to the

creek where the FRM system is located. As shown in Figure 3 and described below the project area is divided into four separate reaches.

1. Little Goose Creek Reach: This reach begins near Sheltered Acres Park and ends in downtown Sheridan just upstream of the concrete-lined channel near an old railroad bridge, in the general area of Broadway Street and A Street.
2. Big Goose Creek Reach: This reach extends from Kendrick Park to the confluence with Little Goose Creek at Mill Park.
3. Downtown Reach: This reach encompasses roughly four blocks of the Little Goose Creek through downtown Sheridan, beginning near Broadway Street and extending west to the confluence with Big Goose Creek at Mill Park. This reach is dominated by a concrete lined channel.
4. Goose Creek Reach: This reach extends from the confluence of Little Goose Creek and Big Goose Creek at Mill Park to the north to Highway 337 (i.e. Fort Road).

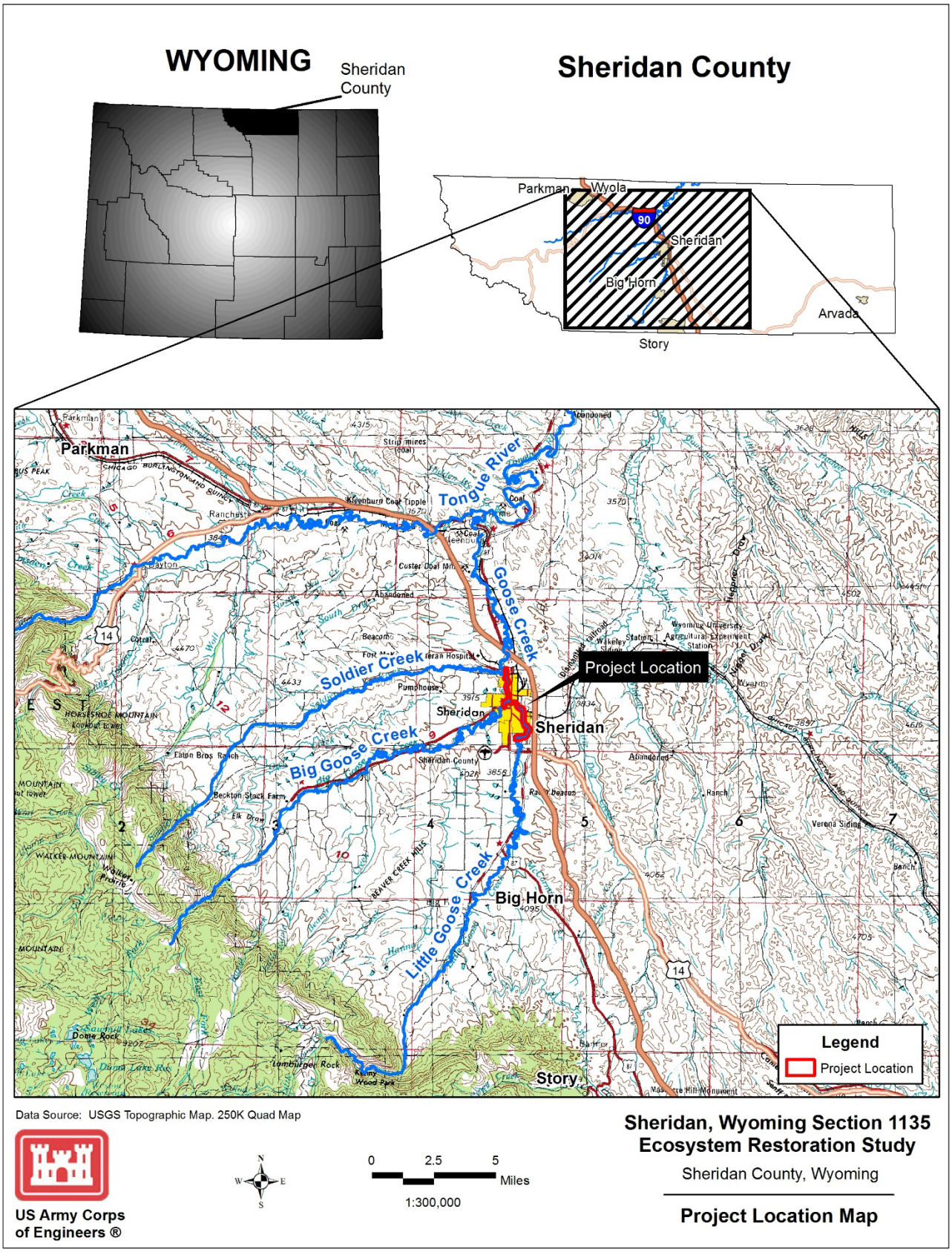


Figure 1. Project location map

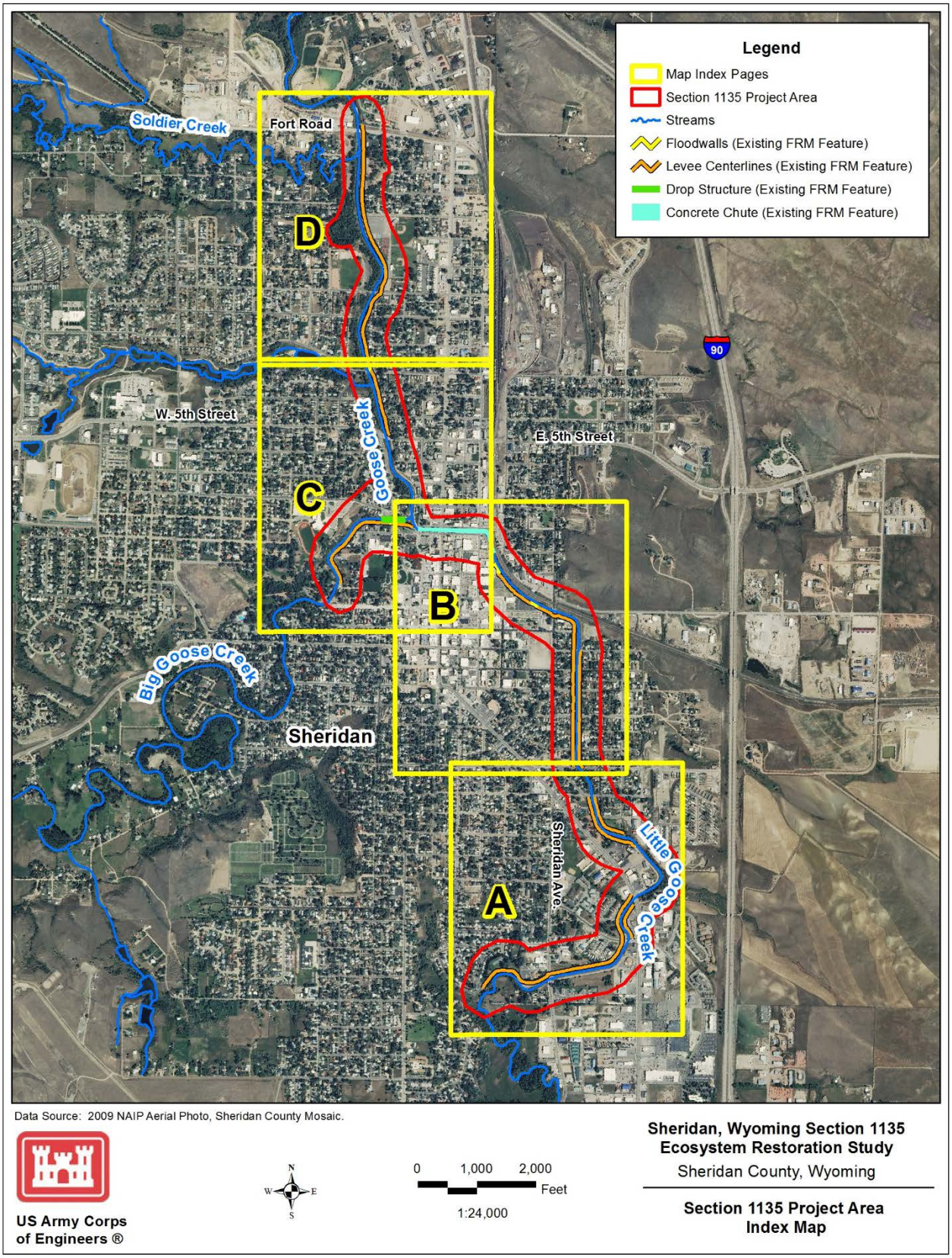


Figure 2. Project area index map

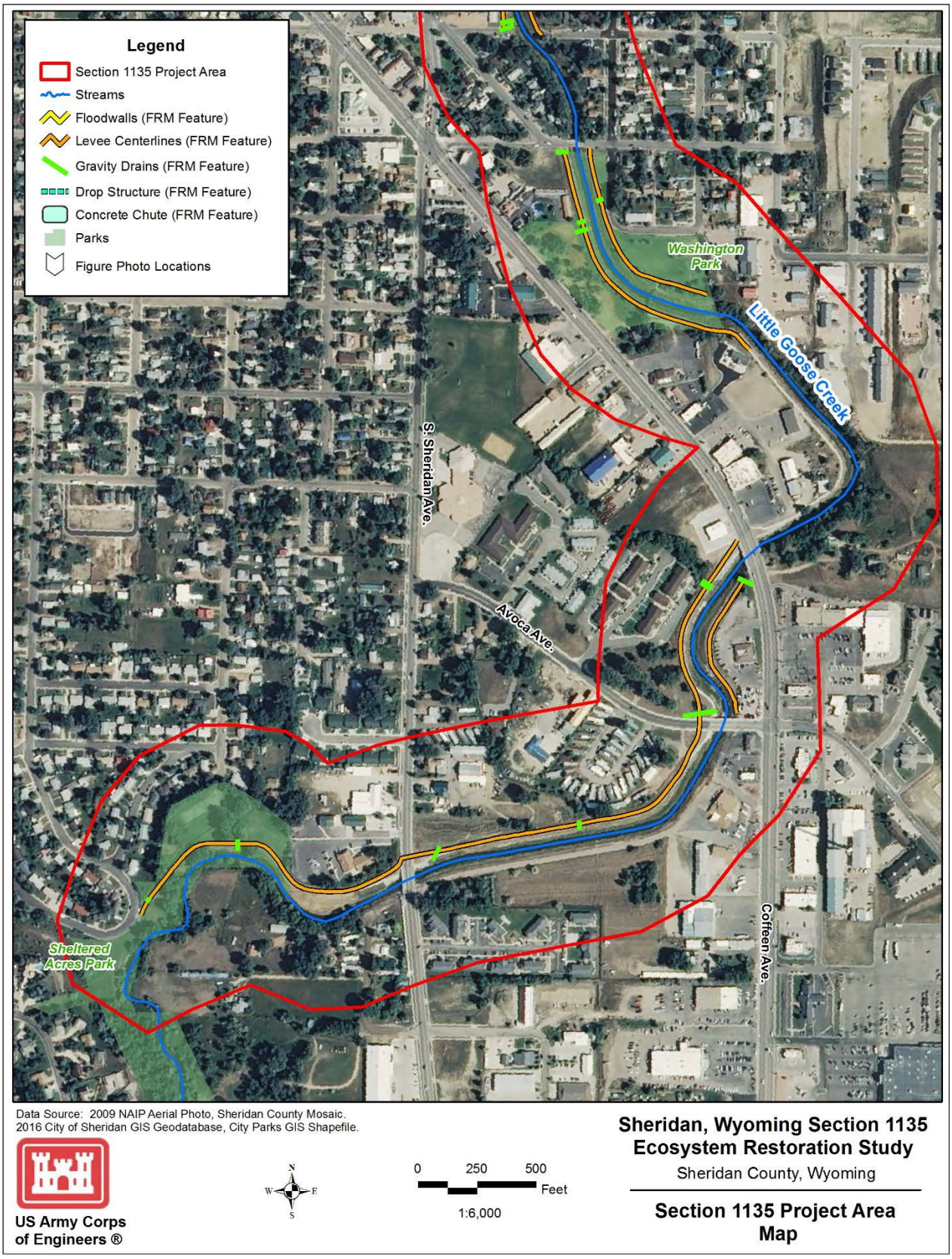


Figure 2A. Section 1135 project area and map (Little Goose Creek)

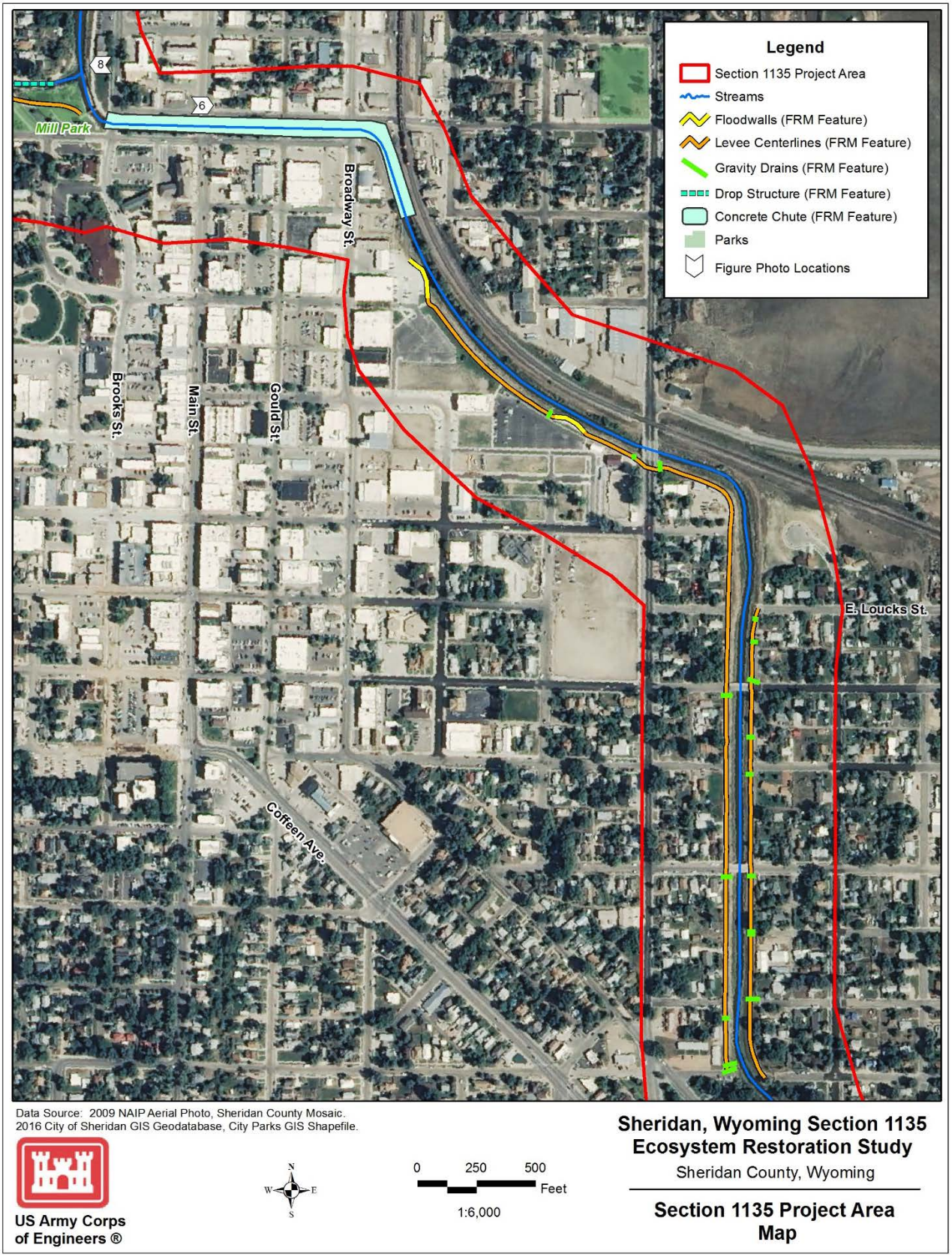


Figure 2B. Section 1135 project area and map (Little Goose Creek)

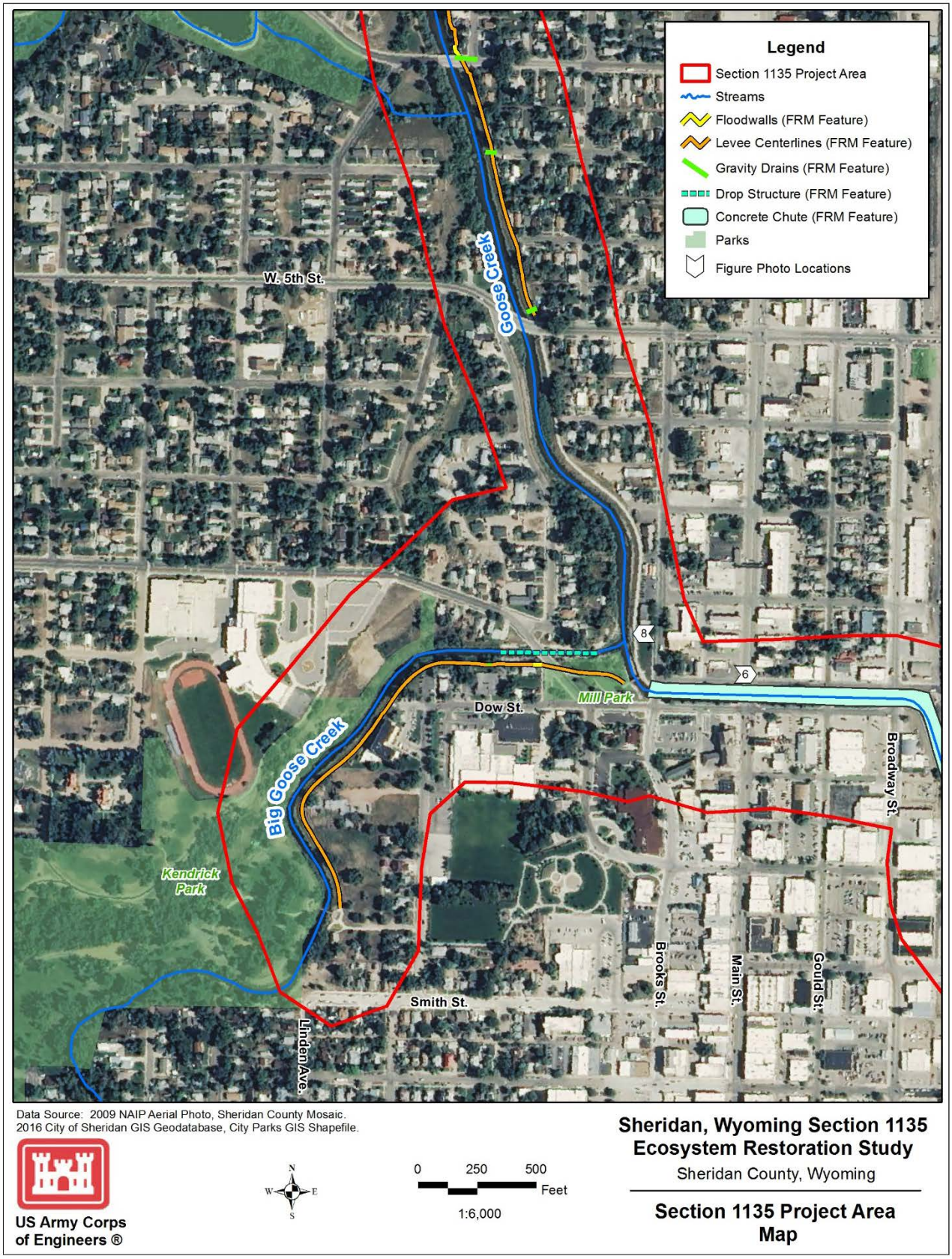


Figure 2C. Section 1135 project area and map (Big Goose and Goose Creeks)

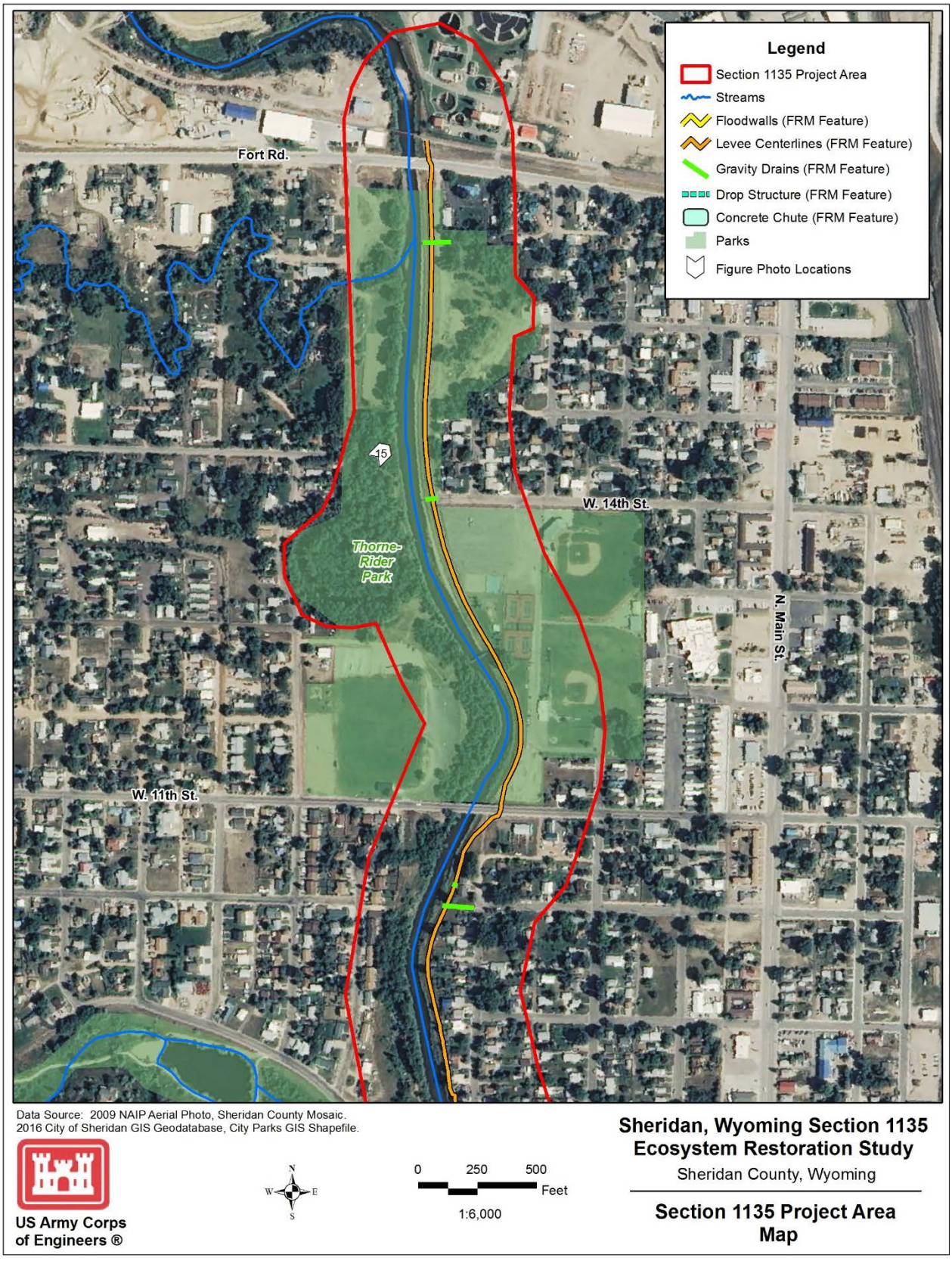


Figure 2D. Section 1135 project area and map (Goose Creek)

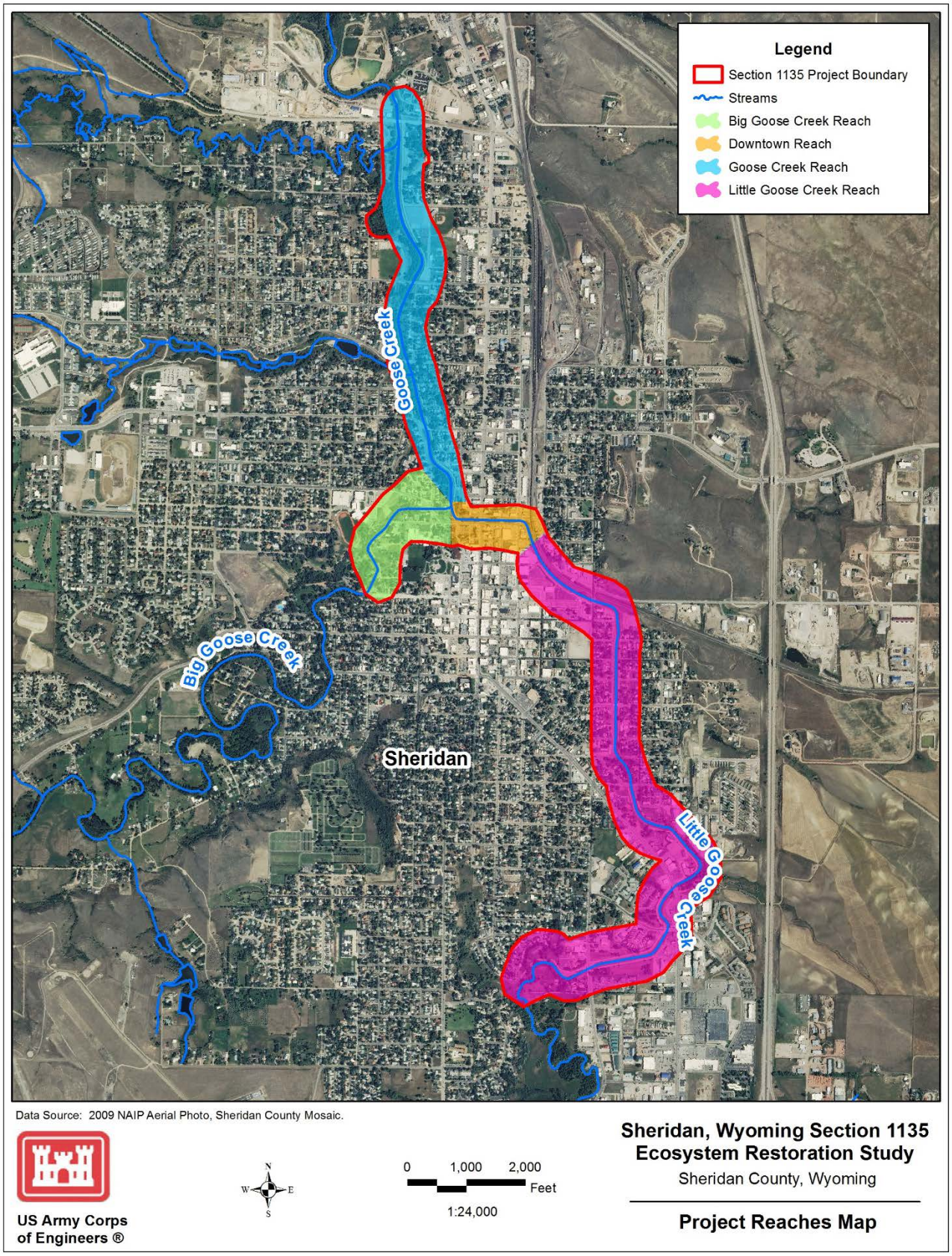


Figure 3. Project reaches map

1.7 Reference Reaches Outside of Project Area

There are several areas outside the existing FRM project, that are part of the study area, that will be used as "reference reaches" for restoration of areas within the Section 1135 project area. Reference reaches are located on Big Goose Creek in Kendrick Park and Little Goose Creek at South Park, both of which are completed local projects. Stream enhancement activities are also currently ongoing north of the project area on Goose Creek.

Community leaders in Sheridan have explored solutions to improve stream function, aesthetics, and the condition of fisheries in Big Goose, Little Goose, and Goose Creeks. To date, three in-channel restoration projects have been designed and implemented in Kendrick Park, South Park, and North Park. The purpose of this work was to restore stream channel aquatic habitat features to the extent practical. These projects serve as good indicators of potential strategies for in-stream restoration in the system of creeks. These projects have been pursued by the local sponsor with local funds, and will serve as good restoration examples for the Section 1135 project.

Within Kendrick Park, a 2008 in-channel rehabilitation project restored over 750 linear feet of stream channel dimensions and hydraulic properties. In South Park, seven cross vanes, 13 straight vanes, four vortex rock weirs, three random rock clusters, and bankfull benches were constructed across 3,966 linear feet of Little Goose Creek. The project has resulted in improved bank stability, decreased lateral migration, and improved sediment transport. Although the primary objectives of the project were to stabilize the channel, additional improvements have developed in the fisheries habitat and the general health of the riparian corridor. Similar activities have since occurred in North Park. Figure 4 shows the locations of reference reaches.

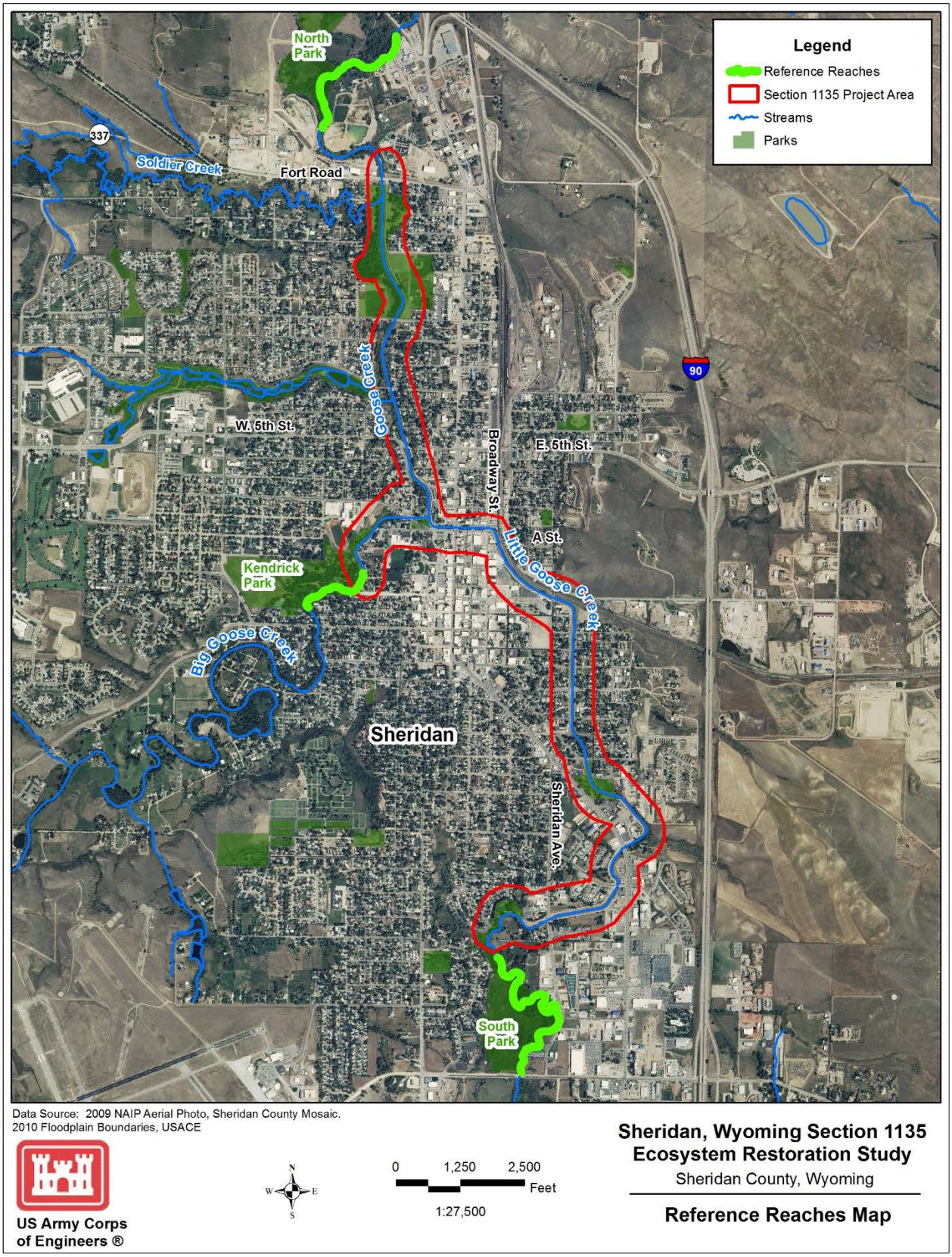


Figure 4. Reference reaches map

1.8 Institutional, Public, and Technical Significance of Area Resources

Identifying resource significance is a critical step in environmental resource planning. Identifying significance of resources is different than the NEPA requirement to determine whether a federal action constitutes a significant impact to the environment. The purposes of identifying resource significance in Corps planning studies are:

- Establish the federal interest in a proposed restoration project and a level of priority for the project at the national, regional, state, and local levels.
- Evaluate individual project plans.
- Communicate information to decision makers to support project justification.
- Communicate information to decision makers to assist in allocating resources among different projects.

Significant resources are generally the resources that are important to people. The three bases for significance are defined below:

- ***Institutional:*** Significance based on institutional recognition means that the importance of an environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies, tribes, or private groups.
- ***Public:*** Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource.
- ***Technical:*** Significance based on technical recognition means that the importance of an environmental resource is based on scientific or technical knowledge or judgment of critical resource characteristics.

Below is a summary of the institutional, public, and technical significance of the Sheridan, Wyoming Section 1135 Ecosystem Restoration Study.

Institutional Significance

A. National/International
   - Restoring migratory bird habitat (shrubs/forested areas/wetlands) in close proximity to the creeks supports national efforts to comply with the MBTA and the BGEPA. Currently there are 15 migratory "Birds of Conservation Concern" all of which are defined within the project area.
   - The Ute ladies'- tresses (*Spiranthes diluvialis*) is a federally-listed threatened species and the Greater sage-grouse (*Centrocercus urophasianus*) was a candidate for listing under ESA but was removed from consideration in 2015. Both exist within the project area and would be considered potential significant resources for analysis within the entirety of the project area according to the ESA.

B. Regional
   - Resources in the study area are discussed in adopted plans. Project area lies within the geographical range of the USFWS's Upper Missouri, Yellowstone and Upper Colombia River Ecosystem Regional Plan (http://www.fws.gov/moyoco/moyoco2.html#MAP).

C. State
   - Project area overlaps multiple WGFD Blue Ribbon Trout Streams, Aquatic Conservation Areas, Aquatic Crucial Priority Areas (Foothills to Prairie Stream and Riparian Corridors and Prairie Stream and Riparian Corridors), and Aquatic Priority Areas (Prairie Stream and Riparian Connectivity and Foothills Stream and Riparian Connectivity). WGFD has identified these crucial priority areas for having significant biological or ecological value and a need to be protected or managed to maintain viable healthy populations of aquatic and terrestrial wildlife for

the present and the future. Two crucial priority areas are listed below.

- Powder-Tongue Rivers and Tributaries Cottonwood-Willow Riparian Ecosystem (key non-game wildlife areas)
- Deciduous Woodlands in the Sheridan area and along the Little Missouri River (WGFD Terrestrial Enhancement Priority Area)

D. Local

- Resources in the study area are discussed in adopted plans. Habitat enhancement is a part of the city of Sheridan's master plans, including the North Main Master Plan (2009), City of Sheridan Parks and Recreation Master Plan (2009), and the Sheridan Joint Planning Area Land Use Plan (2009).

Public Significance

- Three ecosystem restoration projects in excess of $500,000 have been completed by the local sponsor in areas adjacent to the Section 1135 project area. Locations included Big Goose Creek in Kendrick Park, Little Goose Creek at South Park, and on Goose Creek in North Park.
- Currently, three letters have been received from state or local agencies, including the SCCD, WGFD, and WDEQ (see Appendix A8). Each agency has expressed support for the Section 1135 ecosystem restoration project and restoration of the stream resources in the study area. Specific statements made are quoted below.
- The Goose Creeks are a high priority for the community of Sheridan. Grants for stream enhancement efforts on both Big Goose Creek and Little Goose Creek have been awarded by the Wyoming Wildlife and Natural Resource Trust Fund. Volunteer efforts, the community, and recreation and neighborhood conservation groups have all contributed time and labor to assist with debris removal, riparian planting, interpretive education efforts, and ecosystem enhancement projects throughout the Goose Creeks. Some of the agencies and community groups that have provided support, labor and funding for stream enhancement projects include: SCCD, Fort Mackenzie High School, Sheridan High School, Sheridan Junior High School, Holy Name School, Sheridan College, Sheridan County Extension of the University of Wyoming, Trout Unlimited, Boy Scouts of America, RENEW Enterprises of Northern Wyoming, Joey's Fly Fishing Foundation, Bighorn Audubon Society, North Main Association, Sheridan Downtown Association, Sheridan Chamber of Commerce, Flying H Polo Club, WGFD, and the Downtown Sheridan Association – Goose Creeks Committee.
- The Downtown Sheridan Association expresses the community's commitment to the Goose Creeks in the following statement: "The Goose Creeks Committee recognizes that the downtown sections of the Goose Creeks are a part of a greater watershed for which a broader management approach is necessary. The Goose Creeks Committee therefore strives to work as a partner with and encourage partnerships between community, state, and federal organizations to improve and maintain the health and vitality of the greater Goose Creeks watersheds. It is the goal of the Goose Creeks Committee to play an active and ongoing role in developing initiatives to achieve the stream-specific outcomes set forth in the Downtown Master Plan, the City of Sheridan Parks & Recreation Master Plan and the South Park Concept Master Plan."

Technical Significance

- Representativeness: Because the project area is within WGFD crucial and enhancement priority range, restoration would emulate natural habitats or ecosystems within these ranges.
- Scarcity: The WGFD has identified the project area as crucial terrestrial priority areas and reported that wooded draws, and their native herbaceous and shrub understory, of the Northern Great Plains constitute a vegetative type that is in serious trouble (2009). Urbanization, poor farming practices and negative effects from ranching have contributed to the decline of the natural

riparian areas within the project area. Over time, these activities have adversely impacted riparian wetlands, forests, shrubs and native herbaceous land cover while also reducing river/floodplain interaction through levee construction and river channelization. The anthropogenic disturbances would likely continue into the future without a project, and increased degradation of riparian habitat is anticipated.

- Landscape considerations and connectivity: Suitable habitat is scarce and disconnected within the project area, and is most acute in the portions of the project where 1) the concrete channel is located at the terminal end of Little Goose Creek and 2) the drop structures are located near the terminal end of Big Goose Creek. The HSI model outputs will reflect this lack of functional connectivity in the future-without and future-with project conditions (see Appendix A6).
- Biodiversity: Reference reaches adjacent to the flood control channel have higher biodiversity, and the intended result of this project is to also increase the diversity within the flood control channel. Local fishing and user observations indicate that within the restored reference reaches, species such as brown trout (in excess of 19 inches), rainbow trout, small mouth bass, rock bass, sunfish, white fish, bullhead, snapping turtles, mink, muskrat, mallard, Canadian geese, turkey, pheasant, mountain lion, black bear, coyote, white tail deer, mule deer, American dipper, bald eagles, red tail hawk, merlin, owl, mountain blue bird, grouse, chucker, and sand hill crane were observed.

2.0 PURPOSE AND NEED

The purpose of the Sheridan Section 1135 Ecosystem Restoration Study is to restore stream and hydraulic function, both in a physical and ecological manner, throughout the entire project area, restore in-stream habitat connectivity and provide for fish passage, and restore wetland, riparian, and floodplain habitats and connectivity with upstream and downstream reaches in the vicinity of the flood control system. This study is needed to improve degraded aquatic habitats for fish and wildlife, including trout fisheries, which will address environmental degradation due to flood control infrastructure and improve the quality of the environment for residents of Sheridan.

2.1 Need: Environmental Problems

Construction of an FRM project along the system of creeks in Sheridan has adversely impacted ecosystem processes which has resulted in degradation of the quality of aquatic stream habitat, floodplain habitats, and has significantly impaired migratory pathways for fish. The FRM project is a root cause of the environmental degradation within the project area.

Specific components of the FRM project that have impacted the aquatic environment include 1) channelization and levees and 2) the concrete chute and drop structure. These features have affected processes that control hydrologic and sediment regimes, floodplain and aquatic habitat dynamics, and riparian and aquatic biota in the project area. Primary activities such as channel deepening, widening, realigning, and lining have changed the physical, biological, and chemical processes and structure characteristic of a stream transitioning away from a mountain front. Problems resulting from these actions are within the scope of what may be addressed by Section 1135, therefore specific action alternatives to address them were developed during this study.

Environmental problems associated with channelization, levees, the concrete chute, and drop structure are listed in Table 1. These are the problems that this study will address later on through development of restoration measures. Each problem affects the ecosystem in a different way, by disrupting physical, biological, or chemical processes.

Table 1. Problems associated with channelization and levee construction

Problems	Physical ecosystem processes impaired	Biological ecosystem processes impaired	Chemical ecosystem processes impaired
Loss of channel depth diversity and riffle pool sequences	x	x	
Degraded sediment transport processes	x		
Increased channel width-to-depth ratio	x	x	
Altered hydrologic processes between the creek and floodplain	x	x	x
Loss of woody debris	x	x	
Loss of natural channel substrate*	x	x	
Loss of habitat connectivity and migratory pathways for fish*		x	
Loss of native riparian plant communities adjacent to the channel (herbaceous, scrub-shrub, and trees)		x	x
Loss of aquatic plant communities (wetland fringe along the channel and aquatic habitat in the channel)		x	x
Water quality degradation (increased temperatures, lack of dissolved oxygen (DO), altered pH and nitrogen levels)		x	x

*These problems are specific to the concrete chute and drop structure.

In addition to the FRM project and urbanization in Sheridan, additional problems that are considered root causes of the environmental degradation of the creeks within the project area include 1) loss of stream flow due to upstream withdrawals and 2) degraded water quality from upstream land management practices. These activities are occurring on a regional and watershed-scale and have impacts on sediment regimes, floodplain and aquatic habitat dynamics, and riparian and aquatic biota in the project area. Section 1135 allows for a comprehensive assessment of environmental problems, so these problems are acknowledged in this study, solutions to these problems are outside the scope of what may be addressed by Section 1135, therefore no action alternatives to address them were included in this study.

2.1.1 Problems Associated with Channelization and Levee Construction

Figure 5 depicts a typical cross-section of each reach of the project area shown using elevation on the y-axis (feet) and channel cross-section on the x-axis (feet). In most stretches of the project area, the creek channel exhibits a flat-bottomed cross-section with limited natural characteristics. The flat-bottomed cross section has resulted in shallower depths, lower velocities, decreased sediment transport, and increased water temperatures.

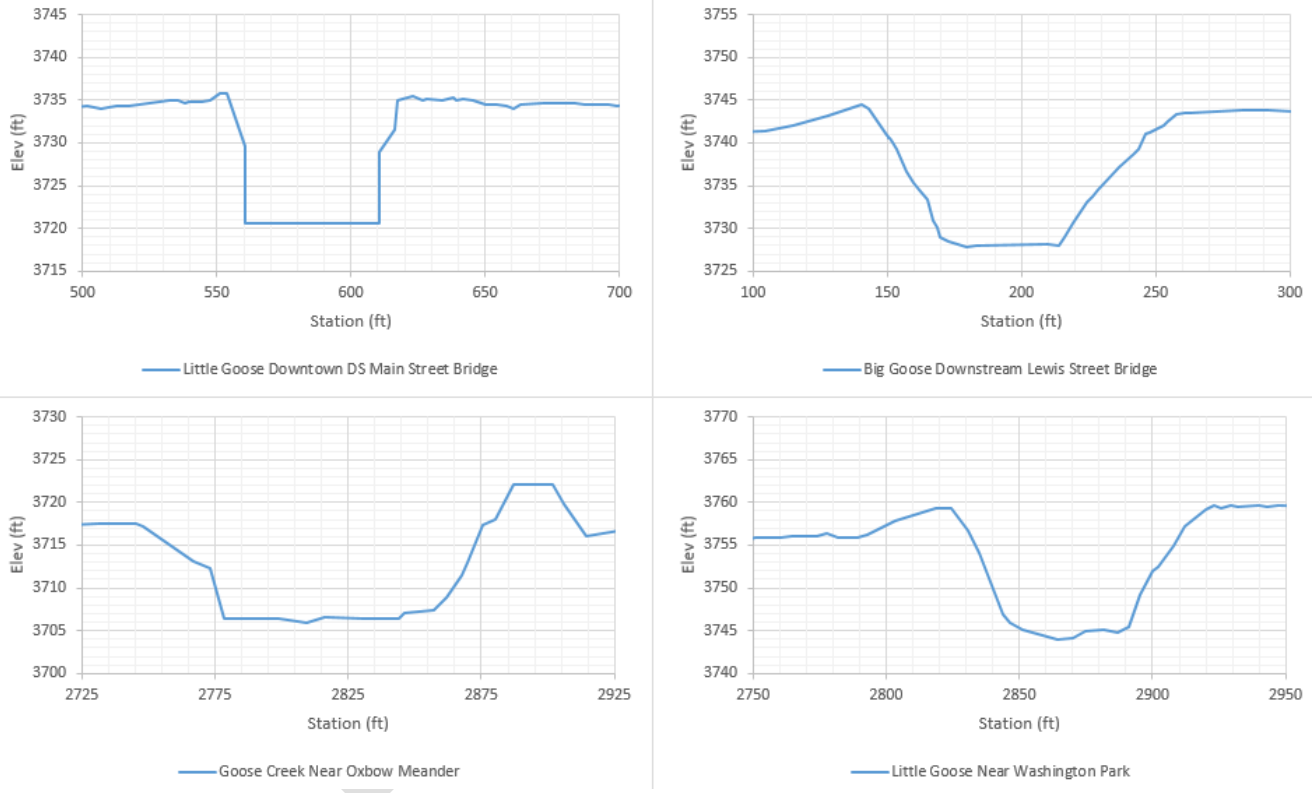


Figure 5. Characteristic stream cross-sections within the project area

Under historic conditions in the area, when the creek exhibited more sinuosity, there would have been significantly more overall stream length and aquatic habitat diversity in the channel. Throughout the project area the total length of stream from all reaches is over four miles. Most of that area consists of channelized or straightened stream channel which no longer exhibits the sinuosity that it once did. Except for a photo from 1958 that covers just a portion of the project area, aerial photography and other evidence of the historic channel footprint is scarce, therefore a historic reference for total stream length in the project area is difficult to accurately estimate. Since construction of the flood control project,

development adjacent to the creek has filled in historic oxbows and meanders through nearly the entire project area.

The magnitude of the loss of stream length due to channelization and development can be expressed by looking at similar reaches of Goose Creek and Little Goose Creek that were not channelized. For example, Big Goose Creek upstream of the flood control project is a meandering urban stream with much more wooded and riparian habitat along its banks. As shown in Figure 6, the distance of in-stream length between two points within the flood control project compared to outside of the flood control project can vary greatly. Two areas of the creek system were compared, and the area on Big Goose Creek which was not channelized has about 1.5 additional miles of stream length over the same point-to-point one mile distance "as the crow flies." Sinuosity in the stream channel would have allowed for a more natural connection to the floodplain, with more wetlands and streamside vegetation.

A summary of observations is provided below:

- On all reaches a natural connection with the floodplain does not exist due to a deepened channel bed with a uniform slope.
- On all reaches the lack of channel sinuosity has eliminated the presence of riffle pool complexes characteristic of these aquatic ecosystems. Fish are especially reliant on riffle-pool sequences for cool, oxygenated water, and therefore are more vulnerable to the previously described effects of urbanization. Lack of fisheries habitat throughout the system of creeks in the project area has been severely impacted from lack of shading, low depth diversity (no pools), and few riffles, runs, or glides.
- On all reaches there is a lack of hydrologic interaction between the floodplain and creek, which has limited the establishment of deep rooted vegetation that would allow for a healthy riparian corridor.
- On all reaches the majority of the riparian vegetation along the stream banks is composed of introduced herbaceous plant communities. Although there are small pockets of wooded vegetation along the stream banks, these pockets are isolated and do not provide habitat patch sizes or suitable habitat connectivity for wildlife. This lack of contiguous wooded habitat within the project area is a consequence of land management practices (maintenance of parkland and levee systems) and the filling and constriction of bank full benches, floodplains, and terraces that historically ran through the city.
- On all reaches, due to the channelization activities (incising and steepening of the side slopes), there is a minimal amount of in-stream vegetation that exists in the system of creeks.
- On all reaches the lack of shading from tall woody vegetation along the banks of the Creeks increases water temperatures and decreases cover for both aquatic and terrestrial wildlife.
- On Goose Creek the channel exhibits a wider channel cross-section which limits natural in-stream habitat and flow conditions. The dynamics of this flat-bottomed cross-section have contributed to widening of the channel, resulting in lower velocity, decreased sediment transport, and higher width-to-depth ratio.
- On Goose Creek lower velocities and high cross-sectional areas contribute to an increase in sediment buildup in the form of center bars with lateral channel migration.
- On Big Goose Creek the left bank downstream of Kendrick Park is instable and exhibits considerable erosion due to the steep slope and from development on the hilltop above.

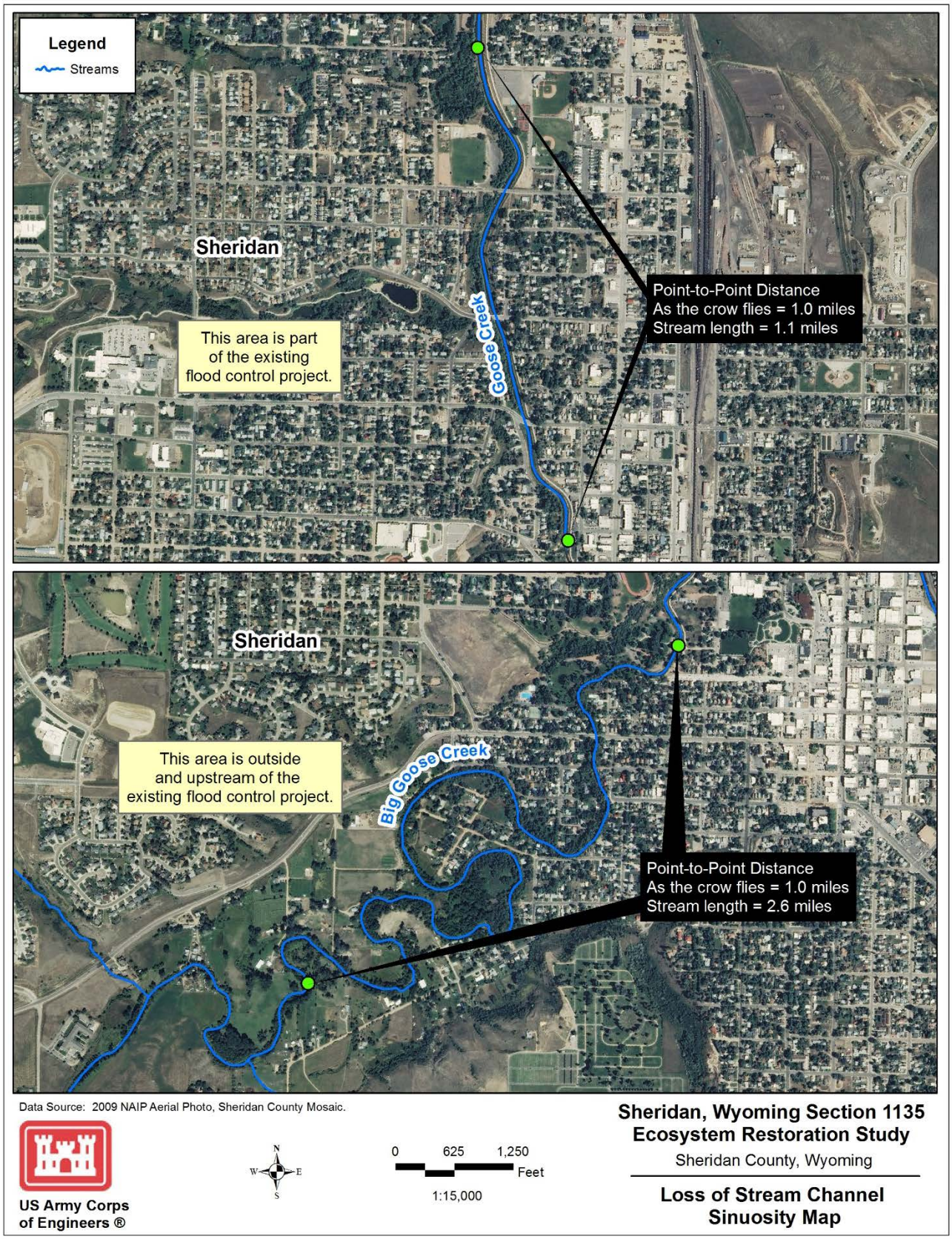


Figure 6. Loss of stream channel/sinuosity map

2.1.2 Problems Associated with the Concrete Chute and Drop Structure

Little Goose Creek in downtown Sheridan has been lined with concrete and now functions as a chute. As shown in Figure 7, the concrete chute has vertical side walls varying in height between nine and 13 feet, a bottom width of 50 feet, and is over 1,500 feet long. This alteration has had a negative effect on the flow regime of the channel in this area. Depth of flow is less than a foot under normal summer flow conditions which inhibits fish migration. Low flows, concrete substrate, and lack of shading contribute to increases in water temperature. The concrete substrate eliminates the presence of vegetation in the channel which reduces oxygenation of the water and disrupts sediment transport processes. Increases in sedimentation within the channel increase the need for channel maintenance.

Figure 7. View looking east at the concrete-lined channel portion of Little Goose Creek

The concrete lined channel has disconnected the upstream and downstream fish populations, especially during low flow conditions, due to the restricting flow regime over the concrete lining. The concrete-lined channel is much wider than the rest of the Little Goose Creek channel upstream. When water enters the lined portion of the creek it spreads out and the creek becomes very shallow during low flow periods, which occur from about July through April. Figure 8 estimates the depth of flow through the concrete channel when flows are between 20 and 50 cubic feet per second (cfs). Twenty to 50 cfs represents the monthly average range of flows in Little Goose Creek in Sheridan, excluding the months of May and June which are high flow months. As shown in the figure, the depth of water in the channel for this range of flows is roughly 0.2 to 0.4 feet and does not exceed 0.6 feet deep, which represents a significant barrier to fish passage over the length of the concrete chute.

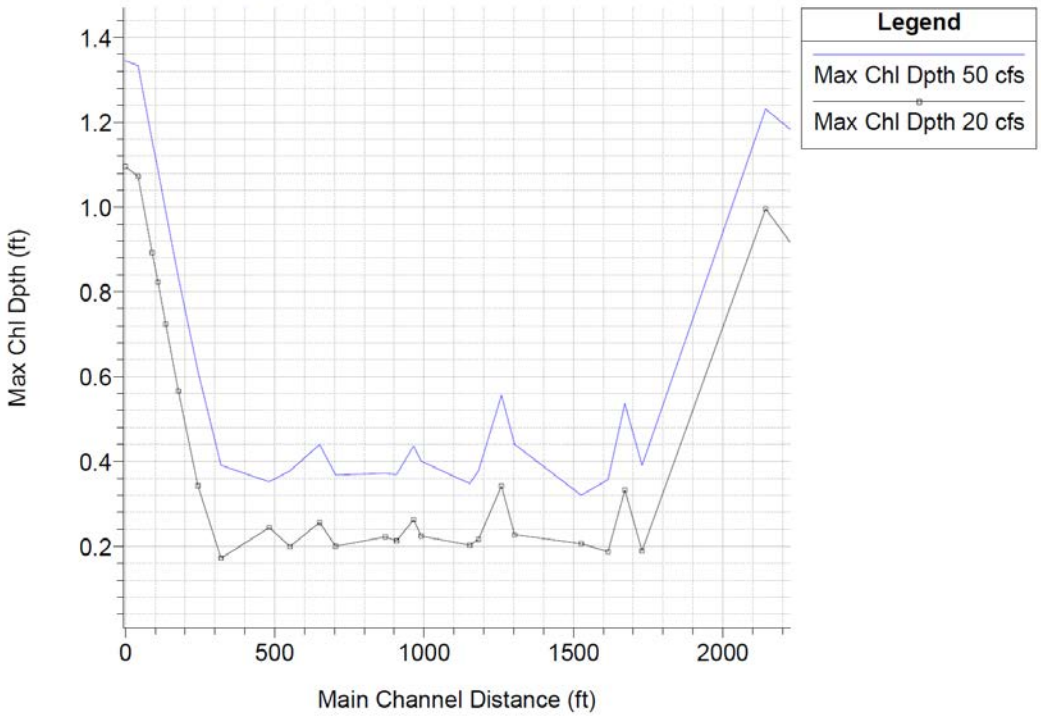


Figure 8. Estimated depth of flow on Little Goose Creek during low flow periods

The grouted drop structures on Big Goose Creek have reduced the amount of vegetation and habitat features such as riffle pool complexes. According to the channel profile in the O&M Manual there are a total of four drop structures that span a distance of approximately 650 feet. One structure is upstream and three structures are downstream of the Lewis Street Bridge. Each structure has a section of two feet thick grouted rip rap on the downstream end of the structure to provide erosion protection. The total vertical drop from the most upstream structure to the farthest downstream structure is about ten feet, and vertical drop for each individual structure tends to vary. As shown in Figure 9, the farthest downstream drop has less of a vertical fall than the two just upstream. The four structures are fish passage barriers at their current height, which ranges from about a foot up to three feet. According to the Wyoming Game and Fish Department (WGFD) minimum drop heights to allow passage for juvenile trout are 0.5 feet, adult trout are 0.9 feet, other natives need 0.4 feet, and that most of the species in the creeks around Sheridan can handle about a drop of about 0.4 feet (Personal Communication, 2015).

Figure 9. Photo looking west upstream at drop structures on Big Goose Creek

2.1.3 Problems Associated with Stream Flow Loss

Withdrawals upstream of Sheridan due to domestic living, livestock, industrial uses, and irrigation are common and contribute to existing poor stream ecosystem in the study area. The primary methods of withdrawals in the system are surface water diversions and reservoir storage. Groundwater wells in the area also reduce stream flows because of the interactions between surface and ground waters. Upstream withdrawals are outside of the scope of problems being addressed by this study, however are discussed here because they impact physical and biological processes in the project area. Stream flow and groundwater withdrawals and diversions upstream of Sheridan have contributed to increased water temperature, limited fish habitat, and virtually eliminated fish passage through the study area, further stressing aquatic and riparian ecosystem processes during summer months when the region's dry climate and low flow period traditionally limits trout survival. Due to flow withdrawals upstream of the city, it is common to observe discharges as low as 20 cfs on Big and Little Goose Creeks within the project area from July through September.

2.1.4 Problems Associated with Water Quality

Water quality degradation issues associated with upstream land use are outside of the scope of problems that may be addressed by this study. Impairments to water quality are acknowledged because they impact biological and chemical processes in the cold water fishery in the system of creeks in the Goose Creek watershed. Many water bodies in the Goose Creek watershed were first listed as impaired for exceedance of the fecal coliform standard in 2000. In 2008, these impairments were changed from fecal coliform to *Escherichia coli* (*E. coli)* to reflect the change in state water quality standard definitions for pathogen impairments.

In 2006, the cold water fishery use on Goose Creek was listed as impaired for sediment and habitat. This impairment was based on a weight-of-evidence approach incorporating a biological assessment of Goose Creek conducted by the Wyoming Department of Environmental Quality (WDEQ). Both the *E. coli* and sediment impairments were identified by WDEQ for Goose Creek from the confluence of Big Goose Creek and Little Goose Creek to the confluence with the Tongue River 12.7 miles downstream. The largest tributary to Goose Creek is Soldier Creek, which was listed as impaired from the confluence with Goose Creek to a distance 3.1 miles upstream for exceedance of the fecal coliform standard in 2000. In 2008, the impairment cause was changed to *E. coli* to reflect the recent change in state water quality standards.

Big Goose Creek along with three of its tributaries (Beaver Creek, Park Creek, and Rapid Creek) were listed as impaired for exceedance of the fecal coliform standard in 2000. The estimated length of impairment identified for Big Goose Creek and its tributaries on the 2012 303(d) list is 32.4 miles. Little Goose Creek was first listed as impaired for exceedance of the fecal coliform standard in 1996. Four tributaries to Little Goose Creek (McCormick Creek, Kruse Creek, Sackett Creek, and Jackson Creek) were also listed as impaired for exceedance of the fecal coliform standard in 2000. In 2006, the cold water fishery use on Goose Creek was also listed as impaired for sediment and habitat. The estimated length of impairment identified for Little Goose Creek and its tributaries on the 2008 303(d) is 17.7 miles.

2.2 Opportunities

The opportunities below were developed by the team through the scoping, data gathering, and characterization of existing conditions phase of the study. The opportunities for the project area are described in the following list.

- Restore natural form and function back to the creek channels.
- Restore connectivity within the system of creeks to benefit fish migration patterns.
- Improve aquatic habitat for fish and other aquatic species.
- Create floodplain wetlands and wetland fringe along the creeks in Sheridan.
- Improve environmental quality by modifying levees, channels, and other FRM features.
- Reverse negative environmental effects of a FRM system that was built in the 1960s that at the time did not require integration of sustainable environmental principles or reflect current social values.
- Integrate recreation features into ecosystem restoration features to reflect public interest.

2.3 Public and Agency Input

Public involvement is an important component of any civil works study. The project delivery team (PDT) integrates input from the public into the six-step planning process. Typically a minimum of two public meetings are held but more may be held as needed to obtain input from the public. The first public meeting is typically referred to as a scoping meeting, which is held early on in the study to gather input on the ecosystem problems, restoration opportunities, study objectives, and to brainstorm potential restoration measures. Scoping meetings are an important part of the NEPA process. NEPA outlines that the intent of scoping meetings is to help to highlight significant issues and frame the scope of the study by involving stakeholders. As part of the scoping process the Corps also conducts an agency scoping meeting, which is intended to receive comments from relevant local, state, and federal resource agencies on the project. The second public meeting typically occurs during the evaluation of plans. Later in the study the PDT will hold the second meeting to gather input on the final array of alternatives being evaluated and the likely recommended plan.

2.3.1 Public Scoping Meeting

A public scoping meeting was held on April 30, 2015. That meeting was attended by 32 members of the public. A summary of comments received during the meeting is listed below.

- Areas of the creek contain large piles of woody debris which could be removed.
- Protecting the water quality of the creeks is important.
- A member of the public asked how the team will measure success of the project. The Corps discussed the general process used for measuring habitat outputs.

- The team was asked for examples of other successful ecosystem restoration projects. The Corps cited examples on its website.
- Upstream of downtown on Big Goose Creek (south of the confluence), there used to be a lot of trees and wildlife. Now there are no trees along/on the levee and no wildlife.
- The ecosystem can be improved but don't forget why the flood control project was put there in the first place.
- West of Sheridan along the Big Goose Creek, areas should be cleaned up so downtown Sheridan doesn't get flooded.
- Broken agricultural levees along Soldier Creek and Big Goose Creek caused the last flooding in Sheridan.
- At the recreation table, a comment was mentioned about the Casper rafting/recreation area.

2.3.2 Expert Interviews and Walkthrough of the Project Area

Interviews were conducted with local and regional experts to 1) assist in the identification of restoration measures that could be implemented within the project area, 2) assess how those measures would benefit the ecosystem, and 3) determine which species would benefit from this restoration. The interview list includes local and regional experts from the WGFD, Sheridan County Conservation District (SCCD), U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Northern Wyoming Community College, University of Wyoming, Stantec, Steady Stream Hydrology, and Barr Engineering. Contact information for all experts was provided to the Corps and the city via e-mail and is included with the electronic submittal for this report.

In all, 20 experts were contacted on March 3rd, 2015, to introduce the project and determine if they would like to participate in the interview process. The text of the email invitation that was sent individually to each expert was approved by the City and the Corps, and is provided with the electronic submittal for this report. Of the experts contacted, 15 agreed to participate in the process. Individuals who agreed to be interviewed were provided with additional details on the project, including the federal interest determination, project reports completed by SWCA, and a list of interview questions. For more detailed information regarding the preparation for and results of the surveys and walk-through see Appendix A5.

2.4 Purpose: Objectives

One of the first steps of the Corps' planning process is to identify the overarching goal of a project, along with specific and measurable project objectives. The period of analysis for this study is 50 years which is assumed to begin following construction of a restoration plan. Construction (if a plan is recommended for this project is assumed to end at the end of 2019, therefore the period of analysis is 2020 – 2070. Measurements of benefits are estimated later in the alternative formulation process. Benefits are calculated at various years over the period of analysis in order to capture the benefits of an alternative over time. Benefits for this study were estimated for target years zero, one, 10, 25, and 50.

Constraints are identified for the planning effort. During the alternative formulation phase, alternatives should be formulated to avoid the planning constraints.

National Objective

In general, the national objective for the Corps in ecosystem restoration planning is to contribute to NER. Contributions to NER are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indexes (but not monetary units).

Specific to the Sheridan Section 1135 study, the goal is to restore ecosystem function and capacity by improving the quality of aquatic, wetland, and riparian habitats along the Goose Creeks in Sheridan, Wyoming in the vicinity of the FRM project that was built in 1966.

Project Objectives

The following three objectives have been identified as the primary objectives for the Section 1135 feasibility study. Table 2 shows how the planning objectives address the previously identified environmental problems and Table 3 shows how the planning objectives relate to the previously identified opportunities.

1. Restore stream and hydraulic function, both in a physical and ecological manner, throughout the entire project area.
2. Restore in-stream habitat connectivity and provide for fish passage.
3. Restore wetland, riparian, and floodplain habitats and connectivity with upstream and downstream reaches in the vicinity of the flood control system.

The following objective has been identified as the secondary objective for the Section 1135 feasibility study.

1. Transform the concrete chute area into a recreational amenity and create connectivity with other recreational features in Sheridan.

Table 2. Linkages between planning objectives and environmental problems

Problems	Objective 1	Objective 2	Objective 3
Loss of channel depth diversity and riffle pool sequences	x		
Degraded sediment transport processes	x		
Increased channel width-to-depth ratio	x	x	
Altered hydrologic processes between the creek and floodplain			x
Loss of woody debris			x
Loss of natural channel substrate*	x	x	
Loss of habitat connectivity and migratory pathways for fish*		x	
Loss of native riparian plant communities adjacent to the channel (herbaceous, scrub-shrub, and trees)			x
Loss of aquatic plant communities (wetland fringe along the channel and aquatic habitat in the channel)	x		x
Water quality degradation (increased temperatures, lack of dissolved oxygen (DO), altered pH and nitrogen levels)	x	x	x

Table 3. Linkages between planning objectives and opportunities

Problems	Objective 1	Objective 2	Objective 3	Secondary Objective 1
Restore natural form and function back to the creek channels.	x	x		
Restore connectivity within the system of creeks to benefit fish migration patterns.		x		
Improve aquatic habitat for fish and other aquatic species.	x	x	x	
Create floodplain wetlands and wetland fringe along the creeks in Sheridan.			x	
Improve environmental quality by modifying levees, channels, and other FRM features.	x	x	x	
Reverse negative environmental effects of a FRM system that was built in the 1960s that at the time did not require integration of sustainable environmental principles or reflect current social values.	x	x	x	
Integrate recreation features into ecosystem restoration features to reflect public interest.				x

2.5 Constraints

The following constraints have been identified for the Section 1135 feasibility study.

1. Maintain the function and protection provided by the existing FRM system.
2. Follow guidelines of the existing FRM project O&M Manual, including specifications related to types of vegetation that may be planted in the vicinity of FRM features.
3. Maintain structural integrity of the roads and bridges adjacent to the FRM project that are not intended to be altered as a result of project activities.

3.0 CURRENT CONDITIONS

3.1 Climate

The climate of the Goose Creek watershed is typical of semiarid and mountainous regions in Wyoming. Approximately 79 percent of the precipitation occurs during the growing season, which is April through early October. Precipitation ranges from under 12 inches in the east-central portion of Sheridan County to more than 30 inches in the Bighorn Mountains (PRISM Climate Group, 2015). Snowfall depth averages 73 inches per year in the higher elevations in the vicinity of Sheridan, but is significantly lower (43 inches per year) in the lower elevations surrounding Sheridan. The growing season lasts between 110 and 140 days. Average annual precipitation for Sheridan is 15 inches. Additional information on climate is located in Appendix A4.

3.2 Drainage Basins and Surface Water Resources

The Goose Creek watershed (hydrologic unit code 1009010102) is in Sheridan County in north-central Wyoming. The watershed drains an estimated 418 square miles and includes the city of Sheridan and the communities of Acme, Beckton, and Big Horn, the Bighorn National Forest (BHNF), rural subdivisions, and several ranches (see Figure 10). The watershed covers an elevation range from 3,644 feet above mean sea level (msl) at Acme to approximately 11,760 feet above msl in the Bighorn Mountains. Little Goose Creek and Big Goose Creek converge to form Goose Creek, which flows through the city of Sheridan and north into the Tongue River (a tributary to the Yellowstone River) and eventually into the Missouri River.

Although most of the watershed (265,840 acres) is in Sheridan County, approximately 44,688 acres are in Johnson County, and 129 acres are in Big Horn County. BHNF makes up 43 percent of the drainage area and is managed as a multiple-use area for recreation, seasonal cattle grazing, logging, and wildlife. Half of the watershed is owned by private landholders, most of which own and operate ranches. These ranches consist of irrigated hay and crop lands, as well as pastureland for cattle grazing. Habitat found on private lands also supports big game, waterfowl, and other wildlife species. The city of Sheridan is the largest and most developed urban area in the watershed. Subdivisions, converted from rural areas, along Little Goose Creek and Big Goose Creek, are increasingly common, particularly in areas close to the city of Sheridan.

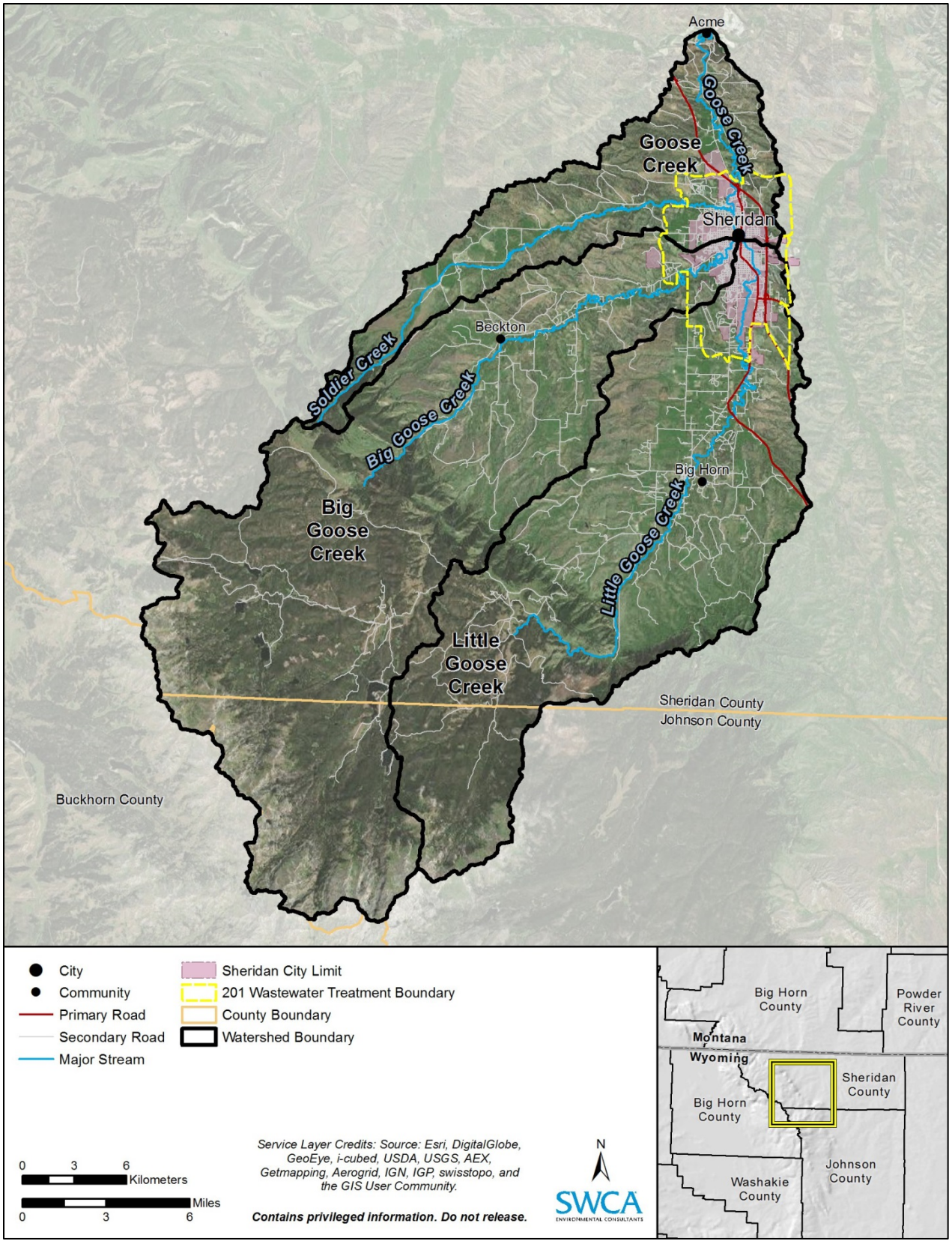


Figure 10. Goose Creek watershed location

As shown in Figure 11, the Goose Creek watershed consists of three subwatersheds: Goose Creek, Big Goose Creek, and Little Goose Creek. The sections below describe these water resources in terms of their locations and extent.

The Little Goose Creek subwatershed is 96,572 acres, and elevations range from 3,723 (in the city of Sheridan) to 10,991 feet. Little Goose Creek is a fourth-order stream that joins with Big Goose Creek to form the main-stem of Goose Creek in the city of Sheridan's downtown area. Little Goose Creek is formed by the convergence of the East Fork and West Fork of Little Goose Creek. Flows in the East Fork of Little Goose Creek are fed by snowmelt from the Bighorn Mountains. Flows in the West Fork of Little Goose Creek are attenuated by Cross Creek, Bighorn, and Park Reservoirs. Additional flows are provided to the West Fork of Little Goose Creek via the inter-basin Park Reservoir diversion from the East Fork of Big Goose Creek. The East Fork and the West Fork of Little Goose Creek converge approximately 0.5 miles upstream of the national forest boundary, after which the creek becomes a fourth-order stream (Strahler, 1957) and flows to the city of Sheridan. The major tributaries to Little Goose Creek are McCormick Creek, Kruse Creek, Jackson Creek, and Sackett Creek. McCormick Creek and Kruse Creek enter Little Goose Creek near the intersections of Highways 87 and 335. Jackson Creek enters Little Goose Creek approximately 0.5 miles north of the Big Horn community. All of these tributaries have a drainage area of approximately 10 square miles or less, and they are designated as third-order streams.

The Big Goose Creek subwatershed is 130,192 acres, and elevations range from 3,728 (in the city of Sheridan) to 11,760 feet. Big Goose Creek is a fifth-order stream that, together with Little Goose Creek, forms the main stem of Goose Creek in the city of Sheridan's downtown area (SCCD, 2003). Big Goose Creek is formed by the convergence of the East Fork and West Fork of Big Goose Creek. Flows in the East Fork of Big Goose Creek are attenuated by Cross Creek, Bighorn, and Park Reservoirs. Flows in the West Fork of Big Goose Creek are attenuated by Dome Lake and Sawmill Reservoirs. The convergence of the East Fork and West Fork of Big Goose Creek is approximately two miles upstream (southwest) of the national forest boundary where Big Goose Creek becomes a fifth-order stream and flows northwest to the City of Sheridan. The major tributaries to Big Goose Creek are Rapid Creek, Park Creek, and Beaver Creek. The largest tributary is Rapid Creek, which joins with Big Goose Creek near Beckton, Wyoming.

The Goose Creek subwatershed is 39,075 acres, and elevations range from 3,594 feet at Acme to 8,560 feet at the headwaters of Soldier Creek. Goose Creek is a fifth-order stream (Strahler, 1957) that forms at the confluence of Little Goose Creek and Big Goose Creek near the intersection of Dow Street and Alger Street in the city of Sheridan's downtown area. Goose Creek flows north to the Tongue River near Acme, Wyoming. Goose Creek's primary tributary is Soldier Creek. Soldier Creek is a fourth-order stream, with a total drainage area of approximately 33.3 square miles. Soldier Creek enters Goose Creek from the west approximately 1,000 feet upstream from the Fort Road Bridge.

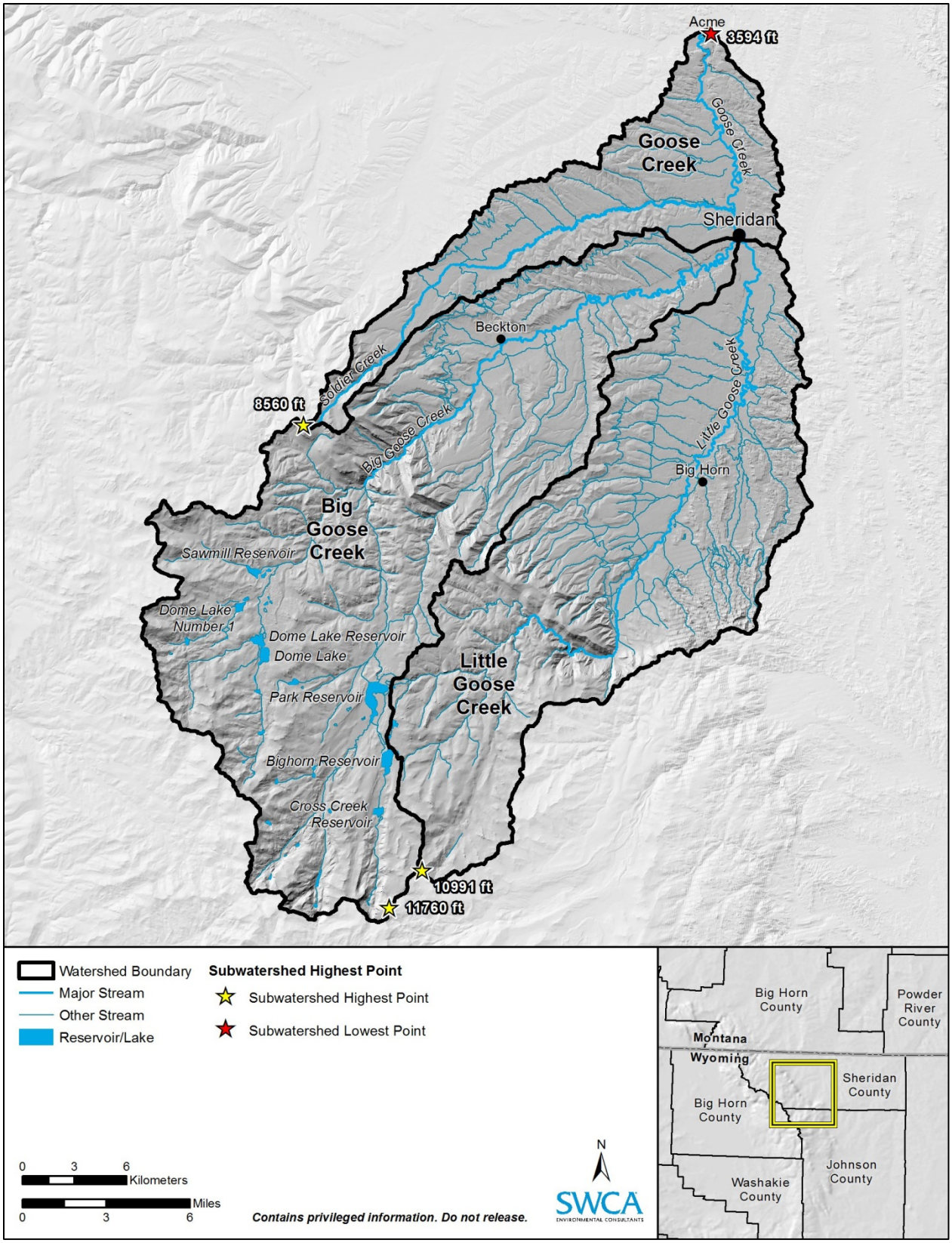


Figure 11. Water resources throughout the Goose Creek watershed

3.3 Socioeconomic Setting

The largest urban area in the Goose Creek watershed is the city of Sheridan, with smaller surrounding communities including Beckton, Big Horn, and Acme. Most of the population in the watershed resides in the city of Sheridan, with an estimated population of 17,444 in 2010 (U.S. Census Bureau, 2014). Outside of the city of Sheridan, an estimated 3,356 people live in the watershed. This population estimate was derived from the number of residential homes on septic systems outside of the city limits and the assumption that there is an average of 2.29 people per household in Sheridan County (U.S. Census Bureau, 2014).

The area's population has grown steadily in recent decades, and population forecasts anticipate continued growth. The population in Sheridan County has increased more than 53 percent since 1970. At an annual rate, the population increase has been 1.2 percent (Wyoming Economic Analysis Division, 2015). Table 4 reflects the current and projected population for the Goose Creek watershed and surrounding area. The state of Wyoming population numbers are provided for comparative purposes.

Table 4. Population of Goose Creek watershed and surrounding area

Area	Population 2010	Estimated Population 2030
Wyoming	563,626*	668,830‡
Sheridan County	29,116*	33,520‡
Goose Creek Watershed	20,800	24,343
City of Sheridan	17,444*	20,083‡
Rural residents in the Goose Creek Watershed	3,356†	4,260§

* Data from U.S. Census Bureau (2014).
† Estimated from septic density map for area outside of the city of Sheridan but in the watershed, multiplied by 2.29 (the average people per household in Sheridan County).
‡ Data from Wyoming Economic Analysis Division (2015).
§ Estimated using a 1.2 percentage increase for Sheridan County.

3.4 Land Use

Land use types surrounding the project area include residential, commercial, industrial, agricultural, and recreational/open space. Comprehensive plans, community and neighborhood plans, and zoning regulations guide and regulate land development and use. The city of Sheridan has regulatory authority over land use in the immediate study area. The Sheridan Joint Planning Area Land Use Plan (2009) is the major planning document for the city. The Parks and Recreation Master Plan has also been adopted and is currently underway that will cover segments of the project area.

Figure 12 provides an overview of land use for the Sheridan study area plus adjacent land uses, defined as a ¼-mile buffer on either side of the project area boundary. Table 5 summarizes land uses in and adjacent to the project boundary. The map uses a geographic information system (GIS) layer and associated data downloaded from the city of Sheridan's land use database. The project area boundary was added for mapping and data analysis purposes. Land use is largely residential with commercial uses primarily along North Main Street and in the northwestern corner. Industrial uses are mainly in the southeastern edge of the study area and dispersed along North Main Street as well.

A map of land use in the watershed is located in Appendix A4.

Table 5. Land uses in and adjacent to the project area

Land Use	Acres	Percentage of Total Acres
Residential	821	57.7
Commercial	299	21.0
Industrial	286	20.1
Agricultural	17	1.2
Total	**1423**	**100**

Source: City of Sheridan land use geodatabase, 2014.

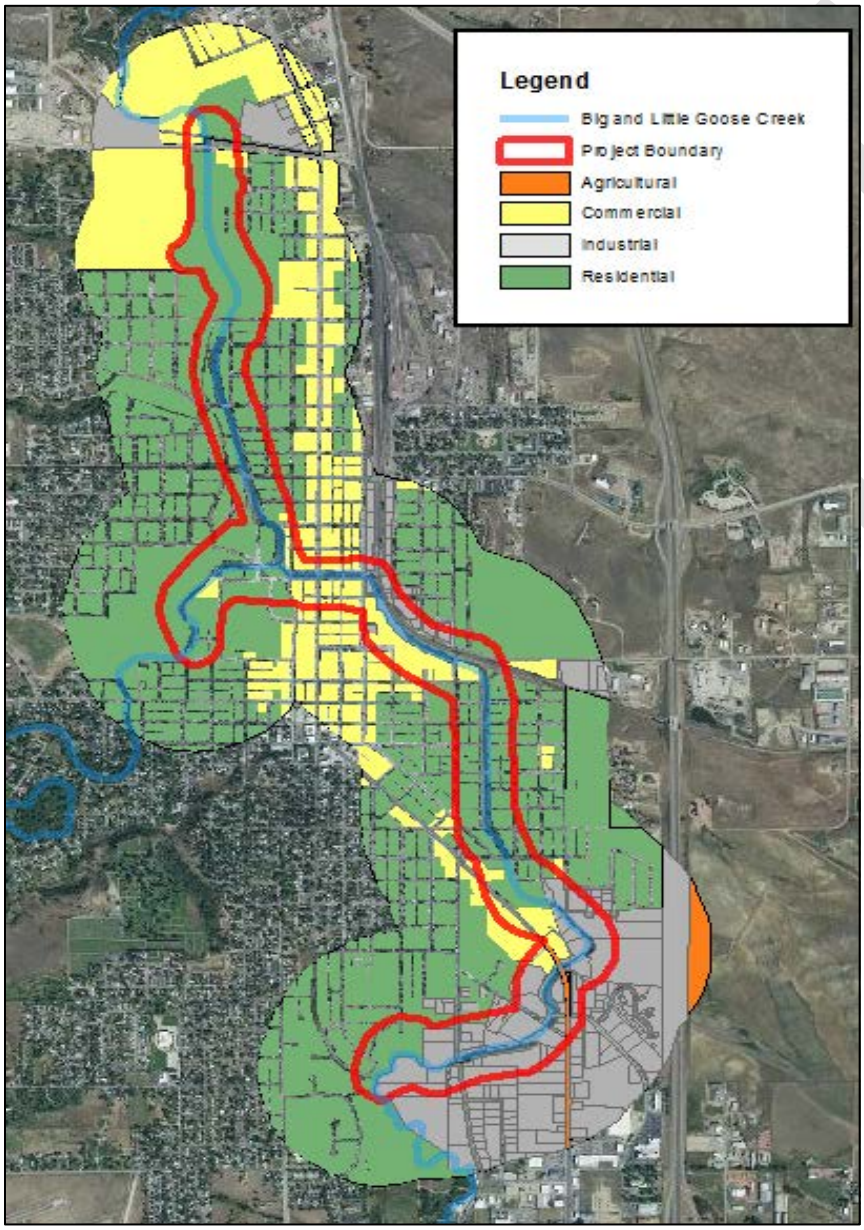


Figure 12. Land use within and adjacent to the project boundary

3.5 Flood Risk Management Project Overview

After a series of costly floods in the early 1900s the city of Sheridan developed a three-stage flood control plan for Little Goose Creek and Big Goose Creek through the city of Sheridan. Work was last completed in 1966, and involved channel straightening and realignment, and the addition of levees and a drop structure to contain the 100-year flood event. The extent of these modifications ranged over 20,000 linear feet on Big Goose Creek, Little Goose Creek, and Goose Creek.

Construction of the FRM project was authorized by the Flood Control Act approved 17 May 1950 (Public Law 516, 81st Congress, 2nd Session). The non-federal sponsor is the city of Sheridan. The city of Sheridan is responsible for providing the operation and maintenance required to ensure the project is functional in time of need. The project consists of levees, channel alterations, drainage structures, a concrete chute, concrete drop structures, and steel sheet pile and bin walls which were designed to protect the city from flood discharges in Little Goose Creek, Big Goose Creek and Goose Creek. The project was completed in two stages with overall completion occurring in 1966. Descriptions of each feature are provided below.

The horizontal datum used in this study is state plane projection, Wyoming East Central NAD 83 and the vertical datum is NAVD88 with units in feet. Bridge survey data for the fifty bridges contained in this model was collected and provided by the sponsor.

3.5.1 Levees

Levees are a significant portion of the FRM project. They were constructed on Little Goose Creek, Big Goose Creek, and Goose Creek. The typical levee section was constructed with a 10-foot top width that was surfaced with four inches of gravel to provide a wearing surface for maintenance and flood fighting traffic. Most of the gravel surfacing was replaced with an asphalt or concrete pavement bike path by the city of Sheridan. A 10-foot wide riverside berm was provided where right-of-way clearances permit. The side slopes are one foot vertical to two feet horizontal. Detailed descriptions of levees on each reach and photos are located in Appendix B.

3.5.2 Channels

Channels were modified throughout the FRM project to convey flood waters. The typical channel section has one foot vertical to two feet horizontal side slopes with a grass cover to control erosion. Along several reaches subject to more severe erosion, the side slopes are armored with riprap. Channel widths vary between 40 feet and 90 feet. Under the 8th Street Bridge, the channel slopes are steepened to 1.5:2 feet (vertical: horizontal) and a side slope paved with a one-foot concrete slab. A typical channel section photo is shown in Figure 13 below.

Figure 13. Typical channel section

3.5.3 Concrete Chute

Through the business district of Sheridan (beginning near Broadway Street and extending west to the confluence with Big Goose Creek at Mill Park), the Little Goose Creek channel is concrete lined. The concrete chute has vertical side walls varying in height between nine and 13 feet, a bottom width of 50 feet and is 1,674 feet long. The chute has vertical construction joints about 25 feet apart. Watertight expansion joints were provided in the walls and slab where the chute adjoins the street bridges, downstream of the right abutment of the railroad bridge and about midway between the railroad bridge and the Broadway Street Bridge. At the downstream end of the chute, a concrete retaining wall extends 70 feet along the right bank of the channel facing downstream. Behind both chute walls is a perforated backfill drain with outlets through the walls about 25 feet apart. Storm sewer extensions, without gates, and gated surface (i.e. gravity) drain outlets were installed at various locations in the walls. The outlet elevations of the un-gated storm sewer extensions are higher than the design water surface elevation during flood periods. Handrails fabricated of galvanized pipe and wire mesh panels were installed on top of the chute walls and retaining walls. A photo of the concrete chute is shown in Figure 7.

3.5.4 Drop Structure

Original Structure

The original drop structure located within Big Goose Creek near the confluence with Little Goose Creek provided a 13-foot vertical drop in grade over a 40-foot wide weir. The side walls were about 43 feet in length and varied in height from about 19 to 26 feet. Wing walls extended about 17 feet downstream from the end sill. Galvanized handrails with wire mesh panels were installed on top of the side walls and wing walls and along the side slopes of the upstream channel for a distance of 40 feet as a safety feature. A safety net fabricated of chain was placed across the channel at the upstream end of the handrail with a warning sign that stated “Danger-Waterfall.”

Modified Structure

The drop structure was modified by the city of Sheridan in 1995 due to safety concerns. The original concrete drop structure with baffle blocks was modified by removing the baffle and eliminating the south concrete wall. Three additional drop structures, consisting of driven sheet pile and grouted riprap, were constructed. The accumulative drop from all four drop structures is 10 feet verses the original 13-foot vertical drop.

A profile of the modified drop structure is shown in Figure 14 below. The figure was taken from the O&M Manual and dates back to the 1990’s when the drop structure was modified. The top portion of the

figure shows the profile of the upstream portion of the structure down to Lewis Street Bridge. The bottom portion of the figure shows the drop structure from the Lewis Street Bridge to the downstream end of the structure. The figure shows four total drops spanning a distance of about 575 feet, as indicated by the stationing (approximately station 6+00 to station 0+25).

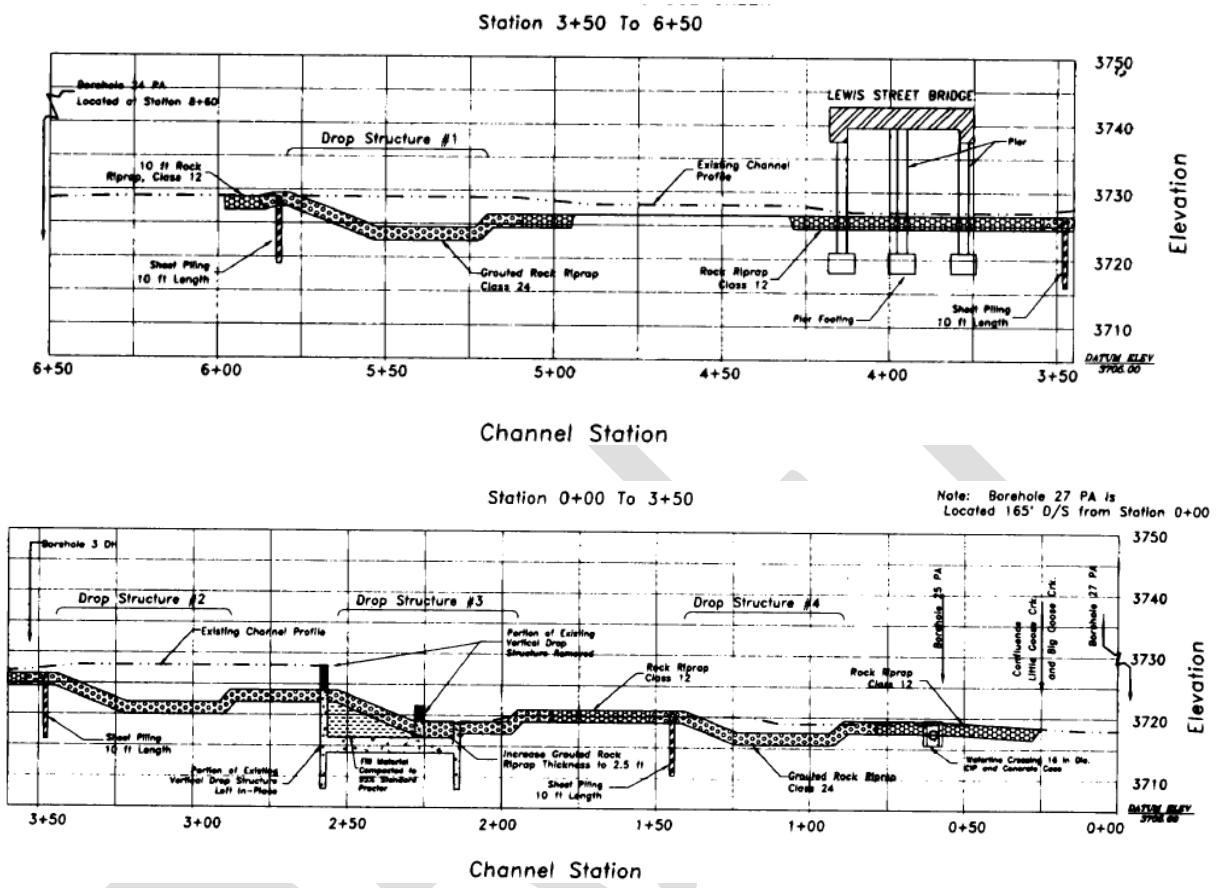


Figure 14. Channel profile of existing modified drop structure

3.5.5 Drainage Structures

There are 37 drainage structures that pass through or under the levees to provide drainage for the leveed areas. Most of the drainage structures are equipped with automatic flap gates on the riverside of the levee. Some of the structures are also equipped with manually operated slide gates mounted in a gate tower. The locations of drainage structures are provided in Appendix B. In addition to drainage structures, there are approximately 17 storm sewer conduits that discharge into the concrete chute through the side walls.

Stormwater outfalls

Although not considered part of the function of the existing FRM project, there are many stormwater outfalls that discharge in the system of creeks in the project area. The city has implemented stormwater design standards and also maintains a municipal stormwater system. Collectively, the urban stormwater system drains 2,027 acres of the city. There are an additional 25 rural drainage basins outside of the city, most of which also discharge directly to streams (WDEQ, 2010). Most of the drainage in these basins is accomplished by natural channels or ditches. Most of these urban drainage basins have no storage for natural attenuation of pollutants. In addition there are stormwater outfalls that discharge into the creeks in town.

3.5.6 Sheet Pile Walls

Sheet pile and bin walls are located throughout the project area. The sheet pile walls are constructed of interlocked steel sheet piling with a steel channel cap welded to the top of the piling. The bin walls are constructed of galvanized metal cells. Riprap protects the channel slopes adjacent to the walls. Relative to other features these are minor components of the existing project.

3.6 Soil and Groundwater Characteristics in Project Area

Soils in Project Area

A description of soils in the Goose Creek watershed is located in Appendix B. This section focuses on soil characteristics in the vicinity of the existing FRM project. Surface and subsurface investigations were made prior to construction of the FRM project during the months of January and February 1957, at which time 74, 12-inch diameter power auger borings and 16, six-inch diameter churn drill borings were completed. The power auger investigations included foundation explorations along the proposed levee alignments and channel relocation sections. The churn drill borings were completed primarily to determine the foundation conditions and soil characteristics at the existing bridge abutments and along the concrete chute proposed for lower Little Goose Creek. Several attempts were made to penetrate the channel alluvium of the creeks, but the abundance of cobble size material generally prevented full penetration.

Prime farmland, as defined by the NRCS, is land that has the best combination of physical and chemical characteristics for producing crops. According to the NRCS Web Soil Survey data reviewed for this project there is no prime farmland in the project area in Sheridan. Specific information on soils, based on the borings that were completed prior to construction of the FRM project, is provided in Appendix B. Additional information on soils may be found in Appendix A4.

Groundwater Observations in Project Area

Little Goose Creek

At the time of construction of the FRM project, groundwater levels reflected essentially the same levels as the water surface of the creek. Average depth to the water table ranges from five to 10 feet.

Big Goose Creek

At the time of construction of the FRM project, average depth to the ground water level ranged from five to 10 feet. A few borings encountered ground water slightly below the water surface of the stream.

Goose Creek

At the time of construction of the FRM project, groundwater data compiled from the individual borings generally showed the water table at the same level as the stream surface. Depth to the water table ranges from five feet to 10 feet.

3.7 Hydrologic and Hydraulic Conditions in Project Area

New hydrologic and hydraulic analyses for Big Goose, Little Goose, Goose, and Soldier Creeks within the city of Sheridan and the unincorporated areas of Sheridan County were performed by the USACE, Omaha District, Hydrologic Engineering Branch, under the Section 22 Planning Assistance to States (PAS) program. PAS was authorized by Section 22, WRDA 1974 (P.L. 93-251) and amended in Section 221, WRDA 1996 to include 50/50 cost sharing of the study with the non-federal sponsor, in this case, the city of Sheridan and Sheridan County. This study was completed in December 2010 (USACE).

The hydrologic and hydraulic analyses conducted by the USACE under the Section 22 study are being utilized for the Section 1135 study. The basis for existing conditions and the evaluation of alternatives is the Hydrologic Engineering Center – River Analysis System (HEC-RAS) model developed in 2009 under a previous Section 22 study. The previous hydraulic analysis for the Goose Creek System consisted of a total of 52 river miles studied using detailed engineering methods. HEC-RAS version 4.0, dated March 2008, was used for the Section 22 study analysis. Profiles were run for the 10-, 2-, 1-, and 0.2-percent annual chance existing conditions and the 1-percent annual chance encroached floodway.

The original TIN provided by the sponsor did not include supplemental hydrographic survey data so the underwater portion of the channel geometry was supplemented with geometric information from the original Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) as well as information from the flood damage reduction project operations and maintenance manual for the community. This information was then field verified with additional survey data which was collected by the local sponsors.

The hydrologic and hydraulic analyses conducted under the Section 22 study were also utilized by the FEMA to prepare a FIS for the community. The FEMA FIS was published in 2014. Floodplain maps and flood elevations are amended periodically by FEMA to reflect changes. The analyses reported by FEMA reflect flooding potentials based on conditions existing in the community at the time of completion of that study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) were selected by FEMA as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year.

Figure 15 shows the one percent chance exceedance floodplain and the 0.2 percent chance exceedance floodplain. As expected, the existing FRM project contains the one percent chance event in the channel across the majority of the project area. This disconnected floodplain limits natural channel forming processes and adversely affects biological processes.

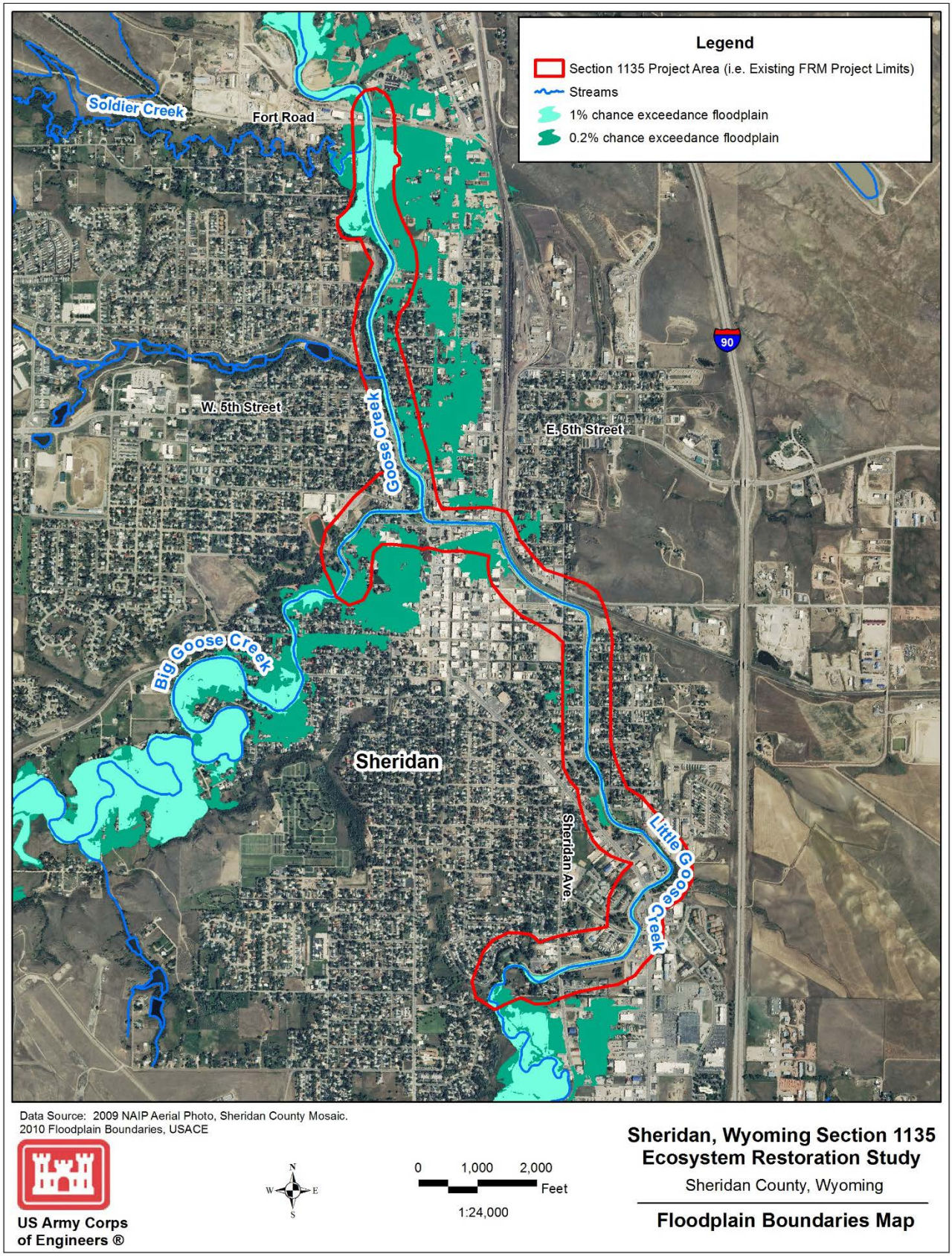


Figure 15. Floodplain boundaries map

3.7.1 Discharge Frequency Relationships

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community. Discharge-frequency relationships were developed at various locations throughout the Goose Creek basin to determine peak flows. Existing data from stream gages in the Goose Creek basin were analyzed to create the frequency curves. For more information on the stream gages used see Appendix C. Flows for 1.5-year, 2.33-year, 10-year, 50-year, 100-year, and 500-year return intervals were computed. Computed flow frequency discharges throughout the study area are shown in Table 6. These flows were developed during a Section 22 study in 2010.

Table 6. Flow frequency discharges throughout the study area (cfs)

River	500 Year	100 Year	50 Year	10 Year	2.33 Year	1.5 Year	FRM Project Design
Big Goose	6,260	4,060	3,300	1,880	890	605	4,000
Goose	9,150	5,940	4,830	2,750	1,300	884	8,100
Little Goose	5,430	3,530	2,870	1,630	772	525	5,000

In the O&M Manual (see Section 3.4) the level of protection provided by the flood control system is stated as three feet of freeboard above the stage elevation of these flows:

- Big Goose Creek above junction (i.e. confluence) - 4,000 cfs
- Goose Creek above Soldier Creek - 8,100 cfs
- Little Goose Creek above junction (i.e. confluence) - 5,000 cfs

Some additional low flow analysis may be necessary in support of meeting flow needs for fish and water quality (*n*-day criteria). However, available flow data may be sufficient, and if not, arbitrary low flow ranges can be used to develop a low-flow rating curve. Some analysis on low flows was presented in the total maximum daily load (TMDL) report (SWCA, 2010), however the analysis only focused on the United State Geological Survey (USGS) Acme Station (#06305700) which represents flow out of the Goose Creek watershed well downstream of Sheridan.

3.7.2 Channel Roughness Values

Channel roughness is a measure of resistance to flow, and when used in a hydraulic model is referred to as a 'manning's n' value. Resistance to flow in a concrete lined channel, such as is downtown Sheridan, is very low, while resistance in a stream covered with large boulders may be quite high. This study adopts manning's n values utilized during the Section 22 study (USACE, 2010), shown in Table 7.

Table 7. Goose Creek manning's n values

	Manning's *n*	
Reach	**In-Channel**	**Overbanks**
Big Goose	0.03-0.05	0.05-0.07
Little Goose	0.017-0.035	0.05-0.07
Goose	0.03-.045	0.05-0.065

3.7.3 Channel Width-Discharge Relationships

Hydraulic geometry relationships that express average bankfull width as a function of bankfull discharge are typically used to determine channel width in restoration design. Engineering Manual (EM) 1110-2-

1418, Channel Stability Assessment for Flood Control Projects, presents guidance for defining this relationship.

Assuming channel forming flows fall between the 2.33 – 10-year events and according to the relationships outlined in EM 1110-2-1418, Little Goose Creek is slightly undersized in terms of channel width, Big Goose Creek falls within the recommended widths, and Goose Creek is slightly oversized.

3.7.4 Stream Geomorphology

Big Goose, Little Goose, and Goose Creek throughout the project reach are in heavily engineered states and do not represent a natural condition. Straightening of the channel predates the construction of the flood risk reduction measures implemented by the Corps. As for the federal project, additional straightening was performed on all three creeks, levees were constructed, a large drop structure was installed at the confluence on Big Goose Creek, and a 1700-foot long concrete chute was implemented above the confluence of Little Goose Creek. The drop structure was modified by the city of Sheridan in 1995 due to safety concerns when a single drop was replaced with a series of grouted structures. There has been very little change to the planform of the creek since installation of the FRM project. In terms of section, much of the project area is characterized by a well-incised channel surrounded by levees or high ground with little to no connection to the natural floodplain. The profiles of the creeks through the project reach are much steeper than the surrounding areas due to channel straightening that has occurred.

Except for the drop structures on Big Goose and the concrete chute on Little Goose, there are no engineered grade controls present within the project boundary. Recently, the City has installed cross-vanes on Little and Big Goose Creeks upstream of the project boundary that provide grade control for the creeks.

In general, the banks are stable within the project reach. Significant portions have been stabilized through installation of riprap revetments and sheetpile. During site visits, the banks were observed to be well vegetated, generally with grasses due to levee O&M requirements.

The stream beds are largely composed of gravels and cobbles exhibiting largely uniform depths. Sediment transport is largely not an issue throughout the project. However, maintenance is often performed within the concrete chute due to removing gravels and cobbles that deposit within its footprint. This is likely due to the over-widened nature of the concrete section and the absence of hydrologic events large enough to remove the material naturally.

3.8 Wetlands in the Project Area

A desktop analysis, literature reviews, and field surveys were used to map potential wetlands and habitat types in and near the project area. Field surveys were conducted from October 7 to 9, 2014. All targeted non-private portions of the project area were accessed and reviewed during the surveys. Field conditions were sunny, with temperatures ranging from 50 to 75 degrees Fahrenheit. Weather conditions did not alter survey protocols or results.

A total of 32 figures were developed which show habitat types mapped within the project area. These figures are located in Appendix A2. Fourteen U.S. Fish and Wildlife Service National Wetland Inventory (USFWS NWI)-defined wetland areas were visited to determine whether they supported the requisite hydrophytic plant species composition for classification. Twelve of the NWI wetlands are classified as either seasonally or temporarily flooded riverine wetlands with unconsolidated shores; all 12 of these NWI wetlands are along the streambanks of Goose Creek in the north portion of the project area. Two of the NWI wetlands are classified as palustrine emergent wetlands. The classification of wetlands in the project

area was based on qualitative assessments of the predominance of hydrophytic plants and the presence of hydrology. The wetland assessments did not include the verification of the presence of hydric soils.

During field surveys, approximately 9.13 acres of wetlands were mapped in the project area. Most of the wetland is a fringe wetland along the system of creeks, occupying narrow bands running through the project area. These wetlands are inundated during high flow events associated with annual spring snow melt.

The project area contains two Cowardin classification wetland types: palustrine emergent (PEM) and palustrine scrub-shrub (PSS). PEM wetlands are the most common wetland type, accounting for 181 wetlands comprising a total of 8.30 acres. PSS wetlands are the second-most common type, accounting for 18 wetlands comprising a total of 0.83 acres.

The wetland plant associations observed in the project area are described in Appendix A2, along with detailed maps showing the distribution of wetlands across the project area.

3.9 Water Use, Appropriations, and Reservoir Storage in Watershed

Water Use and Appropriations

Surface water and groundwater in the Goose Creek watershed is used for municipal, industrial, domestic, recreational, commercial, and agricultural water supplies. Before water can legally be used in Wyoming, the State Engineer's Office (SEO) must issue a water right (permit) to the water user. To obtain water rights in Wyoming, it must be proven that the water will be used for a beneficial use (Wyoming Statutes Title 41, Chapters 3 and 4), though there are additional water right limits and requirements related to priority dates and withdrawal amounts (e.g., water rights for irrigation are adjudicated on the basis of one cfs per 70 acres). Beneficial uses are broadly defined as uses that apply water to a non-wasteful end, such as water for domestic living, livestock, industrial uses, and irrigation.

Surface water, as opposed to groundwater, is the primary source water to Goose Creek watershed, comprising 99.5 percent of all permitted water. Of the beneficial use categories, irrigation and stock-water are the primary water uses in the watershed. Apart from irrigation, most permits in the Goose Creek watershed are issued for domestic use, and most domestic use permits (66 percent) are for groundwater wells (see Appendix A4). Industry and coalbed/natural gas permits make up less than three percent of the total permitted withdrawals in the watershed. The watershed's five coalbed/natural gas permits are concentrated in the north end of the watershed, near the outlet.

Reservoir Storage

Many permitted reservoir facilities are in the Goose Creek watershed, but approximately 89 percent of the watershed's total permitted active storage is in five major reservoirs: 1) Big Goose Park Reservoir (Park Reservoir), 2) Bighorn Reservoir, 3) Twin Lakes Reservoir, 4) Dome Lake Reservoir, and 5) Sawmill Reservoir (SEO 2015). These five major reservoirs are in the headwaters of the Goose Creek watershed in BHNF, and they store spring snowmelt for use throughout the growing season. Most reservoir storage in the watershed is set aside for irrigation, though water rights for Twin Lakes Reservoir are owned by the city of Sheridan. Appendix A4 has more detail on reservoir storage.

Reservoir information was obtained from the Wyoming e-Permit system (SEO, 2015) and the *2014 Water Division 2 Hydrographers' Annual Report Water Division 2* (SEO, 2014). Total active reservoir storage in the Goose Creek watershed is approximately 25,061 acre-feet, or 24 percent of the average total annual flow at the watershed outlet at the USGS Goose Creek gage near Acme, Wyoming. There are approximately 91 permitted reservoirs in the Goose Creek watershed, although most of the reservoirs are minor reservoirs with active storage of less than 80 acre-feet, and in many cases less than 10 acre-feet.

The major reservoirs in the Goose Creek watershed are primarily managed to release stored spring snowmelt to water rights owners over the course of the water year (ending September 30). However, water is only released to permit holders by the reservoirs on a by-request basis. So, if demand is low, a reservoir's storage may not be drained, and it will maintain storage for use in the remainder of the water year. Reservoirs may also be managed for other uses such as fisheries, wetlands, and recreation areas. Some reservoirs also have downstream flow obligations that require a minimum flow to pass through the reservoir at all times (SEO, 2014).

3.10 Water Quality in the Project Area

3.10.1 Standards

Water quality describes the chemical, physical, and biological condition of surface and groundwater. The sections below provide an overview of water quality for surface waters in the Goose Creek watershed. Water quality standards in Wyoming are specific to the designated uses of a waterbody and consist of both numeric limits for individual pollutants and conditions, and narrative descriptions of desired conditions. The state of Wyoming has classified streams in the Goose Creek watershed as Class 2AB waterbodies. Class 2AB waters are defined as follows in the *Wyoming Surface Water Quality Standards:*

> Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the *Wyoming Surface Water Classification List*. Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses (WDEQ, 2013:1-10).

A complete list of WDEQ water quality standards is provided in the *Wyoming Surface Water Quality Standards* (2013). However, select water quality standards applicable to the Goose Creek watershed based on past impairments and designated uses are summarized in Table 8.

Table 8. Surface water quality standards for designated uses in the Goose Creek watershed

Parameter	Water Quality Standard Reference	Standard/Description
Settleable solids	Section 15	In all Wyoming surface waters, substances attributable to or influenced by the activities of man that will settle to form sludge, bank or bottom deposits shall not be present in quantities which could result in significant aesthetic degradation, significant degradation of habitat for aquatic life or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.
Floating and suspended solids	Section 16	In all Wyoming surface waters, floating and suspended solids attributable to or influenced by the activities of man shall not be present in quantities which could result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.
Turbidity	Section 23	(a) In all cold water fisheries and drinking water supplies (classes 1, 2AB, 2A, and 2B), the discharge of substances attributable to or influenced by the activities of man shall not be present in

Parameter	Water Quality Standard Reference	Standard/Description
		quantities which would result in a turbidity increase of more than ten (10) nephelometric turbidity units (NTUs). (b) In all warm water or nongame fisheries (classes 1, 2AB, 2B and 2C), the discharge of substances attributable to or influenced by the activities of man shall not be present in quantities which would result in a turbidity increase of more than 15 NTUs.
E. coli bacteria (previously "fecal coliform")	Section 27	(a) Primary Contact Recreation. In all waters designated for primary contact recreation, during the summer recreation season (May 1 through September 30), concentrations of *E. coli* bacteria shall not exceed a geometric mean of 126 organisms per 100 milliliters during any consecutive 60-day period. Primary contact waters are identified in the *Wyoming Surface Water Classification List.* (b) Secondary Contact Recreation. In all waters designated for secondary contact recreation, and in waters designated for primary contact recreation during the winter recreation season (October 1 through April 30), concentrations of *E. coli* bacteria shall not exceed a geometric mean of 630 organisms per 100 milliliters during any consecutive 60-day period. Waters will be designated for secondary contact recreation through the reclassification and use attainability analysis process outlined in Sections 33 and 34 of these regulations. Secondary contact waters are identified in the *Wyoming Surface Water Classification List.* (c) Single-sample Maximum Concentrations. During the summer recreation season, on all waters designated for primary contact recreation, the following single-sample maximum concentrations of *E. coli* bacteria shall apply: (i) High use swimming areas - 235 organisms per 100 milliliters (ii) Moderate full body contact - 298 organisms per 100 milliliters (iii) Lightly used full body contact - 410 organisms per 100 milliliters (iv) Infrequently used full body contact - 576 organisms per 100 milliliters Single-sample maximum values may be used to post recreational use advisories in public recreation areas and to derive single-sample maximum effluent limitations on point source discharges. An exceedance of the single-sample maxima shall not be cause for listing a water body on the State 303(d) list or development of a TMDL [total maximum daily load] or watershed plan. The appropriate recreational use category (i through iv above) shall be determined by the administrator as needed, on a case by case basis. In making such a determination, the administrator may consider such site-specific circumstances as type and frequency of use, time of year, public access, proximity to populated areas, and local interests.
Biological criteria	Section 32	Class 1, 2, and 3 waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentrations or combinations which will adversely alter the structure and function of indigenous or intentionally introduced aquatic communities.

Source: WDEQ (2013).

3.10.2 Impaired Waters

According to the *Wyoming Water Quality Assessment and Impaired Waters List (2012 Integrated 305(b) and 303(d) Report)* (WDEQ, 2012), 11 waterbodies are listed as impaired for recreation and aquatic life (cold water fish) in the Goose Creek Watershed. The WDEQ categorizes these waterbodies as Category 4 Waters, indicating that designated uses are not supported but a TMDL has been completed. Figure 16 shows these waters and Table 9 contains a list of these waters.

WDEQ's 2014 integrated 305(b) and 303(d) draft report, updated the category of these waters to 4A (WDEQ, 2014), indicating that designated uses are not currently supported, but a U.S. Environmental Protection Agency (USEPA) - approved TMDL has been completed. Solider Creek was categorized as 4C, indicating that the designated uses are not supported and a TMDL is not required due to the finding that impairments are attributed to flow alteration and not a pollutant.

Many water bodies in the Goose Creek watershed were first listed as impaired for exceedance of the fecal coliform standard in 2000. In 2008, these impairments were changed from "fecal coliform" to "*E. coli"* to reflect the change in state water quality standard definitions for pathogen impairments.

In 2006, the cold water fishery use on Goose Creek was listed as impaired for sediment and habitat. This impairment was based on a weight-of-evidence approach incorporating a biological assessment of Goose Creek conducted by WDEQ. Additional information on the water quality data reviewed during data gathering phase of this project may be found in Appendix A4. Both the *E. coli* and sediment impairments were identified by WDEQ for Goose Creek from the confluence of Big Goose Creek and Little Goose Creek to the confluence with the Tongue River 12.7 miles downstream. The largest tributary to Goose Creek is Soldier Creek, which was listed as impaired from the confluence with Goose Creek to a distance 3.1 miles upstream for exceedance of the fecal coliform standard in 2000. In 2008, the impairment cause was changed to *E. coli* to reflect the recent change in state water quality standards.

Big Goose Creek along with three of its tributaries (Beaver Creek, Park Creek, and Rapid Creek) were listed as impaired for exceedance of the fecal coliform standard in 2000. The estimated length of impairment identified for Big Goose Creek and its tributaries on the 2012 303(d) list is 32.4 miles. Little Goose Creek was first listed as impaired for exceedance of the fecal coliform standard in 1996. Four tributaries to Little Goose Creek (McCormick Creek, Kruse Creek, Sackett Creek, and Jackson Creek) were also listed as impaired for exceedance of the fecal coliform standard in 2000. In 2006, the cold water fishery use on Goose Creek was also listed as impaired for sediment and habitat. The estimated length of impairment identified for Little Goose Creek and its tributaries on the 2008 303(d) is 17.7 miles.

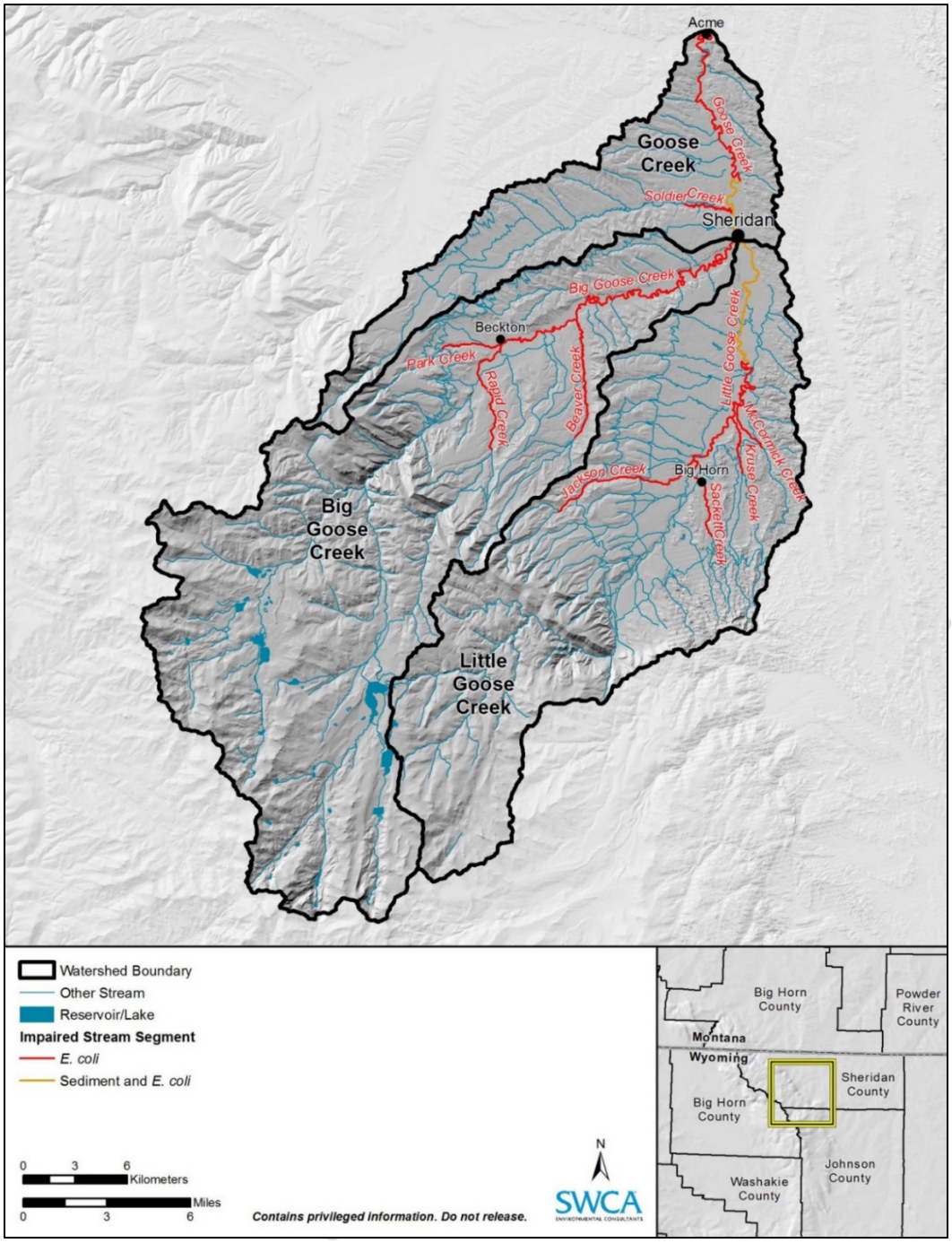


Figure 16. Impaired stream segments in the Goose Creek watershed.

Table 9. Wyoming's Category 4 surface waters

Name	Class	Location	Miles	Uses	Cause of Impairment	List Date	Year TMDL Completed
Goose Creek (tributary to Tongue River)	2AB	From confluence with Little Goose downstream to the confluence with the Tongue River	12.7	Recreation	*E. coli*	2000	2010
Goose Creek (tributary to Tongue River)	2AB	From confluence with Little Goose downstream to the confluence with the Tongue River	12.7	Aquatic life, cold water fish	Habitat alterations, sediment	2006	2010
Soldier Creek (tributary to Goose Creek)	2AB	From the confluence with Goose Creek to a point 3.1 miles upstream	3.1	Recreation	*E. coli*	2000	2010
Big Goose Creek (tributary to Goose Creek)	2AB	From the confluence with Little Goose Creek upstream to the confluence with Rapid Creek	19.2	Recreation	*E. coli*	1996	2010
Beaver Creek (tributary to Big Goose Creek)	2AB	From the confluence with Big Goose Creek upstream to the confluence with Apple Run	6.5	Recreation	*E. coli*	2000	2010
Park Creek (tributary to Big Goose Creek)	2AB	From the confluence with Big Goose Creek to a point 2.8 miles upstream	2.8	Recreation	*E. coli*	2000	2010
Rapid Creek (tributary to Big Goose Creek)	2AB	From the confluence with Big Goose Creek to a point 3.2 miles upstream	3.2	Recreation	*E. coli*	2000	2010
Little Goose Creek (tributary to Goose Creek)	2AB	From the confluence with Big Goose Creek upstream to Brundage Lane in Sheridan	3.5	Recreation	*E. coli*	1996	2010
Little Goose Creek (tributary to Goose Creek)	2AB	From the confluence with Big Goose Creek upstream to Brundage Lane in Sheridan	3.5	Aquatic life, cold water fish	Habitat alterations, sediment	2006	2010
McCormick Creek (tributary to Little Goose Creek)	2AB	From the confluence with Little Goose Creek to a point 2.2 miles upstream	2.2	Recreation	*E. coli*	2004	2010

Kruse Creek (tributary to Little Goose Creek)	2AB	From the confluence with Little Goose Creek upstream to confluence with East Fork Kruse Creek	2.5	Recreation	*E. coli*	2000	2010
Jackson Creek (tributary to Little Goose Creek)	2AB	From the confluence with Little Goose Creek to a point 6.4 miles upstream	6.4	Recreation	*E. coli*	2000	2010
Sackett Creek (tributary to Little Goose Creek)	2AB	From the confluence with Little Goose Creek upstream to the confluence with East Fork Sackett Creek	3.1	Recreation	*E. coli*	2000	2010

Source: WDEQ (2012).

3.11 Hazardous, Toxic, and Radioactive Waste Assessment

The purpose of this assessment, also referred to as a Phase I Environmental Site Assessment, is to identify potential issues associated with Hazardous, Toxic, and Radioactive Waste (HTRW) that may affect the evaluation of ecosystem restoration measures later on in the feasibility study process. In accordance with USACE policy (ER 1165-2-132), construction of civil works projects in HTRW contaminated areas should be avoided where practicable. Additionally, the response to address contamination is the responsibility of the sponsor, not the government. An environmental investigation was completed by the USACE, Omaha District in 2015 in support of the Section 1135 Ecosystem Restoration Study. The cost-shared study is sponsored by the city of Sheridan. The investigation activities included a review of public records, interviews with city officials, and a visual survey of the project area. There are four total reaches within the project area. No concerns of HTRW impacts were found in three out of four reaches, including the Little Goose Creek Reach, Big Goose Creek Reach, and Goose Creek Reach. However, two areas were identified in the Downtown Reach (Interim Site Characterization Report WDEQ, 2014). A summary of the two issues identified in the downtown reach is provided below. Additional information, including the HTRW report and maps are located in Appendix D.

Downtown Reach Issue #1

Source/type of contamination:	Elevated levels of tetrachloroethene (PCE) and its degradation product trichloroethene (TCE) are present in the soil, soil vapor, and groundwater due to release by a former dry cleaner.
Location of contamination:	Approximately 10 feet below ground surface at the southeast corner of Dow and Main Streets.
Ongoing remediation activities:	A remedy implementation plan that includes soil vapor extraction and in-situ chemical reduction was initiated in July 2016 under the WDEQ Orphan Site Remediation Program. Cleanup objectives are expected to be reached in approximately during 2017.
Resolution:	Cleanup objectives meet or exceed the USEPA maximum contaminant level for groundwater and residential screening level for soil and indoor air. These levels are consistent with those accepted by the USACE, Omaha District.

Downtown Reach Issue #2

Source and type of contamination:	Low-level concentrations of PCE and TCE due to release by a former dry cleaner have been detected in the groundwater.
Location of contamination:	Between Gould and Broadway Streets on the north and south sides of the Little Goose Creek channel.
Ongoing remediation activities:	Soil gas concentrations of PCE and TCE were detected above WDEQ screening levels and the area was estimated to pose a potential risk to human health in 2014. However, no action was recommended for the site by WDEQ as concentrations are expected to decrease naturally over time.

Resolution: The USACE, Omaha District concurs with the recommendation for continued groundwater monitoring.

Conclusions

Due to the nature of the project and the proximity of the contamination with respect to the channel, these areas cannot be entirely avoided. Construction work in the vicinity of the channel would require coordination on contaminant levels with the WDEQ, which currently plans to have Issue #1 remediated in 2017. Continued monitoring of levels at both sites is recommended.

3.12 Ecological Resources in Project Area

3.12.1 Ecoregions

Ecoregions are defined as mostly homogenous ecological areas with similar climates, landforms, soils, natural vegetation, hydrology, and other ecological parameters. Identifying ecoregion classifications at a watershed scale becomes important for understanding similarities and differences in the watershed landscape. Two Level III ecoregions are present in the Goose Creek Watershed: the Middle Rockies and the Northwestern Great Plains. The Middle Rockies Ecoregion comprises approximately 52 percent of the watershed and is in the headwaters region of the watershed in BHNF. The Northwestern Great Plains Ecoregion comprises 48 percent of the watershed and is associated with the more populated, lowlands area of the watershed. Each ecoregion is described as follows (EPA, 2014):

> "The climate of the Middle Rockies lacks the strong maritime influence of the Northern Rockies (15). Mountains have Douglas-fir, subalpine fir, and Engelmann spruce forests, as well as some large alpine areas. Pacific tree species are never dominant and forests can have open canopies. Foothills are partly wooded or shrub- and grass-covered. Intermontane valleys are grass- and/or shrub-covered and contain a mosaic of terrestrial and aquatic fauna that is distinct from the nearby mountains. Many mountain-fed, perennial streams occur and differentiate the intermontane valleys from the Northwestern Great Plains (43). Granitics and associated management problems are less extensive than in the Idaho Batholith (16). Recreation, logging, mining, and summer livestock grazing are common land uses."

> "The Northwestern Great Plains ecoregion encompasses the Missouri Plateau section of the Great Plains that is mostly unglaciated. It is a semiarid rolling plain of shale, siltstone, and sandstone punctuated by occasional buttes and badlands. Rangeland is common, but spring wheat and alfalfa farming also occur; native grasslands persist in areas of steep or broken topography. Agriculture is restricted by the erratic precipitation and limited opportunities for irrigation."

Under natural conditions, the ecological systems that would be expected to occur within the geographic location of the project area are 1) Inter-Mountain Basins Big Sagebrush Steppe, 2) Northwestern Great Plains Mixed Grass Prairie, 3) Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland, 4) Great Plains Riparian, 5) Western Great Plains Open Depression Wetland, and 6) Western Great Plains Closed Depression Wetland. Of these six ecological systems, only two were observed within the project area, the Western Great Plains Open Depression Wetland and the Great Plains Riparian, both of which are located within the remnant floodplain of the riparian areas surveyed. The locations where the other ecological systems would be expected to occur under natural conditions are occupied by residential, commercial, and recreational developments.

3.12.2 Flora

Review of Existing Data Sources
Existing plant species occurrence data were obtained from the Wyoming Natural Diversity Database (WYNDD), the Rocky Mountain Herbarium (RMH) Specimen Database, and previous surveys conducted by biologists near the project area. WYNDD collects data from museum collections, resource management agency reports, consultant datasets and reports, and observations by agency, academic, and WYNDD biologists. Data obtained from WYNDD for this project included survey and observation data on state plant species of special concern from 1892 to 1954 and indicated that three such species have the potential to occur within the project area (WYNDD 2014). The RMH Specimen Database is a digital record containing location data associated with species findings submitted to the RMH. A search of that database in 2014 resulted in 42 unique historical plant species accounts from 1892 to 2000. For more recent species accounts in the vicinity of the project area, biologists reviewed three nearby studies with a vegetation component in the vicinity of the project area. The dates of these projects ranged from 2008 to 2011. A total of 39 unique plant species accounts were noted in the review of these projects.

Out of the total of 84 species accounts from these sources, 78 are unique species accounts in the vicinity of the project area. A list of the plants identified through the review of species accounts in the vicinity of the project area is provided in Appendix A3, along with maps including location information associated with these species accounts.

Field Surveys Conducted for the Section 1135 Study
Ninety-two plant species were identified during the field surveys conducted for this study. A comprehensive list of these species is included in Appendix A3. The ecological systems and plant associations observed within the survey area and maps showing the locations of ecological systems are provided in Appendix A3. An association level vegetation map classification will be provided in a GIS shapefile with the electronic submittal package of this report.

3.12.3 Fishes and Aquatic Organisms

Historically, the portions of Big Goose Creek and Little Goose Creek that run through Sheridan supported a stable fish community consisting of native Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) and an assemblage of other native fishes (Annear 2009). After Sheridan was incorporated in 1884, development and settlement of the area began significantly altering the water resources, which impacted the native fishery. Modifications to the system of creeks for flood control impacted water quality, water temperature, in-channel cover, and stream flow, which adversely affected the cold-water fishery. Today, no cutthroat trout are present in the system of creeks, however they do occur downstream of the project area. If stream ecosystem conditions in the study area at Sheridan were improved to support cutthroat trout, it is likely that a cutthroat fishery would reestablish itself in the project area. Table 10 shows the species documented in the Big, Little, and Goose Creeks.

Other culturally, recreationally, and ecologically important species would benefit from habitat restoration and reconnecting the system of creeks to improve fish passage. For example, sauger are a high value species among anglers, and were historically present in the study reach. However, they are now generally limited to habitats near the downstream reservoir in this system since the flood control project was implemented (T. Cundy, WGFD, Personal Communication, 7 Oct 2016). Sauger and many sucker species (Family: Catastomidae) make seasonal spawning migrations, and are also the most likely hosts to fatmucket (Lampsilis siliquoidea) larvae, the only native mussel in the Goose Creek watershed (Mathis, 2015), and thus an important transport mechanism to help restore fatmucket to its native range. Therefore, restoring passage for fishes like sauger and suckers would have secondary ecological benefits

of restoring native mussels in and upstream of the study reach. Additionally, from restoring fish passage, tertiary ecological benefits from fatmucket restoration would 1) further improve water quality because they are filter feeders, and 2) promote trophic processes to build a strong and resilient food web necessary to support fisheries restoration in the Goose Creek system because mussel beds provide important substrates for attachment of primary producers like algae and secondary producers like insect larvae.

Table 10. Fish species known to occur in Big, Little, and Goose Creeks

Fish Species	Native to Drainage	WYGF Species of Greatest Conservation Need	Big Goose Creek	Little Goose Creek	Goose Creek
Black bullhead (*Ameiurus melas*)	Yes	No	x		x
Brook trout (*Salvelinus fontinalis*)	No	No	x	x	
Brown trout (*Salmo trutta*)	No	No		x	
Channel catfish (*Ictalurus punctatu)*	Yes	No			x
Common carp (*Cyprinus carpio*)	No	No		x	x
Creek chub (*Semotilus atromaculatus*)	No	No		x	x
Fathead minnow (*Pimephales promelas*)	No	No		x	x
Flathead chub (*Platygobio gracilis*)	Yes	No		x	
Golden Shiner (*Notemigonus crysoleucas*)	No	No			x
Green sunfish (*Lepomis cyanellus*)	No	No	x		x
Lake chub (*Couesius plumbeus*)	Yes	No		x	
Longnose dace (*Rhinichthys cataractae*)	No	No		x	x
Longnose sucker (*Catostomus catostomus*)	Yes	No	x	x	x
Mountain sucker (*Catostomus platyrhynchus*)	Yes	No	x	x	
Mountain whitefish (*Prosopium williamsoni*)	Yes	Yes		x	
Rainbow trout (*Oncorhynchus mykiss*)	No	No		x	x
Rock bass (*Ambloplites rupestris*)	No	No	x	x	x
Sauger (*Sander canadense*)	Yes	Yes			x
Shorthead Redhorse (*Moxostoma macrolepidotum*)	Yes	No			x
Smallmouth bass (*Micropterus dolomieu*)	No	No	x		x
Stonecat (*Noturus flavus*)	Yes	No	x		x
White crappie (*Pomoxis annularis*)	No	No			x
White sucker (*Catostomus commersonii*)	No	No	x	x	x
Yellow perch (*Perca flavescens*)	No	No			x

3.12.3.1 *Big Goose Creek*

Big Goose Creek contains both cold water and warm water game and nongame species. Eight of the 22 species found in Big Goose Creek are native to the drainage. Of these species, only mountain whitefish (*Prosopium williamsoni*) and sauger (*Sander canadense*) and listed as Species of Greatest Conservation Need (SGCN) by the Keinath et al. (2010). Yellowstone cutthroat trout, which historically occurred in Big Goose Creek, is also a special-status species.

WDEQ currently classifies most of Big Goose Creek as a cold water fishery. The occurrence and relative abundance of cold water game fish, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni*), and grayling (*Thymallus arcticus*), vary along the longitudinal gradient of Big Goose Creek and occurred more frequently in the upper drainage. Brown trout and rainbow trout are the only species actively managed for by the WGFD.

The transition from a cold water fishery to a warm water fishery begins approximately one to two miles downstream of the confluence of Beaver Creek and Big Goose Creek, and it continues downstream to the

city of Sheridan. This transition zone yielded the highest diversity of cold water and warm water game species recorded in Big Goose Creek (SCCD, 2003). Based only on the occurrence and abundance of cold water game fish species in Big Goose Creek, the waterbody appears to be meeting its designated use for fish. The one exception to this is an unknown distance of stream between the warm to cold water transition zone and the confluence of Big Goose Creek with Little Goose Creek in the city of Sheridan (SCCD, 2003).

3.12.3.2 *Little Goose Creek*

Historically, the fish population in Little Goose Creek was dominated by both cold water and warm water game and nongame species. Currently, most of Little Goose Creek is classified by WDEQ as a cold water fishery. Fourteen species have been documented in Little Goose Creek. Five of these species are native to the drainage and one, mountain whitefish, is a Species of Greatest Conservation Need (SGCN). In 1956 and 1958, channel catfish (*Ictalurus punctatus*) were stocked in Little Goose Creek; however, none have been observed by the WGFD.

Fish population trends are generally the same as those observed in Big Goose Creek for the abundance and distribution of cold water and warm water game species. Common warm water game species present in Little Goose Creek downstream of Highway 87 include rock bass and green sunfish. The occurrence and relative abundance of cold water game fish decline dramatically from the Gallatin Ranch Bridge downstream to the Highway 87 Bridge, and no cold water game species were recorded by WGFD from the Woodland Park Bridge downstream to the city of Sheridan.

Based only on the occurrence and abundance of cold water game fish species, Little Goose Creek appears to be meeting its designated use as a cold water fishery, with the exception of an unknown length of stream from the Woodland Park Bridge to its confluence with Big Goose Creek in the city of Sheridan (SCCD, 2003).

3.12.3.3 *Goose Creek*

In the past, fish populations in Goose Creek were dominated by nongame species and to a lesser extent by warm water game species, including northern redhorse, longnose sucker, white sucker, common carp, mountain sucker, rock bass, stonecat, and green sunfish. Brown trout and rainbow trout are the only two cold water game species collected in Goose Creek, and their populations appear to have been marginal (SCCD, 2003). Before 1959, pollution from gravel washing operations and improper treatment of domestic sewage eliminated the fishery of Goose Creek from below the city of Sheridan to the confluence with the Tongue River (SCCD, 2003). Discharge of pollutants into Goose Creek was reduced with the implementation of the Wyoming Pollutant Discharge Elimination System (WYPDES) program in the mid-1970s and upgrades to the Sheridan wastewater treatment plant in 1983 (SCCD, 2003). Sauger is the only species found in Goose Creek that is considered a SGCN by the WGFD (2010).

A limited amount of fish species sampling has been conducted in Goose Creek since 1977, and it appears that warm water game species still dominate fish populations in Goose Creek. Fish species that are currently likely to occur in Goose Creek between the confluence of Big Goose Creek and Little Goose Creek and the Tongue River include black bullhead, common carp, flathead chub, fathead minnow, golden shiner, green sunfish, longnose dace, longnose sucker, shorthead redhorse, rock bass, smallmouth bass, stonecat, white crappie, white sucker, and yellow perch. Although WDEQ classifies Goose Creek as a cold water fishery, dominant game fish comprise warm water species. Therefore, Goose Creek more closely approximates a warm water waterbody (SCCD, 2003). While cold water fish species occur throughout most of the length of Goose Creek, populations are low in abundance and are marginal (SCCD, 2003).

3.12.4 Aquatic Habitat

Healthy aquatic habitat is critical for the establishment and maintenance of good fisheries, benthic macroinvertebrate populations, and other aquatic life. In addition to the physical impacts of the FRM project, Goose Creek and its tributaries historical flow regimes have been altered due to anthropogenic influences. Reservoirs and rerouting of water reduce peak flows, reduce hydrologic variability, and impaired water quality in the Goose Creek Watershed, the net result being adverse impacts to aquatic habitat (SCCD, 2011).

SCCD has been monitoring trends in the biological function and habitat quality of the Goose Creek Watershed since the early 1990s. The biological condition is determined using the Wyoming Stream Integrity Index (Hargett & ZumBerg, 2006) and is based on the analysis of benthic macroinvertebrate monitoring data. Between 1994 and 2012, SCCD monitored biological condition at nine sampling stations on Big Goose Creek, Little Goose Creek, and Goose Creek. SCCD has also conducted stream habitat assessments at 19 stations on Big Goose Creek, Little Goose Creek, and Goose Creek since 2001 (SCCD, 2003; 2006; 2011; 2014). Stream habitat monitoring indicates a general decline in channel condition and habitat quality from upstream to downstream (SCCD, 2003; 2006; 2011; 2014). The results of these monitoring efforts are summarized in the following sections.

3.12.4.1 *Big Goose Creek*

The lower segments of Big Goose Creek in and near the city of Sheridan have been channelized into concrete sections through the city for flood control. Within Kendrick Park, a 2008 in-channel rehabilitation project restored over 750 linear feet of stream channel dimensions and hydraulic properties. In 2009, the WGFD conducted a study to obtain a general understanding of relationships between flow and habitat quality and quantity in the segment of Big Goose Creek that flows through Kendrick Park in Sheridan (Annear, 2009). Results of this study indicate that the overall limiting factor for trout habitat in Goose Creek is water temperature. Local strategies to decrease water temperature by increasing streamside vegetation and shading would help alleviate temperatures during hot summer months. Overall, the best way to eliminate the limiting factor of water temperature is with a regional strategy to increase summer flows in the creeks.

The streambed of Goose Creek was dominated by cobble and coarse gravel throughout, and silt deposition was low at most sampling stations. There was a general trend toward reduced habitat quality and reduced channel condition from Big Goose Creek Canyon to the lowermost sampling station in the city of Sheridan. Channelization of Big Goose Creek in the city has reduced streambank stability, undercut banks, and degraded in-stream and riparian habitat structure.

3.12.4.2 *Little Goose Creek*

The lowermost sections of Little Goose Creek, in and near the city of Sheridan, have been channelized into concrete sections for flood control and development purposes. The SCCD stream habitat assessments indicate a general decline in channel condition and habitat quality from the uppermost sampling station to the lowermost sampling station in the city of Sheridan (SCCD, 2003; 2006; 2011; 2014). However, this trend was not consistent. The lower segment (LG5 upstream of the Brundage Lane Bridge) was in good condition other than relatively high amounts of silt and sand, apparently originating from upstream sources. The poor condition of the lower stream segments is due to artificial channelization that has eliminated some undercut banks, pools, and in-stream and riparian habitat structure. The streambed was dominated by cobble or coarse gravel, with silt and sand increasing from upstream to downstream.

The SCCD biological condition assessment shows a similar trend as shown with the stream habitat assessment (SCCD, 2014).

3.12.4.3 *Goose Creek*

In the upper segments of Goose Creek, most of the stretch has also been channelized (straightened) to protect the city of Sheridan from flooding. The SCCD stream habitat assessments on Goose Creek showed a general improvement in channel condition and habitat quality from the uppermost sampling location in the city of Sheridan to the lowermost sampling location near Highway 339, GC1 (SCCD, 2014). However, the upper reach in the vicinity of Sheridan lacks natural structure required for a quality aquatic environment. The area lacks aquatic vegetation, undercut banks, pools, and in-stream and riparian habitat structure. The channelized streambed was dominated by cobble or coarse gravel, with no silt deposition.

3.12.5 Reptiles and Amphibians

During field surveys conducted for this study, only one reptile species was observed, the Plains garter snake (*Thamnophis radix*). Existing data indicate there is potential for bullsnake (*Pituophis catenifer sayi*), snapping turtle (*Chelydra serpentina*), eastern yellow-bellied racer (*Coluber constrictor flaviventris*), Plains hog-nosed snake (*Heterodon nasicus*) and the western painted turtle (*Chrysemys picta bellii*) to occur in and around the project location. One amphibian was observed, the northern leopard frog (*Lithobates pipiens*), scattered throughout the study area.

3.12.6 Mammals

Fox squirrels, least chipmunks (*Tamias minimus*), mule deer, a red fox (*Vulpes vulpes*), and signs of North American beavers (*Castor canadensis*) were observed during the field surveys. Existing fauna data identified 32 other mammal species as potentially occurring in or near the project area. Canada lynx (*Lynx canadensis*) and grizzly bear (*Ursus arctos arctos*) are listed as threatened, and the gray wolf (*Canis lupus*) is proposed for delisting under the Endangered Species Act (ESA). Black-tailed prairie dog (*Cynomys ludovicianus*) is a Bureau of Land Management (BLM) special status species. Eight of the historically documented mammal species identified in the vicinity of the project area are WGFD SGCN. Additional information may be found in Appendix A3.

3.12.7 Birds

Twenty-seven bird species were observed in and near the project area by biologists during the field surveys. Existing fauna data indicated the potential for another 102 species to occur in or near the project area. In total, 129 bird species may be found within or near the project area. Greater sage-grouse (*Centrocercus urophasianus*) was a candidate for listing under ESA, but was removed from consideration in 2015. Peregrine falcon (*Falco peregrinus*) was delisted from ESA in 1999. Bald eagles and golden eagles are federally protected under the Bald and Golden Eagle Protection Act (BGEPA). The Migratory Bird Treaty Act (MBTA) protects 119 of the 129 bird species that may be found within or near the project area. Thirteen species are designated Birds of Conservation Concern by the USFWS. Ten BLM special status species could occur near the project area. Seventeen bird species are WGFD SGCNs. Additional information may be found in Appendix A3.

3.12.8 Invasive/Exotic Species

The 2014 State Designated Weed and Pest List was used to compile a noxious weed list for the project. Pedestrian intuitively guided surveys for noxious plant species were conducted during field surveys. Populations of these species were mapped after they were encountered during surveys. Seven plant species from the 2014 State Designated Weed and Pest List were identified during the field surveys, as shown in Table 11. Maps depicting the distribution of the noxious weeds populations within the survey area are provided in Appendix A3.

The New Zealand mud snail is an invasive mollusk found in drainages in Wyoming. The tiny snails can reach densities of 100,000 snails per square meter in infected areas (University of Wyoming, 2004). There are no known populations of mud snails within the project area and none were observed during the field surveys.

Table 11. State of Wyoming listed noxious weeds observed within the survey area

Family	Scientific Name	Common Name	Population Type
Asteraceae	*Cirsium arvense* (L.) Scop.	Canada thistle	Dispersed
Convolvulaceae	*Convolvulus arvensis* L.	Field bindweed	Dispersed
Boraginaceae	*Cynoglossum officinale* L.	Gypsyflower	Dispersed
Poaceae	*Elymus repens* (L.) Gould	Quackgrass	Dispersed
Euphorbiaceae	*Euphorbia esula* L.	Leafy spurge	Localized
Scrophulariaceae	*Linaria dalmatica*	Dalmation toadflax	Localized
Lythraceae	*Lythrum salicaria* L.	Purple loosestrife	Localized

3.12.9 Threatened and Endangered Species

No federally listed or state plant species of special concern occurrences were observed during the field surveys. However, potential habitat was identified for the federally listed threatened Ute ladies'-tresses (*Spiranthes diuvialis*) and three state species of special concern: pretty dodder (*Cuscuta indecora* var. *neuropetala*), Teal love grass (*Eragrostis hypnoides*), and large bur-reed (*Sparganium eurycarpum*). Details on the habitat requirements of these species are included in the following sections. The potential habitat locations are included in Appendix A3.

Federally Listed Species

Ute Ladies'-Tresses

Ute ladies'-tresses (*Spiranthes diluvialis)* was listed as a threatened species under the ESA on January 17, 1992 (USFWS 1992). Ute ladies'-tresses habitat typically consists of moist, sub-irrigated, or seasonally flooded soils in valley bottoms, gravel bars, oxbows, or floodplains bordering springs, lakes, rivers, or perennial streams at elevations between 4,650 and 5,420 feet (Heidel, 2007). The orchid is most commonly found in areas with soils that remain wet into the flowering period beginning in late July. They often grow in association with riparian plant species such as sedges (*Carex* sp.), rushes (*Juncus* sp.), milkweed (*Asclepias* spp.), redtop (*Agrostis stolonifera*), horsetail (*Equisetum* spp.), blue-eyed grass (*Sisyrinchium* spp.), white clover (*Trifolium repens*), and willow (*Salix* sp.) (Heidel, 2007). In Wyoming, Ute ladies'-tresses orchids bloom from early August to early September (Heidel, 2007).

WYNDD rare plant data did not indicate any known Ute ladies'-tresses occurrences within the project area's watershed or otherwise in the vicinity of the project area. However, SWCA conducted field surveys and identified potential habitat for this species within the project area. Potential habitat was identified on two small point bars within the ordinary high water mark (OHWM) of Little Goose Creek and along several wetland areas on stream banks within the project area.

Although a initial habitat assessments identified suitable conditions existed for Ute ladies'-tresses at two small locations (approximately 0.4 acres) within the project area , subsequent field investigations by USACE revealed that these areas consisted of thick monocultures of brome and reed canary grass. It is unlikely the listed species would be able to germinate and persist based on the density of the existing vegetation.

State Species of Special Concern

Pretty dodder

Pretty dodder is a stringy, yellowish, rootless, parasitic herb that attaches to a variety of woody and herbaceous hosts near sandy roadsides, stream banks, and lakeshores. It is a Great Plains species but is also found in Mexico and Central and South America. In Wyoming, it has been collected in Platte, Goshen, and Sheridan Counties. Pretty dodder was documented in 1892 at the Sheridan Experimental Farm, approximately 6 miles east of the project area (WYNDD, 2014). This species has the potential to occur within the riparian areas of the project area.

Teal love grass

Teal love grass is an annual, stoloniferous, mat-forming grass that grows along muddy or sandy shores of lakes and rivers and in moist, disturbed sites (RMH Specimen Database 2014). It has been documented in all of the lower 48 states of the United States, with the exception of Arizona. Teal love grass was documented along Goose Creek between the cities of Sheridan and Ranchester in 1953 (WYNDD, 2014). This species has the potential to occur within the riparian areas of the project.

Large bur-reed

Large bur-reed is a stout, erect, perennial forb that ranges in height from 50 to 120 cm. Its leaves are 8 to 15 mm wide and up to 100 cm long, alternate, and distinctly V-shaped in cross-section. It is found in wet meadows and marshes in shallow water on mud. Two extant occurrences and one historical occurrence of large bur-reed are documented for Wyoming (RMH Specimen Database, 2014). Large bur-reed was documented in Sheridan County approximately 3.3 miles from the project area in 1896 (WYNDD, 2014). This species has the potential to occur within the large crescent shaped wetland located at Thorne Rider Park in the northern portion of the project area.

3.13 Habitat Suitability Index Models

The purpose of the Habitat Suitability Index (HSI) models is to evaluate the environmental benefits of the restoration alternatives. Two types of models were selected for this study. Aquatic habitat models were selected to evaluate in-stream restoration alternatives and terrestrial habitat models were selected to evaluate riparian restoration alternatives. The HSI models are used to numerically assess the current quality of habitat, future without project quality of habitat, and the quality of the habitat that would develop under various alternative scenarios.

The Corps and WGFD met on April 2, 2015, to discuss and select the HSI models that would be used to characterize existing environmental conditions and evaluate the benefits of riparian and aquatic ecosystem restoration in the project area. The aquatic and terrestrial species models selected are shown in Table 12. Multiple models were used for each type of habitat because each species model has different habitat and water quality parameters that are desirable for restoration. Detailed descriptions of the models and model inputs are located in Appendix A6.

Table 12. Summary of HSI models used

HSI Model Name	Type of Habitat Addressed by HSI Model	Type of Alternatives Evaluated
Brown trout	Aquatic habitat	In-stream alternatives
Brown thrasher	Terrestrial habitat	Riparian alternatives
Yellow warbler	Terrestrial habitat	Riparian alternatives
American mink	Terrestrial habitat	Riparian alternatives

The HSI models reference numerous literature sources in an effort to consolidate scientific information on species-habitat relationships. Models utilize a numerical index of habitat suitability on a 0.0 to 1.0 scale, based on the assumption that there is a positive relationship between the index and habitat carrying capacity. Table 13 shows a summary of the meaning of numerical HSI scores. The models vary in generality and precision, due in part to the amount of available quantitative habitat information and the frequent qualitative nature of existing information. These models are approved by USACE for use on ecosystem restoration studies.

Table 13. A comparison of mathematical HSI scores and verbal expressions

Habitat Suitability Index	USFWS	Sheridan Project
0.0 < 0.2	Poor	Very Low (<0.1) Low (0.1<0.2)
0.2 < 0.4	Marginal	Marginal
0.4 < 0.6	Fair	Moderate
0.6 < 0.9	Good	Above Average
0.9 ≤ 1.0	Optimum	Optimum

Once the individual species' HSI scores have been calculated, these can be multiplied by a unit of measure (acres) to obtain species-based habitat units (HUs). For Sheridan, the scores of the three terrestrial species representing the riparian community were averaged for those alternatives above the OHWM and the brown trout score was utilized for habitat analysis below the OHWM. The community HSI is then multiplied by the size of the habitat (acres of cover type) to get the community HU outputs. Community HUs for each community are calculated for target years 0, 1, 10, 25, and 50, and are entered into the Institute for Water Resources (IWR) Planning Suite NER Outputs calculator, which interpolates the HUs for non-target years during the 50-year period of analysis. It then totals the yearly HUs over 50 years, and this sum is divided by 50 to yield Average Annual Habitat Units (AAHUs) for the overall project. The AAHUs for the no-action alternative, also referred to as the future without-project condition, are subtracted from each with-project alternative. The result is net AAHUs for each alternative that are input into the Cost Effectiveness/Incremental Cost Analysis (CE/ICA) module of the IWR Planning Suite to determine the most economically efficient restoration alternatives.

3.13.1 Aquatic Habitat Models

Initially the proposed approach to measure aquatic habitat benefits was to run two aquatic habitat models, and the results of the two models would be averaged. In addition to the brown trout model, the cutthroat trout model was proposed to be used. However, cutthroat trout are much more sensitive to water temperature than the brown trout. During discussion between the Corps and WGFD, it became apparent that the only effective way to lower water temperatures enough to improve cutthroat trout suitability in the project area would be through partnering with local community groups and individual landowners and

ranch/agriculture operators to implement riparian and land best management practices (BMPs) to reduce water withdrawals and protect riparian shading, and reduce livestock access to creeks. Increasing the amount of water in the creeks and protecting the riparian habitats would provide the necessary foundation to sufficiently decrease water temperatures to produce measureable benefits in a cutthroat trout HSI model. The only way to realize these benefits would be through addressing upstream withdrawals, which is outside the scope of this study. Increasing woody vegetation along the stream could benefit the water temperatures but not significantly enough for cutthroat trout to see a numerical benefit in the model. Further, habitat quality improvements to measurably affect brown trout HSI output scores will also represent real improvements to a suite of habitat and water quality factors for cutthroat trout and other native fishes in the system of creeks. Improvements that transfer to other cold water fishes beyond brown trout include reduced temperature due to increased shading and quality pool habitat, improved refuge cover, improved spawning habitat, and improved water and substrate quality to support primary production, periphyton attachment, and insect production. As a result, the cutthroat trout HSI model was eliminated in the analysis and brown trout model was selected as the only model because it appeared more appropriately scaled to address the planning objectives within the scope of the study.

To best measure the restoration of ecological function, the HSI modeling process was scrutinized to determine whether or not it was capturing all the effects of significant ecological deficiencies present in the study area. As such, it was determined that fish passage was a significant threat to fish population resiliency, and that the HSI models available would not directly account for improvements to fish passage. The brown trout HSI model does not capture improvements to habitat connectivity in the streams. The Corps and WGFD agreed the best solution to account for this model deficiency was to include the acreage footprint made accessible by passage improvements in the benefit calculation. As such, the HSI model would be able to credit the project for opening access to restored areas upstream in the study area, but would not double count the degree of benefits realized at each upstream restoration site, which was another option that was considered.

3.13.2 Riparian Habitat Models

Three terrestrial habitat models were selected to measure the habitat quality of the project area. The results of the three models are averaged for a final score. The three HSI models selected are the brown thrasher, yellow warbler, and American mink. All of the terrestrial species selected for HSI model inclusion require woody habitat, which is limited within the project area. Detailed descriptions of the models and model inputs are located in Appendix A6, and brief overviews are below.

- The brown thrasher was selected to represent breeding habitat for aviary species that prefer nesting in shrubs to mid-successional stages of forest. Although the preference is to breed in low-lying woody species, the males are territorial and prefer to sing from the tops of trees above their nest.
- The yellow warbler was selected to represent breeding habitat for other neo-tropical songbirds such as Macgillivray's warbler, yellow-breasted chat and common yellowthroat. The yellow warbler is a neo-tropical migratory bird that breeds in willow and alder stands along streams, ponds, or within wetlands throughout a large portion of the United States, including Wyoming.
- The mink model was chosen to represent riparian habitat variables that would benefit from restoration: vegetative cover along the shoreline and stream sinuosity (or the degree of shoreline disturbance). The mink is not abundant in Wyoming, but it is known to be distributed throughout the state and is within the habitat range of this model.

3.13.3 Existing Conditions Habitat Suitability Values

A breakdown of existing condition HSI values by reach and habitat type is provided in Table 13. The locations of sampling points to derive existing conditions HSI values were determined collaboratively between the Corps and WGFD to distribute sampling effort to capture data about each part of the study area: including Big Goose Creek, Little Goose Creek upstream of the concrete channel, Little Goose Creek in the concrete channel, and Goose Creek. We assumed for the purposes of modeling that each sampling location would be representative of the habitat quality for that reach (see Table 13). Because it was later determined that multiple alternatives would be developed with in a single reach, we also assumed that the all site specific alternatives within a reach also reasonably reflected the existing conditions habitat quality for that reach. Some terrestrial habitat project reaches have a range of HSI values shown because the habitat quality varied among locations that were modeled on that reach. Because of the constraints identified limiting terrestrial restoration potential on Big Goose Creek, no existing conditions data were collected and no alternatives were considered there.

Table 14. Existing conditions HSI values

	Little Goose Creek Reach	Big Goose Creek Reach	Downtown Reach	Goose Creek Reach
Aquatic habitat	0.200	0.200	0.000	0.00
Terrestrial habitat	0.054 - 0.157	No data	0.000	0.058 - 0.270

3.14 Cultural Resources Assessment

Human habitation of the project area extends back approximately 10,000 years. The chronological periods include the Paleoindian period (ca. 11,500 – 8,000 years before present (BP)), Early Archaic period (ca. 8,000 – 5,000 years BP), Middle Archaic period (ca. 5,000 – 3,000 years BP), Late Archaic period (ca. 3,000 – 1,500 years BP), and Late Prehistoric period (ca. 1,500 – 500 years BP). Archeologists developed this chronology based on different projectile point styles and climate conditions (Sanders 2002).

Sheridan, Wyoming lies within the Tongue River Watershed, the ancestral homeland of the Crow people (WyoHistory.org 2011). The confluence of Little Goose Creek and Big Goose Creek, turning into Goose Creek, is near the center of the city. The historic Bozeman Trail runs east of the city. Named for Civil War General Philip Sheridan, the city was formally incorporated in 1884 (WyoHistory.org 2011). The confluence of two perennial waterways increases the probability of precontact archeological remains. Historic Era properties, eligible for listing on the National Register of Historic Places (NRHP) are likely due to the age of the city, and close proximity to historic trails and historic military forts.

The study area encompasses the Area of Potential Effect (APE) as defined in 36 CFR Part 800 for compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966. In accordance with the NHPA, federal agencies, such as the Corps, are required to consider any effects to historic properties that result from federal undertakings. Preliminary cultural resource investigation of the APE, accomplished using the Wyoming Cultural Records Office Web database (WYCRO) and internet searches, revealed the potential for historic and pre-contact cultural resources.

The FRM project was built in 1966 through a partnership between the city of Sheridan and the U.S. Army Corps of Engineers. The project collectively encompasses about 4.25 linear miles of stream channel on Little Goose, Big Goose, and Goose Creeks. Major features of the existing project consist of levees, channel alterations, a concrete chute, and a concrete drop structure.

A preliminary cultural resource investigation for the Public Land Survey System (PLSS) sections containing the study area was accomplished using the WYCRO web database and the National Park Service (NPS) Google Earth layer of the National Register of Historic Places (NRHP). These sources revealed 51 sites in the PLSS sections that are eligible for listing on, or are currently listed on the NRHP, and five sites are unevaluated. In addition, an intensive cultural resource inventory of the downtown study reach segment was conducted by Cultural Resource Associates, Inc. (Weston 2015).

Although numerous historic properties have been recorded along the study area one-mile buffer, construction of the existing project, such as channel deepening, widening, realigning, and lining along the entire 4.25 miles of the study APE have completely altered the characteristics of a healthy stream transitioning away from the mountains. The extent of the channel modifications has resulted in a low probability of discovering unrecorded subsurface historic properties.

Two intensive cultural resource inventories were conducted in within the study area. Information on cultural resources is provided in Appendix E. The urban setting of the study area means that much of the surface is covered in asphalt or concrete and the underlying sediments have been subject to disturbances on multiple occasions by construction events. During 2015 the downtown segment was subject to an intensive cultural resource inventory, A total of 25.8 acres were surveyed, resulting in one historic isolate and 15 historic sites recorded. No prehistoric cultural materials were not anticipated, and none were encountered. A second intensive cultural resource inventory, totaling 32.62 acres, covered the remaining segments of the study area on Goose, Big Goose and Little Goose Creeks. One site recorded in the 2015 survey was amended and submitted as an historic district. Five new historic properties were recorded, and again, prehistoric cultural materials were not anticipated, and none were encountered.

Consultation with the Wyoming State Historic Preservation Office (SHPO) was initiated for this study. A formal letter was sent to SHPO (dated May 2, 2017), and the SHPO responded in a letter (dated June 7, 2017). The SHPO requested that a cultural resources investigation be conducted for the reaches of the study not previously covered. The Corps completed a Class III intensive inventory in July of 2017, and submitted the preliminary results to SHPO for review on 30 Aug 2017. The final report and agency determination of effect was submitted to SHPO on 2 February 2018. Once the SHPO review is complete the response, and effect determination, will be included in this decision document prior to completing the final USACE policy compliance review.

3.15 Recreation Resources Assessment

The city of Sheridan is the largest urban center within Sheridan County, with an estimated population of 17,444 in 2010. Sheridan County had an estimated population of 29,116 people in 2010. It's located between South Dakota's Black Hills and Devils Tower to the east, and Yellowstone National Park and the Grand Tetons to the west. Located in the heart of the Rocky Mountains and nestled between Little and Big Goose Creeks, Sheridan is framed by the backdrop of the Big Horn Mountains and rolling plains.

The city of Sheridan has an active and engaged parks and recreation community. Sheridan recently completed its Parks and Recreation Master Plan to help provide direction for the maintenance, updating and expansion of the community's park and recreation system. The Parks and Recreation Master Plan guided the community through a four-phased planning process that involved identifying the existing inventory of recreation resources in Sheridan, assessing community need and preferences for parks and recreation, developing a plan of action, and finally plan adoption and implementation. The Parks and Recreation Master Plan was quite comprehensive in scope with its consideration of all types of recreation (i.e. sports focused recreation facilities, youth development opportunities, exercise opportunities, along with natural areas, and trails and pathways), it does provide valuable information about recreation

conditions. The Parks and Recreation Master Plan builds upon other city planning efforts including the Sheridan Joint Planning Area Land Use Plan Draft (January 2009) and the Sheridan Pathways Master Plan (2007). The Pathways Master Plan helped establish the city's vision for developing a pedestrian-friendly community (and beyond) that encourages alternative transportation and exercise by providing conveniently located pathways and trails.

As described in the Sheridan Pathways Master Plan, there are a variety of existing Sheridan parks, trails and pathways (2009). Based on information gathered for the Pathways Master Plan, it's estimated that there are 516.2 acres of park land within the Sheridan planning area, with 102.8 acres identified as 'natural areas' (approximately 20 percent). Additionally, Sheridan has approximately five miles of hard surface multi-use trails that meander through and connect multiple parks facilities. As identified in the Pathways Master Plan, Sheridan has plans to develop a more comprehensive system of trails to continue encouraging public access to active recreation opportunities such as walking, biking or running, and to provide alternative transportation opportunities.

4.0 FUTURE WITHOUT-PROJECT CONDITION

In addition to the existing conditions analysis, a future without-project condition was also analyzed. The forecast of the future without-project condition reflects the conditions expected during the 50-year period of analysis and three additional increments, years one, 10, and 25. The future without-project condition provides the basis from which alternative plans are formulated and impacts are assessed. The future without-project condition is the basis of comparison for the alternatives later in the study. Generally, the existing conditions presented in Chapter 3 reflect the future condition. Future without-project environmental condition forecasts were made in relation to the HSI models. No change in HSI values is projected over the 50-year period of analysis. Values shown for existing conditions are also the future without-project condition HSI values.

Future without- and future with-project descriptions are presented below as they relate to the HSI models chosen to evaluate habitat conditions.

American mink habitat

Future-without project: In the next 50 years, riparian habitat represented by the mink model is anticipated to be similar to current conditions. Although upstream projects may divert and impound more water, it is likely that Big Goose Creek, Little Goose Creek, and Goose Creek flows would continue to be perennial at this location. Because there is very little to begin with, tree canopy cover is not expected to substantially decrease in 10, 25 or 50 years, but this would also depend on extreme weather and the amount of damaged trees that would occur during unforeseen storms. For the small amount of shrubs that are currently within the proposed restoration areas, it is anticipated that as they die or are otherwise negatively impacted, more shrubs would grow to take their place. Stream condition could worsen as a result of anthropogenic pressure on this area from adjacent land use and upstream river manipulation projects. There is so little riparian habitat within the urbanized reach of Sheridan that conditions are generally unable to degrade below currently existing conditions. Therefore, in the next 50 years, riparian habitat represented by the mink model is anticipated to be similar to current conditions.

Yellow warbler habitat

Future-without project: Currently no shrubs are present within any of the lands chosen for restoration, according to the data collected. However, some shrubs are likely to be sporadically present at some of the locations and it is anticipated that over the next 50 years, the average height of the shrubs and saplings in the riparian zone is anticipated to remain unfavorable to yellow warblers or their surrogate species. Yellow warbler habitat in the future is expected to be similar to current conditions, therefore no change in HSI values is projected.

Brown thrasher habitat

Future-without project: Habitat future-without project outputs over the 50-year period of analysis are fairly low primarily due to the small amount of areas that are currently occupied by forested habitat that have been identified as potential restoration areas coupled with the low likelihood that trees would be planted without this project. Brown thrasher habitat in the future is expected to be similar to current conditions, therefore no change in HSI values is projected.

Brown trout habitat

Future-without project: In the next 50 years, in-stream habitat quality is anticipated to be similar to current conditions, which includes habitat suitability index scores of zero in Goose Creek downstream of the confluence. Based on reasonably foreseeable habitat quality changes under the future without-project scenario on Little Goose Creek, no marked change in habitat quality was expected to occur. However, because some of the existing forested riparian area that currently provides shading on the Little Goose

Creek reach is privately owned, there is risk these trees could be removed by the owner or not replaced with other shading vegetation after exceeding their life expectancy. Therefore, there is a minimal risk that in-stream habitat quality could be worse in 50 years than the model predicted as most likely under the future without-project scenario.

5.0 ECOSYSTEM RESTORATION PLAN FORMULATION AND RECOMMENDATION

Plan formulation for this ecosystem restoration study consisted of several steps. Plans are formulated with consideration to the four planning criteria of effectiveness, efficiency, acceptability, and completeness. In addition to the four planning criteria, Table 15 shows the summary of measures and site plans considered and Table 16 shows the summary of evaluations and comparison of alternatives.

Restoration measures are developed based on potential **effectiveness** at achieving restoration objectives, combined into alternatives, and then the initial screening takes place. The initial screening of measures is intended to eliminate those measures which are not constructible or sustainable from an engineering standpoint. Sponsor **acceptability** is also used to screen alternatives at this stage. Plans may be further developed or modified during this step. This step is primarily accomplished at the early stages of the planning process, but iterative reformulation of plans is done on an as-needed basis throughout the entire process.

After measures are screened, restoration designs are developed into more detail, including modification to achieve a planning objective or stay within the limits of a constraint. Design work, cost estimating, and habitat output modelling is conducted. Utilizing the CE-ICA tool, alternatives are compared based on costs and habitat unit outputs.

A plan is selected based on the efficiency and effectiveness of each specific alternative and in relation to all the alternatives assessed by the CE-ICA model. **Acceptability** to the sponsor and public and also **acceptability** in terms of compliance with existing laws and regulations is determined. The preferred plan undergoes detailed real estate assessment and an abbreviated cost and schedule risk analysis is conducted to establish contingencies to ensure that the **completeness** criterion is met.

Table 15. Summary of measures and site plans considered

Restoration Sites	**Riparian sites**	**Report Section to Reference for Details**	**In-stream sites**	**Report Section to Reference for Details**
	13 initial sites	5.1.1	12 initial sites	5.1.2
	6 sites eliminated		0 sites eliminated	
Total	**7 sites carried forward**		**12 sites carried forward**	
Restoration Measures	**Riparian measures**	**Report Section to Reference for Details**	**In-stream measures**	**Report Section to Reference for Details**
	Remove invasive plants Excavate to restore wetland hydrology Planting hydrophytic vegetation Levee setbacks Reconnect oxbow to creek Use stormwater for wetland hydrology	5.1.1	Random boulder clusters Cross vanes Vanes / vanes with J-hooks Newbury rock riffles Toe revetments Channel realignment "W" cross vanes Modify drop structure Modify concrete chute	5.1.2
Total	**6 riparian measures**		**9 in-stream measures**	

Table 16. Summary of evaluation and comparison of alternatives

Initial Array of Restoration Alternatives	**Riparian Alternatives**	**Report Section to Reference for Details**	**In-stream Alternatives**	**Report Section to Reference for Details**
	2-4 different alternatives per site	5.2.1	1-7 different alternatives per site	5.2.2, 5.2.3, 5.2.4
	18 total sites/alternatives		**28 total sites/alternatives**	
	Evaluation of benefits	5.3	Evaluation of benefits	5.3
	Evaluation of costs	5.4	Evaluation of costs	5.4
	Best Buy Alternatives			
	1 - No Action	5.5	1 - No Action	5.5.4
	6 - Actionable Best Buy Alts.		13 - Actionable Best Buy Alts.	
Total	**7**		**14**	
Final Array of Restoration Alternatives	**Comparison/Evaluation of Final Alternatives**			
	Combined Riparian and In-stream Alternatives	**Number of Alts.**		**Report Section to Reference for Details**
	No Action Alternative	1		5.5.3
	Total Combined Actionable Riparian and In-Stream Alternatives	19		5.5.4
	Total Combined Actionable Riparian and In-Stream Plans	20		5.5.4
	National Ecosystem Restoration Plan / Recommended Plan*	1		5.6

Note: Integration of recreation features occurs after selection of the recommended plan. See Chapter 6.0 for details. Recreation features were developed for the recommend plan only.

5.1 Initial Array of Restoration Measures

Two types of ecosystem restoration measures were developed for this study to achieve the planning objectives.

1. The first type is riparian restoration measures, which are intended to improve habitat adjacent to the channel. These measures are focused on improving certain components of the ecosystem, including overall wetland quantity and quality, overall canopy volume and cover, density and composition of emergent and forested wetland vegetation, and upland buffers.
2. The second type is in-stream restoration measures, which are intended to improve aquatic habitat within the creek channel. These measures are focused on improving certain components of the ecosystem, including baseflow water temperatures, channel depth, DO, and habitat diversity.

The Corps and city of Sheridan worked with local and regional experts to assist in the identification of restoration measures that could be implemented within the project area, assess how those measures would benefit the ecosystem, and determine which species would benefit. Participation and input from local/regional natural resource professionals allowed for effective and efficient development of restoration measures. Local and regional experts from government entities who participated included representatives from the WGFD, SCCD, and the NRCS. Experts from consulting firms who participated included representatives from SWCA, Stantec, Steady Stream Hydrology, and Barr Engineering. Additional information on the participants is located in Appendix A5.

Each representative participated in a project walk-through of the site with the Corps and the city of Sheridan PDT present. Nine regional experts, not including Corps, City, and SWCA staff, attended the walk-through and provided input on the restoration opportunities and approaches. During the walk-through, potential restoration was considered throughout the FRM project area, and site-specific opportunities and benefits were discussed. Following the walk-through, all attendees gathered in a meeting room and outlined specific restoration approaches for riparian and aquatic restoration. All comments collected during the expert interviews and walk-throughs are provided in Appendix A5 and included with the electronic submittal for this report. The initial array of restoration measures was developed during this project walk-through, which was held on May 7, 2015. Measures and alternatives were refined and modified using professional judgement of the PDT throughout the study. As measures were developed to a higher level of detail, multiple iterations of meetings with local experts occurred to obtain feedback which could be used to make refinements on restoration designs.

5.1.1 Riparian Measures and Screening Results

Riparian restoration measures:
This section describes the initial array of riparian restoration measures developed. The riparian measures developed for the study include:

- Remove invasive vegetation to improve habitat
- Excavate to restore wetland hydrology
- Restore native riparian cover by seeding and planting hydrophytic vegetation
- Setback levees to reconnect creek with floodplain
- Reconnect oxbow to creek
- Use stormwater drainage to supplement wetland hydrology

Identification of potential riparian restoration sites
A total of 13 riparian sites were initially identified. No riparian restoration sites were identified on the Big Goose Creek, with the exception of one alternative at the confluence, mainly due to the popularity of Kendrick Park outweighing the value of potential restoration as a land use change to the area. This area is also small relative to the sizes of Little Goose Creek and Goose Creek reaches.

Riparian sites are labeled by site A through M on Figures 17A and 17B. Riparian restoration sites are shown as polygons on the maps and were determined based on topographic characteristics, existing habitat quality, and restoration potential. Figure 17A shows sites on the Little Goose Creek Reach and Figure 17B shows sites on the Downtown and Goose Creek Reaches. Green polygons represent sites where some or all of the measures were carried forward and red polygons represent sites where no measures were carried forward.

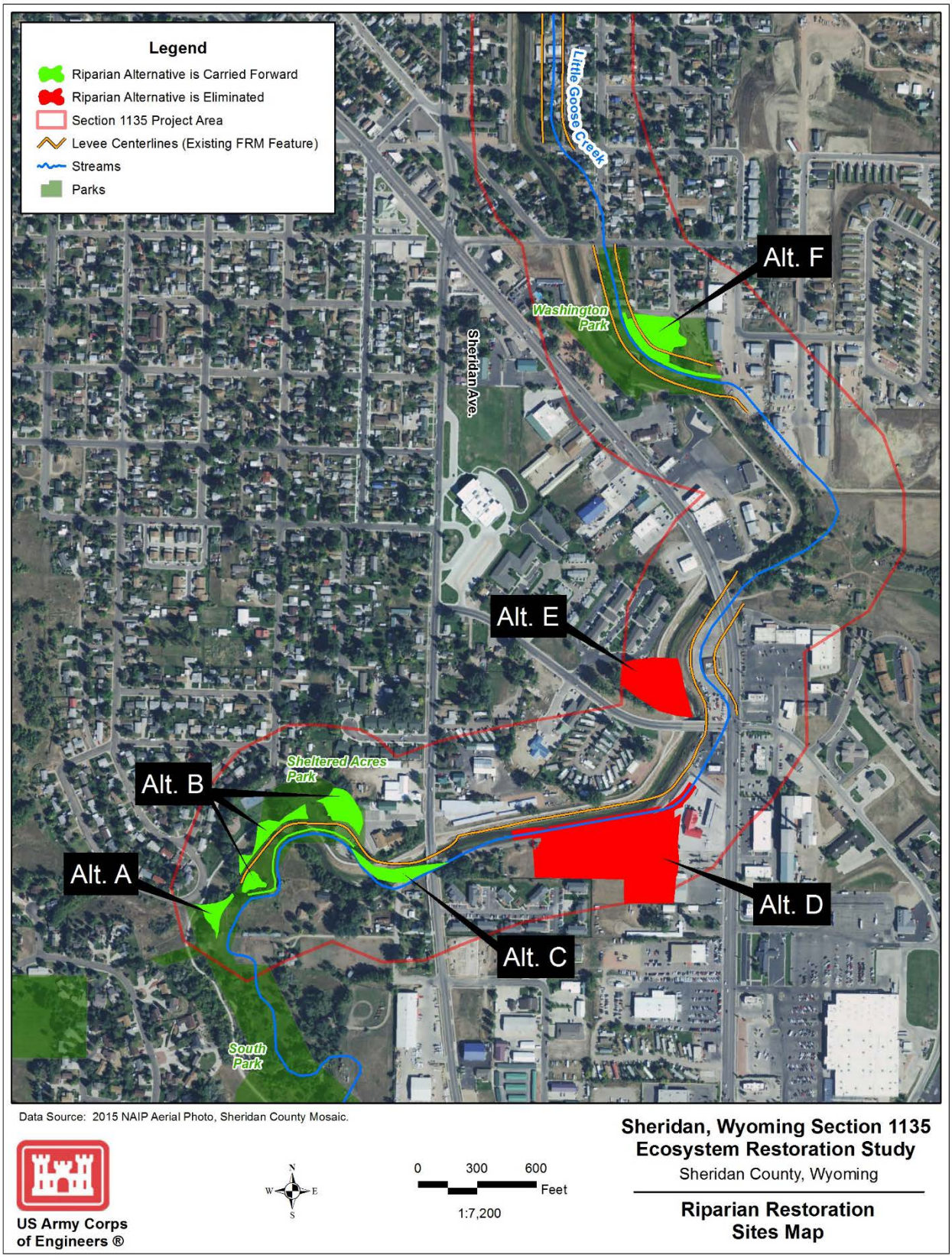


Figure 17A. Riparian restoration sites

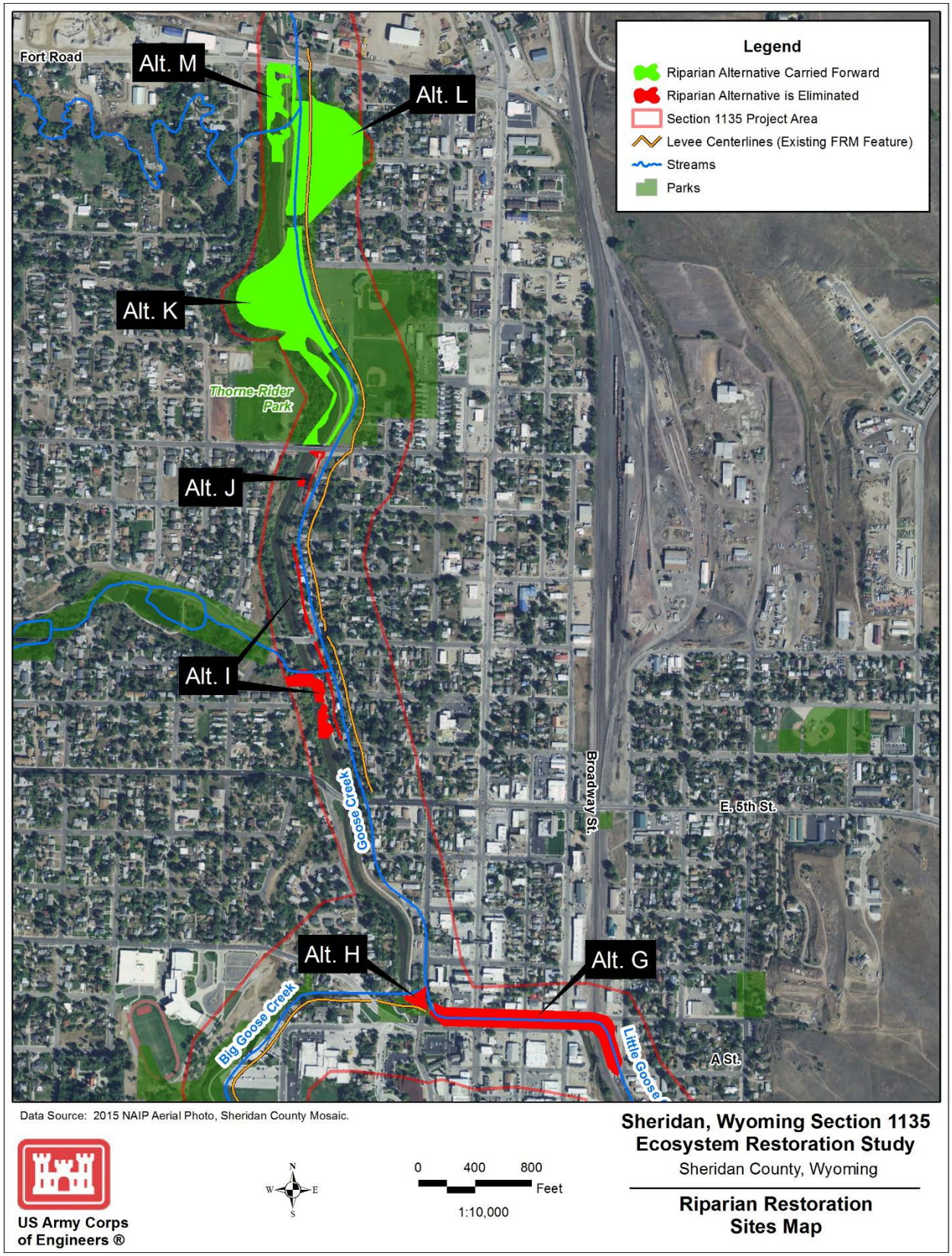


Figure 17B. Riparian restoration sites

5.1.1.1 *Riparian measures screening results*

Riparian measures were assigned to each riparian site based on the potential to improve the riparian ecosystem, constructability of the measure, and compatibility with surrounding land uses. Table 17 shows the riparian measures that were initially considered, as well as the results of the initial screening of those measures. Boxes marked with an "x" indicate that measure was initially considered for the site. Boxes shaded with green indicate the measure was carried forward to the next phase and boxes shaded with red indicate the measure was eliminated from consideration.

Table 17. Riparian restoration measures considered for each site

Site #	Remove invasive vegetation to improve habitat quality	Excavate to restore wetland hydrology	Restore native riparian cover by seeding and planting hydrophytic vegetation	Setback levees to reconnect creek with floodplain	Restore channel sinuosity / channel realignment	Restore oxbow adjacent to creek	Use stormwater drainage to supplement wetland hydrology
A	x	x	x		x		
B	x	x	x	x			x
C	x	x	x				
D	x	x	x		x		x
E	x	x	x	x			
F	x	x	x	x			
G	x	x	x				
H	x	x	x				
I	x	x	x				
J	x	x	x				
K	x	x	x		x	x	
L	x	x	x	x	x		
M	x	x	x				

Measures for sites A, B, C, F, K, L, and M were carried forward. While measures for site A were carried forward, the channel realignment measure was eliminated because it was not cost-effective. Measures for site B was also carried forward, however the levee setback measure for this site was eliminated because it was not cost-effective relative to other measures, and utilizing local stormwater ditches to supplement wetland hydrology was eliminated for being unacceptable from the sponsor's standpoint.

Sites D, E, G, H, I, and J were identified by the PDT, sponsor, and local experts as having the potential for ecosystem restoration. However, they were eliminated during initial measures screening for the reasons outlined in the bullets below.

- Site D – real estate was unavailable and location became unacceptable for consideration for restoration by the sponsor.
- Site E – engineers had concerns with the feasibility of construction in this area and it was evident that it would be inefficient from a cost perspective. Approximately 12 feet of excavation would be required to provide water resource restoration value.
- Site G – the real estate available downtown is too limited to provide space to accommodate riparian habitat.
- Site H – this area was recently re-developed by the sponsor as parkland.
- Site I – inefficient due to high costs, constructability issues, and operations and maintenance concerns led to elimination.

- Site J – inefficient due to high costs, constructability issues, and operations and maintenance concerns led to elimination.

5.1.2 In-Stream Measures and Screening Results

In-stream restoration measures:
This section describes the initial array of in-stream measures developed. The following is a list of in-stream measures developed for the study.

- Create random boulder clusters
- Create cross vanes
- Create vanes or vanes with J-hooks
- Create Newbury rock riffles
- Create toe revetments
- Restore channel sinuosity / channel realignment
- Create "W" shaped cross vane at the confluence
- Modify existing drop structures for fish passage
- Modify concrete chute and restore natural channel

Identification of potential in-stream restoration sites
A total of 12 in-stream sites were identified. In-stream restoration sites occur within the channel and were identified based on the current condition of the stream habitat in a particular location. Because the majority of the project area has been degraded, the restoration potential is high throughout. Each project reach has in-stream restoration potential.

Figures 18A and 18B show the locations of the in-stream restoration sites. All sites were carried forward for further analysis at this phase.

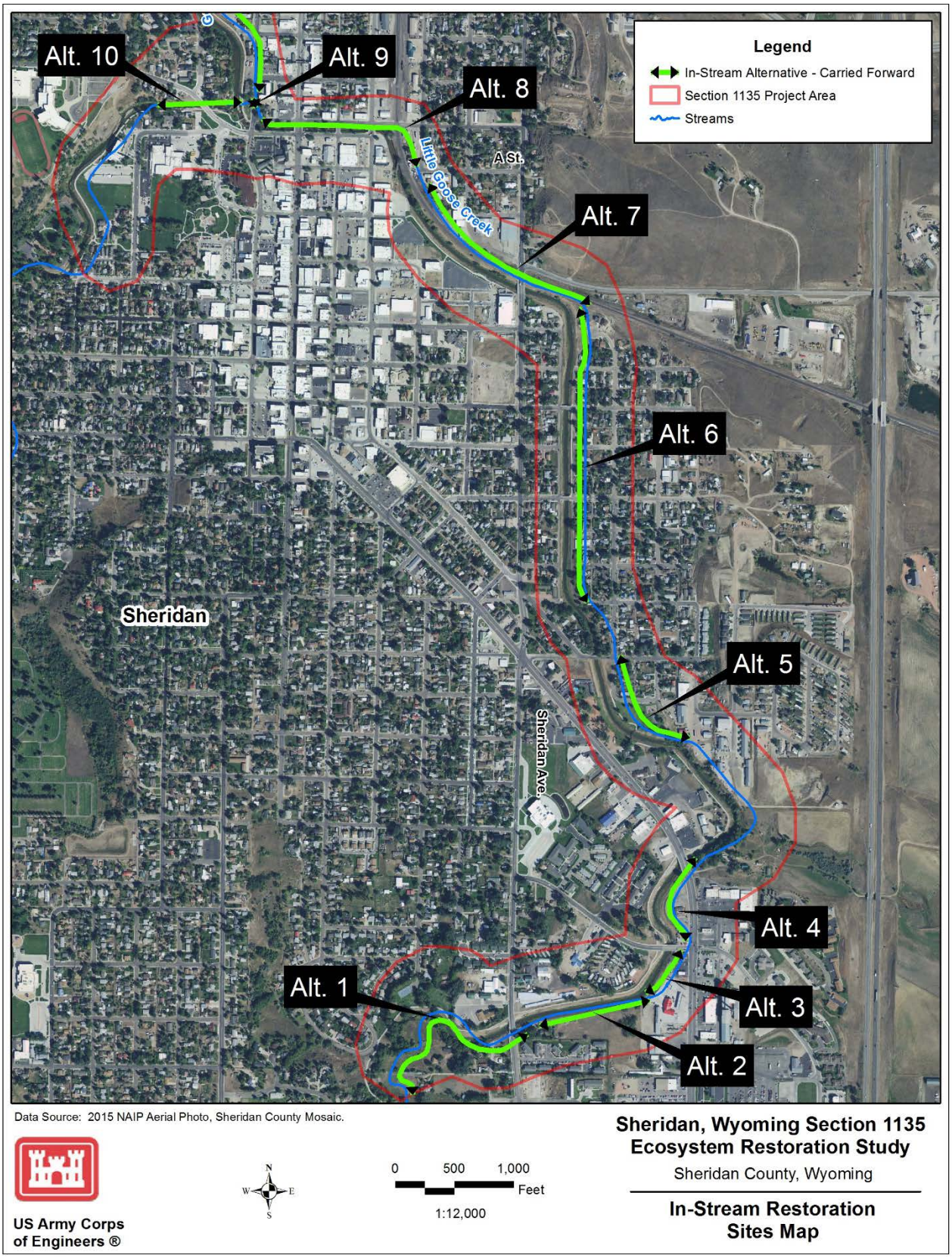


Figure 18A. Initial array of in-stream restoration sites

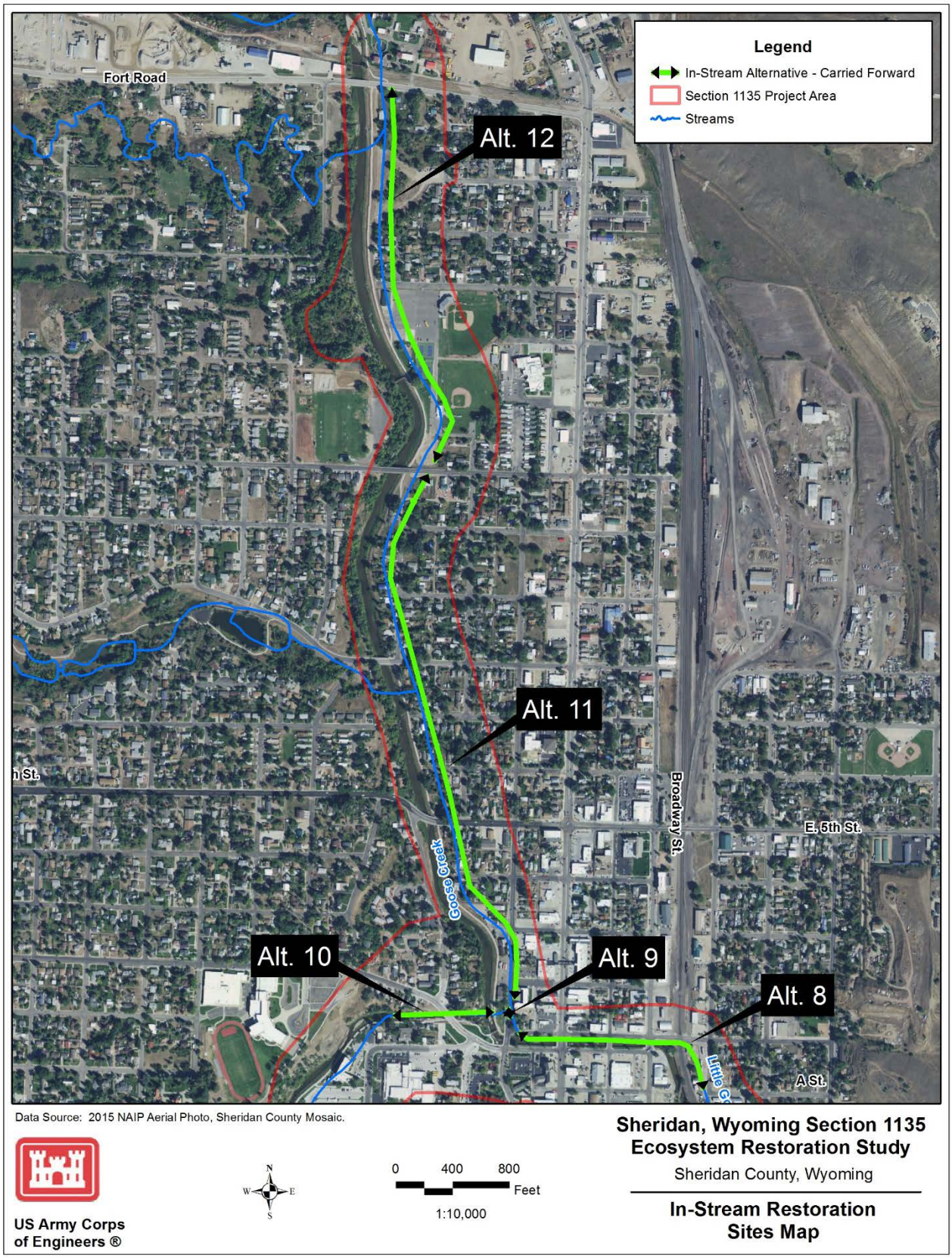


Figure 18B. Initial array of in-stream restoration sites

In-stream measures screening

In-stream measures were assigned to each in-stream site based on the ability of a measure to sustain long-term performance within the local channel geometry and hydrologic regime. For some reaches of the system only one method of in-stream restoration was evaluated because other measures were not suitable due to engineering or concerns with long-term effectiveness and sustainability. Table 18 lists the measures that were considered for each site. Boxes marked with an "x" indicate that measure was initially considered for the site. Boxes shaded with green indicate the measure was carried forward to the next phase and boxes shaded with red indicate the measure was eliminated from consideration.

Among measures that were considered for the in-stream restoration sites, everything was carried forward except for the channel realignments for sites one and two. Channel realignment for site one was eliminated for being inefficient from a cost standpoint and for site two for being unacceptable to the sponsor and lack of real estate availability.

Table 18. In-stream restoration measures considered for each site

Site #	Create random boulder clusters	Create cross vanes	Create vanes or vanes with J-hooks	Create Newbury rock riffles	Create toe revetments	Restore channel sinuosity / channel realignment / reconnect oxbow to channel	Create "W" shaped cross vane at the confluence	Modify existing drop structures for fish passage	Modify concrete chute and restore natural channel
1		x	x	x		x			
2	x		x			x			
3		x		x					
4			x						
5	x		x		x				
6		x							
7		x							
8									x
9							x		
10								x	
11		x	x	x					
12		x	x	x		x			

5.1.3 Converting Measures to Alternatives

Of the restoration measures carried forward to develop into alternatives, it is important to know how they relate to the study objectives. The relationship between study objectives and restoration measures is shown in Table 19. The restoration measures shown are developed into alternatives in the following section. Alternatives are defined as one or more measures at each site. Each alternative is not required to address all the planning objectives.

Table 19. Relating study objectives to measures

Study Objective	Restoration Measures	"In-stream" or "Riparian" Classification
Restore stream and hydraulic function, both in a physical and ecological manner, throughout the entire project area.	*Create random boulder clusters *Create cross vanes *Create vanes or vanes with J-hooks *Create Newbury rock riffles *Create toe revetments *Restore channel sinuosity / channel realignment *Create "W" shaped cross vane at the confluence	In-stream
Restore in-stream habitat connectivity and provide for fish passage.	*Modify existing drop structures for fish passage *Modify concrete chute and restore natural channel	In-stream
Restore wetland, riparian, and floodplain habitats and connectivity with upstream and downstream reaches in the vicinity of the flood control system.	*Remove invasive vegetation to improve habitat quality *Excavate to restore wetland hydrology *Restore native riparian cover by seeding and planting hydrophytic vegetation *Setback levees to reconnect creek with floodplain *Divert creek into floodplain (no levee setback) *Reconnect oxbow to creek *Use stormwater drainage to supplement wetland hydrology	Riparian

5.2 Ecosystem Restoration Alternatives

Following the screening of measures, detailed descriptions of alternatives were developed to specify how each alternative could be restored using the restoration measures carried forward. Alternatives are defined once specific restoration actions (i.e. measures) are identified for a site. At this point habitat restoration alternative plans and conceptual level engineering designs were developed to a level of detail appropriate for this phase of the study process. The ecosystem restoration benefits are expressed in non-monetary terms as the net average annual habitat units (AAHUs) over the 50-year period of analysis. For each future-without project and future-with project plan, the AAHUs and AA costs were entered in the IWR Planning Suite Software.

Plans are cost effective if no other plan produces an equal or greater number of environmental outputs at a lower cost. Cost effective analysis ensures that the least cost solution is identified for each level of environmental output, eliminating inefficient alternative plans from further consideration. The number of cost-effective plans are further refined (reduced), but using IWR Planning Suite to identify 'Best Buy' plans. Best buy plans are plans that are most efficient at providing environmental output, when the incremental cost per incremental output are compared between plans of increasing size. The concept of best buy plans is revisited later.

Due to the large number of alternatives and plans (both riparian and in-stream), there were too many alternative plan combinations for IWR Plan to generate combined plans (due to software storage limitations), without first eliminating some of the less efficient riparian and instream alternatives. So prior to creating combined (riparian and in-stream) plans, first all riparian alternatives were input in to IWR Plan, riparian plans were generated, and the best buy or most efficient riparian alternatives were identified from the collection of cost effective riparian plans. Then, all instream alternatives were input in

to IWR Plan, in-stream plans were generated, and the most efficient or best buy in-stream alternatives were identified from the collection of cost effective instream plans. Lastly, the most efficient alternatives that had been identified for in-stream and riparian were input into IWR Plan, and alternative plans were generated that included both in-stream and riparian alternatives.

Note that alternatives at each location are independent of all other locations. A measure or combination of measures at any particular location are considered to constitute an 'alternative', and may or may not be combinable with other measures at that location. Each alternative was entered in IWR Plan as a solution and the alternative number as a scale of the solution. Solution scales, or different alternatives for the same location were generally not combinable, so two different plans for the same area would not be included in the same generated alternative plan. There were two alternatives where the different measures were evaluated as being combinable at that location. Alternatives 5A, 5B, and 5C are combinable. Alternatives 2A and 2B are also combinable. The reason for this is that random boulder clusters were determined to be combinable with vanes or vanes with J-hooks and toe revetments (for Alternative 5 only).

5.2.1 Riparian Alternatives

The purpose of these alternatives is to restore wetland, riparian, and floodplain habitats and connectivity with upstream and downstream reaches in the vicinity of the flood control system. Each riparian restoration alternative had at least two variations that were developed, with the type of plantings being the differentiating factor between many of the alternative variations. For each alternative, topsoil will be stockpiled and treated for re-use and all excess unusable soil would be disposed of in an approved location. Appendix A6 contains the plan views of each alternative that shows the locations of plantings at each alternative.

All of the alternative variations for each location are mutually exclusive. For example, Alternative A1 is not combinable with A2.

Table 20 shows the in-stream restoration alternative descriptions. The letter corresponds to the site location and the number refers to a variation (i.e. alternative) that is considered at that particular site.

Table 20. Riparian action alternative descriptions

Alt. #	Acres	Description
A1	**0.32**	Excavate a depression to groundwater in an existing upland location. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland shrubs with accompanying native emergent vegetation understory. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation.
A2	**0.32**	Excavate a depression to groundwater in an existing upland location. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland trees with accompanying native emergent vegetation understory. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation.
B1	**1.28**	Excavate a depression to groundwater at a disc golf course dominated by upland vegetation. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Plant a mixture of hydrophytic and upland shrubs with accompanying native emergent vegetation understory to the north and west of the emergent wetland. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation.

B2	**1.28**	Excavate a depression to groundwater at a disc golf course dominated by upland vegetation. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Plant a mixture of hydrophytic and upland trees with accompanying native emergent vegetation understory to the north and west of the emergent wetland. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation.
C1	**0.36**	Excavate, seed, and plant native hydrophytic emergent vegetation on the entire floodplain bench.
C2	**0.36**	Excavate, seed, and plant native hydrophytic emergent vegetation on most of the floodplain bench. Plant native shrubs with accompanying native emergent understory in the area furthest from the levee toe in accordance with ETL 1110-2-583.
F1	**1.10**	Remove and dispose of existing concrete pedestrian trail within the project area. Excavate existing levee to original ground surface. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. As elevation increases moving inland from the creek, plant a mixture of hydrophytic and upland shrubs with accompanying native emergent vegetation understory to the east of the emergent wetland. Reconstruct the new setback levee to bind the eastern portion of the project area. Reconstruct concrete pedestrian trail on top of the setback levee. Plant a native grass upland buffer between the toe of the setback levee and the shrub area. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek.
F2	**1.10**	Remove and dispose of existing concrete pedestrian trail within the project area. Excavate existing levee to groundwater. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. As elevation increases moving inland from the creek, plant a mixture of hydrophytic and upland trees with accompanying native emergent vegetation understory to the east of the emergent wetland. Reconstruct the new setback levee to bind the eastern portion of the project area. Reconstruct concrete pedestrian trail on top of the setback levee. Plant a native grass upland buffer between the toe of the setback levee and the shrub area. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek.
K1	**5.53**	Excavate to restore connectivity between Goose Creek and an oxbow. This will serve as the new channel. Fill in the existing channel to elevation that would receive overflow from Goose Creek approximately every one in two and a half years. Seed and plant native hydrophytic emergent vegetation in the filled-in channel. Excavate inside meander of the new channel to groundwater and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland shrubs with accompanying native emergent vegetation understory. Plant upland shrubs at higher elevations to provide additional riparian habitat benefits. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. All native trees should not be removed.
K2	**5.53**	Excavate to restore connectivity between Goose Creek and an oxbow. This will serve as the new channel. Fill in the existing channel to elevation that would receive overflow from Goose Creek approximately every one in two and a half years. Seed and plant native hydrophytic emergent vegetation in the filled-in channel. Excavate inside meander of the new channel to groundwater and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland trees with accompanying native emergent vegetation understory. Plant upland trees at higher elevations to provide additional riparian habitat benefits. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. All native trees should not be removed.
L1	**3.22**	Remove and dispose of existing concrete pedestrian trail within the project area. Excavate existing levee to groundwater. Use other excavated soil to fill-in the existing channelized portion of Goose Creek. Create a new channel that meanders through the floodplain where the levee used to be. Seed and plant native hydrophytic emergent vegetation in the filled-in channel. Excavate inside meander of the new channel to groundwater and plant native hydrophytic emergent vegetation at the lowest elevation. Surround new channel with a mixture of native hydrophytic and upland shrubs with accompanying native emergent

		vegetation understory. Reconstruct the new setback levee to bind the eastern portion of the project area. Reconstruct concrete pedestrian trail on top of the setback levee. Plant a native grass upland buffer between the toe of the setback levee and the shrub area. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek.
L2	**3.22**	Do not setback the levee. Excavate a depression to groundwater in an existing upland location. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland shrubs with accompanying native emergent vegetation understory. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation.
K1L1	**8.75**	See K1 and L1 descriptions. Plans at sites K and L may be combined.
K2L1	**8.75**	See K2 and L1 descriptions. Plans at sites K and L may be combined.
K1L2	**8.75**	See K1 and L2 descriptions. Plans at sites K and L may be combined.
K2L2	**8.75**	See K2 and L2 descriptions. Plans at sites K and L may be combined.
M1	**1.61**	Excavate areas near the Soldier Creek and Goose Creek confluence groundwater in an existing upland location. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland shrubs with accompanying native emergent vegetation understory. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation. All native trees should not be removed.
M2	**1.61**	Excavate areas near the Soldier Creek and Goose Creek confluence groundwater in an existing upland location. Seed and plant native hydrophytic emergent vegetation at the lowest elevation. Surround wetland depression with a mixture of native hydrophytic and upland trees with accompanying native emergent vegetation understory. Remove invasive and/or undesirable wetland plants and topsoil on the banks of Little Goose Creek. Replace with native hydrophytic emergent vegetation. All native trees should not be removed.
18 Total Plans		

5.2.2 In-Stream Restoration Alternatives

The purpose of these alternatives is to restore stream and hydraulic function, both in a physical and ecological manner, throughout the project area. In addition, these alternatives may address the need for restoration of in-stream habitat connectivity to provide for fish passage. In-stream habitat structures are intended to provide shelter and habitat for fish and other aquatic organisms as well as help to establish channel bed and bank stability. The city of Sheridan has installed in-stream habitat structures, primarily cross-vanes, on Little Goose Creek and Big Goose Creek upstream of the limits of the flood control project. Based on the success of those structures, additional input from the local experts, and professional judgment of the PDT, a suite of structures was considered for application throughout each project reach.

Most of the alternatives considered at each location are mutually exclusive. However, for Alternative 2, the Corps biologist determined that cross vanes and random boulder clusters could be combined by alternating the features along that reach of Little Goose Creek and it would be beneficial for the in-stream habitat. Similarly, for Alternative 5 the three types of measures were combinable. As a result, these combinations of measures were ran as individual alternatives in CE-ICA.

Alternatives 12A (Newbury rock riffles) and 12B (cross vanes) were eliminated from consideration because restoration of channel sinuosity was carried forward at this location. They were out-competed from a benefit standpoint and not compatible from a constructability standpoint with the restoration of channel sinuosity.

Table 21 shows the in-stream restoration alternative descriptions. The number corresponds to the site location and the letter refers to a variation (i.e. alternative) that is considered at that particular site.

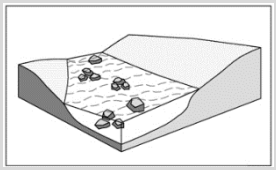
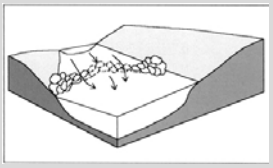
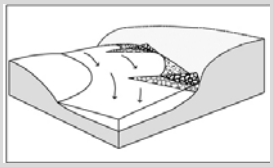
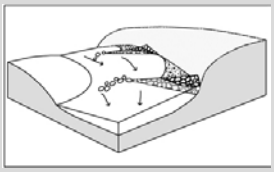
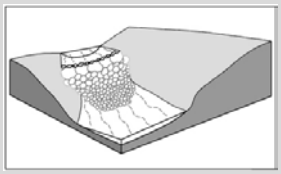
Table 21. In-stream action alternative descriptions

Alternative #	Descriptions
1A	Newbury rock riffles
1B	Cross vanes
1C	Vanes or vanes with J-hooks
2A	Vanes or vanes with J-hooks
2B	Random boulder clusters
2AB	Cross vanes and random boulder clusters
3A	Newbury rock riffles
3B	Cross vanes
4A	Vanes or vanes with J-hooks
5A	Vanes or vanes with J-hooks
5B	Toe revetment
5C	Random boulder clusters
5AB	Vanes and toe revetment
5ABC	Vanes, toe revetment, random boulder clusters
5AC	Vanes, and random boulder clusters
5BC	Toe revetment and random boulder clusters
6A	Cross vanes
6B	Newbury rock riffles
7A	Cross vanes
7B	Newbury rock riffles
8A	Modify concrete chute and restore natural channel
8B	Modify concrete chute and restore natural channel
9A	"W" shaped cross vane at the confluence
10	Modify existing drop structures for fish passage
11A	Newbury rock riffles
11B	Cross vanes
11C	Vanes or vanes with J-hooks
12C	Vanes or vanes with J-hooks
28 Total Plans	

5.2.2.1 *Habitat Structures Descriptions*

For all of the in-stream alternatives, except 8 and 10, the primary restoration technique is in-stream habitat structures. The types of structures considered are described below in Table 22.

Table 22. In-stream habitat structure descriptions

In-stream structure type	Description
Random Boulder Clusters 	Boulder clusters are simple, natural-looking features that add visual diversity and habitat to degraded, uniform reaches. Consequences of failure are generally slight. Natural streams with beds coarser than gravel often feature large roughness elements like boulders that provide hiding cover and velocity shelters for fish and other aquatic organisms. If a constructed or modified channel lacks such features, adding boulder clusters may be an effective and simple way to improve aquatic habitat. They also provide stony substrate for attachment-type macroinvertebrates. If bed material is fine enough for scour to occur, boulders also develop stable pool habitat and physical diversity associated with a range of depths, velocities, and bed material sizes. Boulder clusters can make a relocated or reconstructed channel look more natural and add visual interest to an otherwise uniform view. If desirable, boulder clusters may be configured to trap woody debris and provide additional cover benefits. Boulder clusters provide fish rearing habitat, and areas for adult fish.
Cross Vanes 	Cross vanes are "V"-shaped rock structures stretching across the width of the stream, with the lowest part of the structure being at the vortex of the "V" located at the point farthest upstream. The downstream ends of the "V" are keyed into the streambanks at bankfull elevation. This upstream-pointed shape forms a scour pool inside of the "V." Cross vanes are basically two vanes constructed on opposing banks. Cross vanes are used to provide grade control and enhance aquatic and fisheries habitat. Cross vanes redirect water away from the streambanks, and into the center of the channel. This serves to decrease shear stress on unstable banks, as well as creating aquatic habitat in the scour pools formed by the redirected flow. Cross vanes serve to increase in bank cover due to an increase in water level at the bank above the weir, create holding pools and refuge cover in the scour pool during high and low flows, and create "feeding lanes" for fish at the interface between fast and slow moving water. In addition, cross vanes can contribute to bed stability.
Vanes / Vanes with J-Hooks  	Vanes are redirective, discontinuous, transverse structures angled into the flow in order to reduce local bank erosion by redirecting flow from the near bank to the center of the channel. The in-stream tips of the structures are typically low enough to be overtopped by all flows and crests slope upward to reach bankfull stage elevation at the bank. Vanes with J-Hooks are redirective, discontinuous upstream-pointing transverse stone structures with the tips placed in a downstream-pointing "J" configuration. Tips are partially embedded in the streambed so that they are submerged even during low flows. The structures redirect flows away from unstable streambanks, while enhancing aquatic habitat and physical diversity through creation of scour pools. Vanes and Vanes with J-Hooks decrease velocity, shear stress and stream power adjacent to the bank, and increase them in the center of the channel. Sediment transport competence and capacity are maintained as a result of the increased shear stress and stream power in the center third of the channel, where the J-Hook is located. Backwater occurs adjacent to the bank, encouraging sediment deposition in the near-bank areas, and reducing active bank erosion. Additional environmental benefits of Vanes with J-Hooks include improved benthic habitat, creation or maintenance of pool and riffle habitat, improved fish rearing habitat, and holding areas for adult fish.
Newbury Rock Riffles 	Newbury rock riffles are ramps or low weirs with long aprons made from riprap or small boulders that are constructed at intervals approaching natural riffle spacing (5 to 7 channel widths). The structures are built by placing rock fill within an existing channel. The upstream slope of the rock fill is typically much steeper than the downstream slope, which creates a longitudinal profile quite similar to natural riffles. These structures provide limited grade control, pool and riffle habitat, and visual diversity in otherwise uniform channels.

Source: Transportation Research Board (2005). Environmentally Sensitive Channel and Bank Protection Measures. NCHRP.

5.2.3 Drop Structure Modification Description (Alternative 10)

Restoration of in-stream habitat connectivity to provide for fish passage is important for restoring aquatic health to the system of creeks. The current drop structure does not allow for fish passage for the majority

of species. Alternative 10 is intended to modify the existing structure to improve the migratory pathway connection for fish between Goose Creek and Big Goose Creek. A single variation of Alternative 10 was carried forward for comparison and evaluation. The design of this alternative utilized input from multiple local sources, in addition to experts within the Corps. The WGFD provided guidance that a vertical drop of 0.4 feet would facilitate passage for 90 percent of the fish species expected in the study area. An additional constraint is a steep hill on the left bank (facing downstream) of Big Goose Creek, approximately 1,000 feet upstream of the confluence. The hill is overly steepened and geotechnically unstable. The sponsor has requested that any proposed modifications to the drop structure configurations not encroach upon this area and potentially further the instability.

The result of those constraints is an alternative design consisting of a series of 25 structures on a spacing of 22 feet are proposed with a vertical drop of 0.4 feet each. The new configuration daylights at approximate station 7+50, 150 feet upstream from the current first drop structure. The new configuration is similar in construction to the drops currently present, in that sheetpile cutoff walls surrounded by riprap are used. Spacing between the structures is less than what would typically be recommended due to the constraint to not encroach on the area of instability. Partial removal of the original concrete drop structure will be required as well as removal of the current drop structures. A summary of changes to the current structure and proposed drop structure features is located in Table 23. A plan view of the proposed drop structure is shown in Figure 19. The red lines in the figure represent the proposed new structure in Alternative 10. Drop structure design during the feasibility phase is based on modeling using existing HEC-RAS models. The design will be refined during the design phase, which may result in modifications to the recommendation in this report.

Table 23. Proposed features of new drop structure (Alternative 10)

	Existing Features to be Demoed	New Features to be Constructed
# of Drop structures (0.4' per drop)	4	25
Distance between (ft.)	Varies	22
Width of sheetpile (ft.)	65	65
Driving depth of sheetpile (ft.)	10	10
Sheetpile (sq. ft.) per structure	650	650
Riprap per structure (tons)	300	130

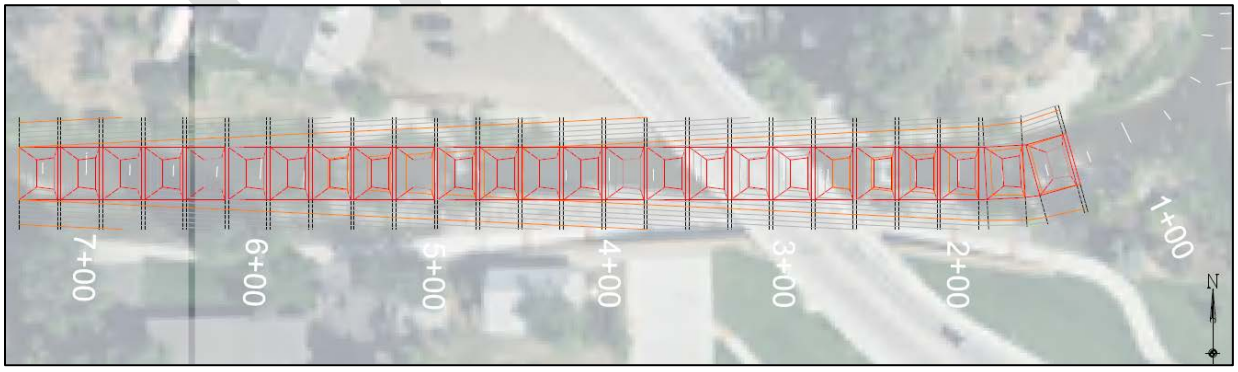


Figure 19. Proposed drop structure configuration plan (Alternative 10)

5.2.4 Downtown Reach Modification Descriptions (Alternative 8)

Restoration of in-stream habitat connectivity to provide for fish passage is important for restoring aquatic health to the system of creeks. The concrete chute in the Downtown Reach provides no habitat value, and its length (approximately 1,200 feet) further reduces the likelihood that desirable or sensitive fish, like trout, could endure navigating its entire length during low flow periods because water depth is too shallow, nor during high flow periods because no cover is available for resting habitat as the chute was designed to efficiently pass water with laminar flow and high velocity. Alternative 8 is intended to modify the existing concrete chute to restore the migratory pathway connection for fish between Goose Creek and Little Goose Creek and to convert the chute to a more natural low flow channel condition.

There are multiple design challenges with modifying the concrete chute to provide a more natural low flow channel to allow for fish passage. Design challenges with this alternative include:

- Conversion of the concrete base to a natural substrate results in a large change in channel roughness.
- Due to the change in channel roughness, additional conveyance area is required to maintain current level of flood protection and avoid violating that planning constraint. Removal of 1st Street, Dow Street, or portions of both will be required.
- Roads and bridges adjacent to the flood risk management project will be impacted and in some cases require reconstruction. The city has expressed willingness to remove and not replace Gould Street Bridge but the other three bridges will require lengthening to account for the widened flood conveyance area.
- Sufficient real estate will need to be acquired for the upstream and downstream transitions into the new chute. In particular at the upstream end, the increase in hydraulic head resulting from removal of the concrete will require a wider transition.
- Locations of utilities are not fully know, which results in an underestimation of costs.

Two variations of Alternative 8 (8A and 8B) are described here, even though multiple configurations were analyzed. The primary constraint of not affecting the current level of flood protection in the area is the main factor affecting the design of these alternatives. Additional information on the engineering analysis that was conducted for this alternative is available in Appendix F (Structural Engineering) and Appendix C (Hydraulic Engineering).

Alternative 8A

Alternative 8A involves removing the chute between 1st Street and Dow Street. The required width to convey flood flows at the current level of protection is assumed to be about 90 feet. Dow Street will remain a two lane road and 1st Street will be removed. A new retaining wall will be placed along Dow Street on the north side where 1st Street is currently located. This alternative includes replacing all of the bridges in order to lengthen them, although the city of Sheridan has indicated that the Gould Street bridge does not need to be replaced. The plan view of this showing the footprint of this alternative in comparison to the footprint of the existing concrete chute is shown in Figure 20. Figure 21 shows the existing condition cross-section of the concrete chute and Figure 22 shows the cross-section of this alternative.

Alternative 8B

Alternative 8B involves removing the chute between 1st Street and Dow Street. A new retaining wall with a box culvert attached will be placed along Dow Street. The box culvert will carry flood flows during high flow events and allow for a sloped transition on the north side. A sloped transition on the north side will eliminate the need for constructing a new retaining wall. Because of the width of the retaining wall

and availability of space, this concept would have a new two lane road along Dow Street and would remove the road along 1st Street. This alternative includes replacing all of the bridges in order to lengthen them, although the city of Sheridan has indicated that the Gould Street bridge does not need to be replaced. The plan view of this showing the footprint of this alternative in comparison to the footprint of the existing concrete chute is shown in Figure 20. Figure 21 shows the existing condition cross-section of the concrete chute and Figure 23 shows the cross-section of this alternative.

Conclusions

The conclusions of the analysis of Alternative 8 are as follows:

- A narrower, deeper low flow channel for fish passage is constructible but requires removal of the entire base of the concrete chute. Removal of a narrow portion of the concrete in the middle of the channel would lower the existing channel invert, and eventually silt in, and was not an effective option.
- The existing development in downtown Sheridan creates a massive design challenge related to formulation of this alternative within the design constraint that requires maintaining the current levels of flood protection.
    - The sponsor stated a willingness to remove 1st Street to accommodate alternatives. Hydraulic modelling evaluation indicated that all of that real estate will be necessary to maintain current levels of flood protection.
    - At the upstream end of the flood control channel, east of Broadway Street, a real estate parcel on the left bank (facing downstream) of the river will be required to accommodate increased hydraulic stages resulting from removal of the concrete transition.
    - Slight modification to the channel downstream of the existing concrete chute is required to maintain flood control stages.
    - While Alternatives 8A and 8B can be configured to maintain the current levels of flood protection, additional hydraulic modelling will be required, particularly upstream of Broadway Street.
- All alternatives will require the removal or replacement of the current bridges in the reach.
- Costs of Alternatives 8A and 8B are currently estimated to be over $20 million. These current cost estimates are likely underestimating the true costs because of the remaining hydraulic modeling needs and associated project features.

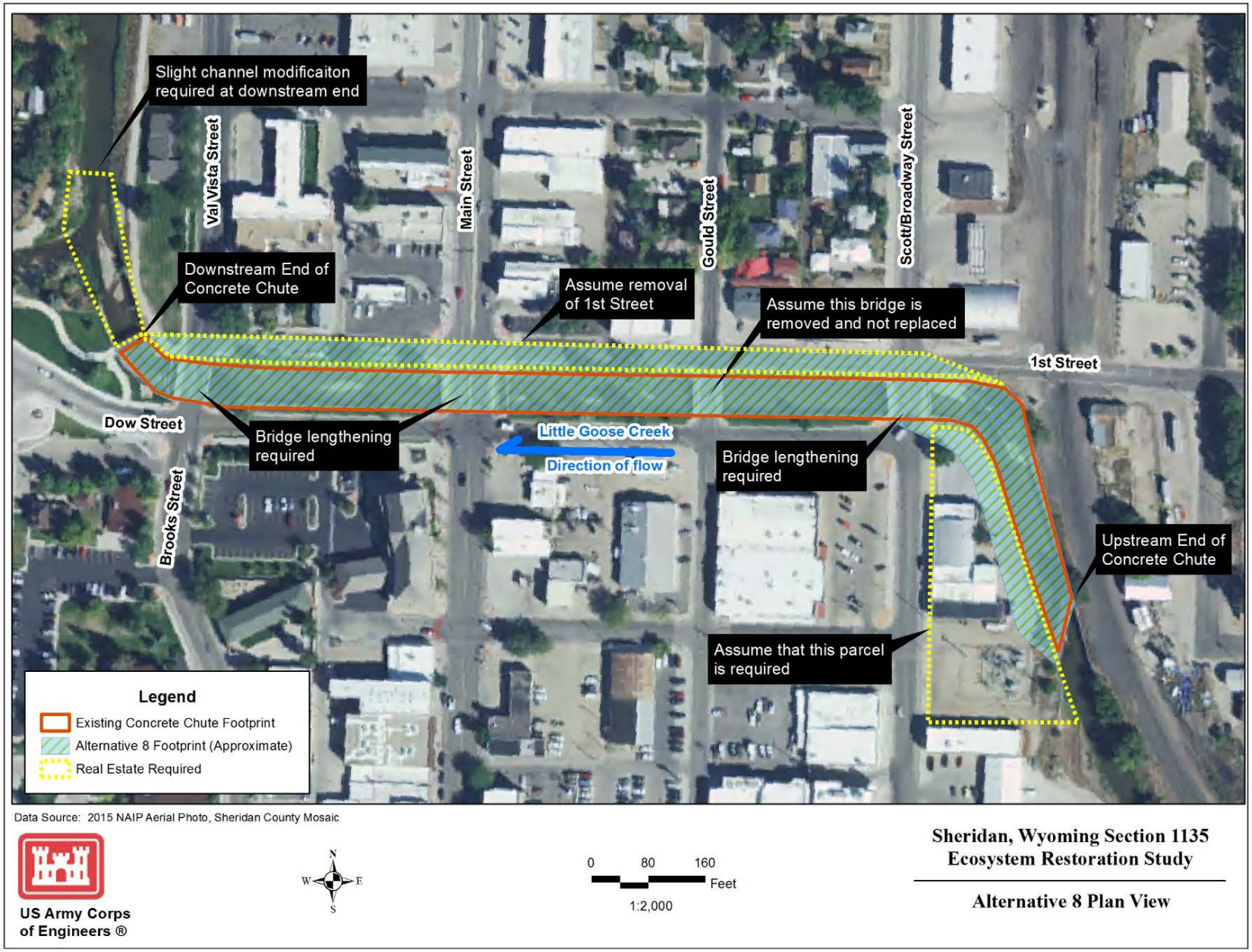


Figure 20. Alternative 8 plan view

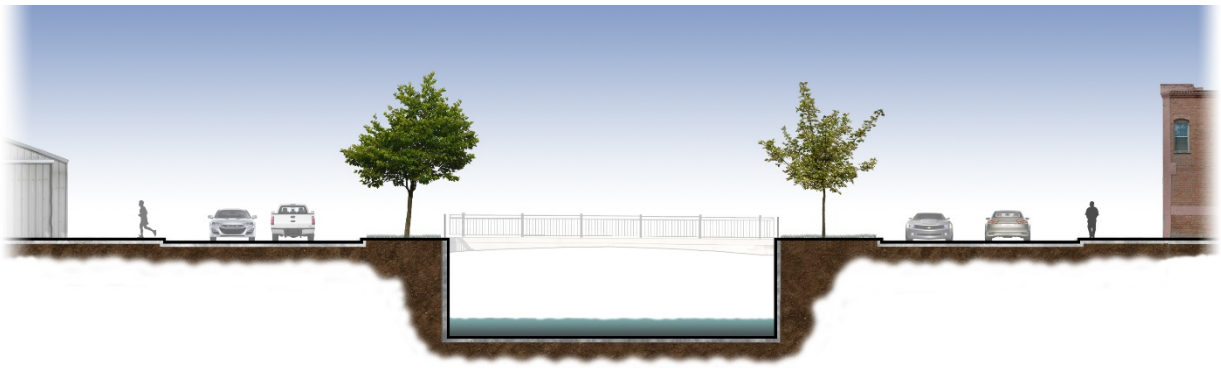


Figure 21. Existing conditions cross-section of concrete chute

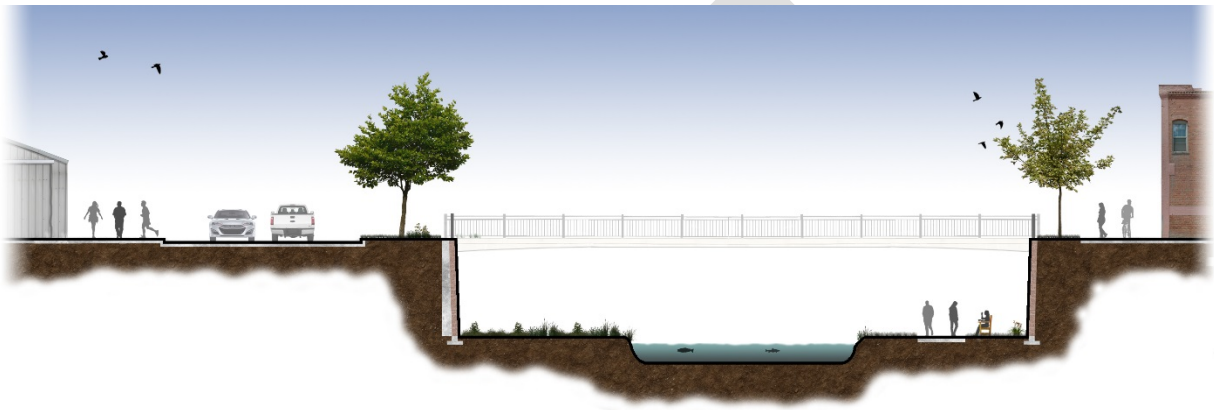


Figure 22. Alternative 8A cross-section of concrete chute

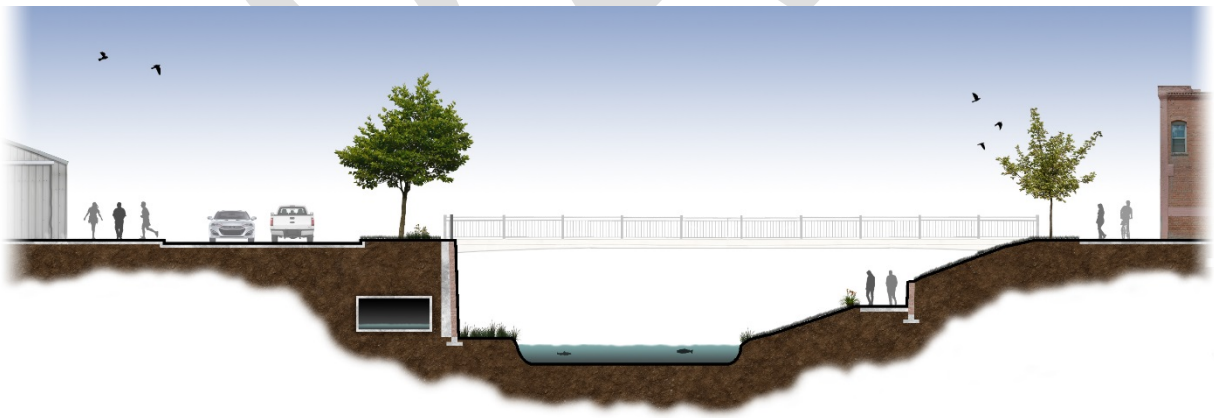


Figure 23. Alternative 8B cross-section of concrete chute

5.3 Benefits of Ecosystem Restoration Alternatives

A total of 46 alternatives were carried forward for evaluation using HSI models (18 riparian alternatives and 28 in-stream alternatives were evaluated). Ecosystem restoration benefits are based on the results of the Habitat Evaluation Procedures (HEP) analysis and the restoration area footprint for each alternative plan. The alternatives were evaluated using HEP developed by USFWS. These models multiply the area of habitat by its quality, to provide a HU. The habitat quality is calculated using HSI models, for one or more indicator species. The with-project HSI model results for the alternatives are located in Appendix A6. For this study, mink, yellow warbler, brown thrasher and the brown trout were the riparian and

aquatic indicator species chosen, in cooperation with state agencies and local experts, as these species needs include the desired federally significant wetlands and migratory bird habitat; and HSI models were available for these species. HSI models for these species are approved by USACE.

For each future-without project and future-with project alternative, the average of two species-specific HUs for each target year (years 0, 1, 10, 25, and 50) were entered into the NER Outputs calculator in the IWR-Planning Suite (Version 2.0.6.0), decision support software. The IWR Planning Suite calculator determined the gross AAHUs over the 50-year period using linear interpolation. The net AAHUs for each alternative consist of a positive number, and the net AAHUs for the no action alternative equal zero.

Table 24 presents the net increase in AAHU's for riparian alternatives. Alternatives K and L are located on the same parcel of land and it was assumed that the entire parcel of land would be required for implementation of either K or L. In order to prevent double counting the real estate costs in CE-ICA, the four combinations of K and L were combined and run as four alternatives in model as shown below (K1L1, K2L1, K1L2, and K2L2).

Table 24. Habitat unit outputs of riparian alternatives

Alternative	Size of Site (acres)	Average Annual Habitat Unit for No Action	AAHU for Action Alternative	Net AAHU of the Action Alternative
A1	0.32	0.050	0.170	0.120
A2	0.32	0.050	0.168	0.118
B1	1.28	0.142	0.665	0.523
B2	1.28	0.142	0.815	0.673
C1	0.36	0.023	0.079	0.056
C2	0.36	0.023	0.162	0.139
F1	1.1	0.074	0.609	0.535
F2	0.54	0.036	0.274	0.238
K1L1*	8.75	1.220	5.371	4.151
K2L1*	8.75	1.220	4.937	3.717
K1L2*	9.53	1.275	4.986	3.711
K2L2*	9.53	1.275	4.552	3.277
M1	1.65	0.150	0.890	0.740
M2	1.61	0.148	0.880	0.732
K1*	5.53	1.034	3.408	2.374
K2*	5.53	1.034	2.974	1.940
L1*	3.22	0.186	1.963	1.777
L2*	4	0.241	1.577	1.336

*Alternatives K and L are additive, meaning they may be combined

Tables 25 presents the net increase in AAHU's for in-stream alternatives. Since Alternatives 2A and 2B are not mutually exclusive, the combination of the two (Alternative 2AB) was ran as another alternative in the model, which also prevented double counting real estate costs. Similarly, Alternatives 5A, 5B, and 5C are not mutually exclusive. The possible combinations of the three (Alternatives 5AB, 5ABC, 5AC, and 5BC) were ran in CE-ICA as separate alternatives in the model, which also prevented double counting real estate costs.

Table 25. Habitat unit outputs of in-stream alternatives

Alternative	Size of Site (acres)	Average Annual Habitat Unit for No Action	Average Annual Habitat Unit for Action Alternative	Net Average Annual Habitat Unit of the Action Alternative
1A	1.10	0.220	0.911	0.691
1B	0.55	0.110	0.313	0.203
1C	0.58	0.116	0.298	0.182
2A	0.55	0.110	0.278	0.168
2B	0.55	0.110	0.169	0.059
2AB	0.55	0.110	0.337	0.227
3A	0.14	0.028	0.116	0.089
3B	0.09	0.018	0.048	0.030
4A	0.19	0.039	0.101	0.062
5A	0.48	0.096	0.247	0.151
5B	0.48	0.096	0.146	0.049
5C	0.48	0.096	0.146	0.049
5AB	0.48	0.096	0.297	0.200
5ABC	0.72	0.096	0.735	0.639
5AC	0.72	0.145	0.734	0.589
5BC	0.48	0.096	0.195	0.099
6A	0.83	0.166	0.475	0.309
6B	1.31	0.263	1.089	0.826
7A	0.55	0.110	0.314	0.204
7B	1.04	0.208	0.862	0.654
8A	1.45	0	3.084	3.084
8B	1.45	0	3.084	3.084
9A	0.31	0	0.135	0.135
10A	0.41	0	1.789	1.789
11A	5.47	0	2.437	2.437
11B	5.47	0	2.437	2.437
11C	5.47	0	2.437	2.437
12C	5.01	0	3.238	3.238

5.4 Costs of Ecosystem Restoration Alternatives

Implementation costs for each alternative were developed for riparian and in-stream alternatives and are shown in Tables 26 and 27, respectively. All costs are estimated at FY17 price levels. Estimated costs include construction costs, value of land interests required, real estate administrative costs, construction engineering and design, construction management (supervision and administration), and contingencies. These costs were estimated by Corps cost engineers using M-CACES (MII, TRACES) software. Additional information on cost is located in Appendix G (Cost Engineering), Appendix F (Structural Engineering), and Appendix B (Geotechnical).

Construction was assumed to occur over six quarter years for a 1.5-year construction period. Real estate costs and preparation of plans and specifications are expected to occur in the first and second quarter. It was estimated that 20 percent of construction costs would occur in each of the first four quarters and 10 percent of construction costs would occur in each of the fourth and fifth quarters. Interest during construction (IDC) is included as part of the economic "first costs" of the project. The cost of IDC was calculated using the FY17 discount rate of 2.875 percent in the Corps-certified IDC calculator within IWR Planning Suite, decision support software.

Real estate costs are feasibility level estimates. The estimated costs of each plan include the value of land interests required by the specific alternative, including a 20-percent contingency. These costs were estimated on a per-acre basis by the Corps real estate specialist. In addition, the Corps real estate specialist estimated the federal and non-federal administrative and legal costs involved in acquiring real estate interests, determining their fair market value, etc. These costs were converted to cost per acre before being applied to each alternative. The construction costs also included markups of 18 percent for engineering and design and 14 percent for construction management (supervision and administration), and an overall construction contingency of 38 percent. The contingencies were developed by performing a cost and schedule risk analysis in accordance with Corps policy for civil works studies.

The sponsor is expected to perform inspections after completion of construction. The project biologist estimated expenditures for inspection and for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) for each riparian alternative including costs per acre for management of noxious weeds and invasive species. OMRR&R costs for in-stream alternatives were collaboratively estimated by the engineering and biologist team members. Inspection costs were present-valued and amortized over 50 years based on the FY17 discount rate of 2.875 percent. For each potential plan component, the annualized costs for inspection were added to the annualized "first costs" and the annual cost of OMRR&R to form the average annual (AA) cost.

In order to compare costs with AA environmental outputs, it is necessary to convert all project costs to AA costs. The AA costs for each plan were calculated by estimating the present value of the stream of costs and then amortizing the costs over the 50-year period of analysis (using a FY17 discount rate of 2.875 percent). Additional details on the costs are available in Appendix G.

Table 26. Riparian alternative implementation costs ($)

Site Plans	Total Construction Cost [1]	Real Estate Land & Easement Costs	IDC (1.5 years, 2.875%)	Total Project Cost	Annualized First Costs	Annual Costs [2]		Total Average Annual Cost
						Monitoring (Years 1,3,5)	O&M	
A1	13,267	5,586	461	19,315	733	176	194	946
A2	25,352	5,586	757	31,695	1,203	176	745	1,966
B1	50,239	27,229	1,895	79,363	3,012	704	177	3,263
B2	55,473	27,229	2,023	84,724	3,215	704	324	3,613
C1	18,860	14,679	820	34,359	1,304	197	81	1,406
C2	24,216	14,679	951	39,846	1,512	197	202	1,734
F1	66,878	24,256	2,229	93,363	3,543	605	224	3,831
F2	32,493	24,256	1,388	58,136	2,206	297	457	2,695
K1L1	785,141	300,319	26,546	1,112,006	42,199	5,346	3,024	45,782
K2L1	768,539	300,319	26,140	1,094,998	41,553	5,346	4,019	46,131
K1L2	740,533	300,319	25,455	1,066,307	40,464	5,775	5,121	46,190
K2L2	723,930	300,319	25,049	1,049,298	39,819	5,775	6,116	46,540
M1	54,049	34,913	2,176	91,137	3,458	908	217	3,771
M2	80,987	34,913	2,834	118,735	4,506	908	170	4,771
K1	426,832	300,319	17,783	744,934	28,269	3,575	914	29,501
K2	410,230	300,319	17,377	727,926	27,623	3,575	1,909	29,850
L1	358,309	300,319	16,107	674,735	25,605	1,771	2,110	27,900
L2	313,700	300,319	15,016	629,036	23,871	2,200	4,207	28,308

[1] Total Construction Cost Includes Construction, Engineering & Design, Supervision & Administration, and Contingency Costs.
[2] The annual costs were annualized using FY2017 discount rate of 2.875% over 50 years.

Table 27. In-stream alternative implementation costs ($)

Site Plans	Total Construction Cost [1]	Real Estate Land & Easement Costs	IDC for 1.5 Yr, 2.875%	Total Project Cost	Annualized First Costs	Annual Costs [2]	Total Average Annual Cost
						O&M	
1A	78,775	21,640	2,456	102,870	3,904	3,029	6,932
1B	63,105	21,640	2,073	86,817	3,295	2,411	5,705
1C	46,891	21,640	1,676	70,207	2,664	1,762	4,426
2A	25,905	4,190	736	30,831	1,170	975	2,145
2B	14,871	4,190	466	19,528	741	-	741
2AB	40,776	4,190	1,202	46,168	1,752	555	2,307
3A	11,022	23,984	1,437	36,443	1,383	420	2,705
3B	12,383	23,984	889	37,256	1,414	476	1,890
4A	16,711	3,664	498	20,874	792	628	1,420
5A	32,641	5,928	943	39,512	1,499	1,219	2,718
5B	152,553	5,928	1,775	160,256	6,081	6,026	11,815
5C	6,864	5,928	313	13,105	497	-	497
5AB	185,194	5,928	2,573	193,695	7,350	7,245	11,335
5ABC	192,058	5,928	2,741	200,727	7,617	7,245	11,602
5AC	39,505	5,928	1,111	46,544	1,766	1,219	2,985
5BC	159,417	5,928	1,943	167,287	6,348	6,026	9,114
6A	91,501	11,391	2,516	105,408	4,000	3,490	7,490
6B	86,703	11,391	2,399	100,493	3,814	3,285	6,169
7A	60,953	7,249	1,668	69,870	2,651	2,324	4,976
7B	95,990	7,249	2,525	105,763	4,014	3,717	7,731
8A	22,261,822	257,907	550,742	23,070,472	875,480	8,609	884,089
8B	23,240,267	257,907	574,671	24,072,846	913,518	8,609	922,127
9A	20,010	13,941	830	34,781	1,320	780	2,100
10A	1,799,994	76,456	45,890	1,922,340	72,949	21,064	94,013
11A	140,343	35,454	4,299	180,096	6,834	5,481	12,315
11B	138,908	35,454	4,264	178,626	6,779	5,424	12,202
11C	109,200	35,454	3,538	148,192	5,624	4,174	9,798
12C	522,555	23,741	13,360	559,656	21,238	20,780	42,018

[1] Total Construction Cost Includes Construction, Engineering & Design, Supervision & Administration, and Contingency Costs.
[2] The annual costs were annualized using FY2017 discount rate of 2.875% over 50 years.

5.5 Evaluation and Comparison of Alternatives

5.5.1 Incremental Analyses and Selection of the Final Plan

Cost effectiveness analysis is conducted to ensure that the least cost solution is identified for various levels of environmental output. Its purpose is to eliminate inefficient alternatives, based on comparing average annual environmental outputs with the average annual cost of an alternative. The IWR Planning

Suite software program (IWR-PLAN) classifies a plan as cost effective if no other plan provides the same level of output for less cost and if no other plan provides more output for the same or less cost.

5.5.2 Cost-Effective and Incremental Cost Analysis of Individual Alternatives

Incremental cost analysis is conducted to show changes in costs for increasing levels of environmental outputs. It provides data for decision-makers to address the question: "Is the next level worth it?" It measures the incremental or additional cost of the next additional level of environmental output. IWR-Plan identifies the subset of a scenario's cost effective plans that are superior financial investments as 'best buys". Best buys are the most efficient plans at producing the output variable; they provide the greatest increase in the value of the output parameter for the least increase in the value of the cost parameter. The first best buy is the most efficient plan, producing output at the lowest incremental cost per unit. If a higher level of output is desired than that provided by the first best-buy, the second best buy is added as long as the recommended benefits are greater than the incremental costs, and so on.

5.5.3 No Action Alternative

The No Action alternative is and always considered as a baseline for comparison of other alternatives and also fulfills a requirement of NEPA. The Corps of Engineers planning process also refers to this as the future without project condition. Under this alternative, the system of creeks in Sheridan continues to have impaired ecosystem processes which has resulted in degradation of the quality of aquatic stream habitat, floodplain habitats, and has significantly impaired migratory pathways for fish. Biological and physical ecosystem processes that remain degraded due to loss of channel depth diversity and riffle pool sequences, channel incising, altered hydrologic processes between the creek and the floodplain, and loss of woody debris and natural channel substrate. Degraded native riparian plant communities adjacent to the creek and degraded aquatic plant communities in the channel will continue to impair both biological and chemical ecosystem processes. Increased water temperatures, lack of DO, altered pH and nitrogen levels, and loss of habitat connectivity and migratory fish pathways will continue to impact fish and prevent healthy fish communities from becoming established in the Section 1135 project area.

5.5.4 Cost Effectiveness and Incremental Cost Analysis of Individual Alternatives

Incremental cost analysis is conducted to show changes in costs for increasing levels of environmental outputs. It provides data for decision-makers to address the question "Is the next level worth it?" It measures the incremental or additional cost of the next additional level of environmental output. IWR-Plan identifies the subset of a scenario's cost effective plans that are superior financial investments as 'best buys". Best buys are the most efficient plans at producing the output variable; they provide the greatest increase in the value of the output parameter for the least increase in the value of the cost parameter. The first best buy is the most efficient plan, producing output at the lowest incremental cost per unit. If a higher level of output is desired than that provided by the first best-buy, the second best buy is added as long as the recommended benefits are greater than the incremental costs, and so on.

The riparian and in-stream plans identified in the previous iterations of IWR Plan were input into a combined IWR Plan model generating 589,824 total plans. Out of the 589,824 plans, 584 plans were cost effective and 19 were identified as best buy plans. The alternatives and inputs used in IWR Plan are shown in Table 28. These plans were used to generate combined riparian and in-stream plans. A cost-effective analysis was completed on the combined plans, represented in the scatter plan shown in Appendix A6.

Table 28. Riparian and in-stream combined best buy alternatives

Most Efficient Alternatives					
In-Stream	**AA Cost ($)**	**AA Output (HU)**	**Riparian**	**AA Cost ($)**	**AA Output (HU)**
1A	$6,932	0.69	A1	$946	0.12
2AB	$2,307	0.23	B2	$3,613	0.67
3A	$2,705	0.09	C2	$1,734	0.14
4A	$1,420	0.06	F1	$3,831	0.53
5ABC	$11,602	0.64	K1L1	$45,782	4.15
5AC	$2,985	0.59	M1	$3,771	0.74
6B	$6,169	0.83			
7B	$7,731	0.65			
8A	$884,089	3.08			
9A	$2,100	0.14			
10	$94,013	1.79			
11C	$9,798	2.44			
12C	$42,018	3.24			

CE-ICA was conducted on the best buy plans to evaluate the changes in costs as levels of AAHUs increase. CE-ICA measures the incremental or additional cost of the next additional level of environmental output and is typically one of the last steps during the plan selection process.

Table 29 summarizes the net gains in AA environmental outputs (functional units), AA costs, and the AA cost per environmental output for each plan. As shown, for each plan the AA cost per environmental output is associated with the number of environmental outputs gained by the addition of an alternative. Note that the base condition is listed first (the No Action alternative), and the AA environmental outputs represent the net gain over the No Action alternative. In-stream and riparian alternatives are both included in this table, and the added alternative in each row is highlighted in bold text.

Table 29. Average annual habitat outputs, average annual costs, and average annual cost per environmental output

Plan #	In-Stream Alternatives[1]	Riparian Alternatives[1]	Net AAHU Outputs	AA Cost	Inc. Cost Per Output	Total Cost[2]
1	No Action	No Action	0.00	$0	$0	$0
2	**11C**	-	2.44	$9,798	$4,021	$340,794
3	**5AC**, 11C	-	3.03	$12,483	$4,558	$434,186
4	5AC, 11C	**M1**	3.76	$16,253	$5,107	$565,335
5	5AC, 11C	**B2**, M1	4.44	$19,866	$5,369	$691,006
6	5AC, 11C	B2, **F1**, M1	4.97	$23,697	$7,162	$824,248
7	5AC, **6B**, 11C	B2, F1, M1	5.80	$29,866	$7,464	$1,038,816
8	5AC, 6B, 11C	**A1**, B2, F1, M1	5.92	$30,811	$7,899	$1,071,703
9	**1A**, 5AC, 6B, 11C	A1, B2, F1, M1	6.61	$37,744	$10,026	$1,312,828
10	1A, **2AB**, 5AC, 6B, 11C	A1, B2, F1, M1	6.84	$40,051	$10,160	$1,393,062
11	1A, 2AB, 5AC, 6B, 11C	A1, B2, F1, **K1L1**, M1	10.99	$85,832	$11,029	$2,985,467
12	1A, 2AB, 5AC, 6B, **7B**, 11C	A1, B2, F1, K1L1, M1	11.64	$93,563	$11,812	$3,254,362
13	1A, 2AB, 5AC, 6B, 7B, 11C	A1, B2, **C2**, F1, K1L1, M1	11.78	$95,297	$12,487	$3,314,683
14	1A, 2AB, 5AC, 6B, 7B, 11C, **12C**	A1, B2, C2, F1, K1L1, M1	15.02	$137,315	$12,977	$4,776,167
15	1A, 2AB, 5AC, 6B, 7B, **9A**, 11C, 12C	A1, B2, C2, F1, K1L1, M1	15.15	$139,415	$15,534	$4,849,207
16	1A, 2AB, **4A**, 5AC, 6B, 7B, 9A, 11C, 12C	A1, B2, C2, F1, K1L1, M1	15.22	$140,834	$22,815	$4,898,590
17	1A, 2AB, **3A**, 4A, 5AC, 6B, 7B, 9A, 11C, 12C	A1, B2, C2, F1, K1L1, M1	15.30	$143,539	$30,530	$4,992,676
18	1A, 2AB, 3A, 4A, 5AC, 6B, 7B, 9A, **10A**, 11C, 12C	A1, B2, C2, F1, K1L1, M1	17.09	$237,552	$52,549	$8,262,684
19	1A, 2AB, 3A, 4A, **5ABC**, 6B, 7B, 9A, 10A, 11C, 12C	A1, B2, C2, F1, K1L1, M1	17.14	$246,469	$180,579	$8,572,840
20	1A, 2AB, 3A, 4A, 5ABC, 6B, 7B, **8A**, 9A, 10A, 11C, 12C	A1, B2, C2, F1, K1L1, M1	20.23	$1,130,558	$286,651	$39,323,773

1 – The bold alternative is the alternative added or modified in each plan.
2 – Cost includes implementation costs and operation and maintenance using the discount rate over a 50-year period.

Table 30 shows the description of the added alternative to each of plans 1 – 20, the incremental HU output, the incremental cost, and the incremental cost per HU for each plan. It also provides the justification for each added increment. Any of the plans 1 – 18 (including *"No Action"*) would meet the criteria of being cost-effective and incrementally justified. Plan 18 addresses ecosystem problems discussed in Chapter 2 and meets study objectives which address those problems. The incremental cost per HU for Plan 18 is $52,549/HU and is associated with adding an in-stream drop structure that improves fish passage and stream connectivity. This connectivity and fish passage provide significant benefit to improving the stream and related environment both within the study area and beyond, therefore Plan 18 and increment site plan 10 are justified for inclusion. Alternatives 19 and 20 are not incrementally justified due to the high cost per unit of habitat output. The significant added cost of plans 19 and 20 per unit of habitat compared to plans 1 – 18 make them inefficient from a cost standpoint.

Table 30. Evaluation of plans

Plan #	Added Best Buy Increment to Plan	Description of Increment Added	Incremental Output (HU)	Incremental Cost ($)	Incremental Cost per Output ($)	Justification
1	No Action	See Section 5.5.3.	0	$0	$0	Any of Plans 1 - 18 (including "no action") would meet the criteria of being cost-effective and incrementally justified. As shown, the cost for each unit of habitat output increases gradually from Plans 1 - 18.
2	11C	In-stream: Construct vanes as in-channel habitats.	2.44	$9,798	$4,021	
3	5AC	In-stream: Construct vanes and random boulder clusters as in-channel habitats.	0.59	$2,685	$4,558	
4	M1	Riparian: Excavate areas and restore wetland hydrology and plant native emergent wetland vegetation. Plant upland/wetland buffer. Remove invasives.	0.73	$3,770	$5,107	
5	B2	Riparian: Excavate areas and restore wetland hydrology and plant native emergent wetland vegetation. Plant upland/wetland buffer to the north and west of the emergent wetland. Remove invasives.	0.68	$3,613	$5,369	
6	F1	Riparian: Excavate, restore wetland hydrology, and plant native emergent wetland species in park area. Reconstruct the new setback levee to bind the eastern portion of the project area. Remove invasives.	0.53	$3,831	$7,162	
7	6B	In-stream: Construct Newbury rock riffles as in-channel habitats.	0.83	$6,169	$7,464	
8	A1	Riparian: Excavate areas and restore wetland hydrology and plant native emergent wetland vegetation. Plant upland/wetland buffer. Remove invasives.	0.12	$945	$7,899	
9	1A	In-Stream: Construct Newbury rock riffles as in-channel habitats.	0.69	$6,933	$10,026	
10	2AB	In-Stream: Construct vanes and random boulder clusters as in-channel habitats.	0.23	$2,307	$10,160	
11	K1L1	Riparian: Restore connectivity between Goose Creek and an oxbow by realigning the channel on south half (K1). Realign channel east of existing creek by reconstructing the new setback levee on north half (L1). Plant wetland species on inside bends. Fill existing channel to elevation that would receive periodic overflow from Goose Creek. Plant emergent wetland species in the overflow channel. Plant wetland/upland buffer and remove invasive species.	4.15	$45,781	$11,029	
12	7B	In-stream: Construct Newbury rock riffles as in-channel habitats.	0.65	$7,731	$11,812	
13	C2	Riparian: Excavate areas and improve wetland hydrology and plant native emergent wetland vegetation on the floodplain bench.	0.14	$1,734	$12,487	
14	12C	In-stream: Construct vanes as in-channel habitats.	3.24	$42,018	$12,977	
15	9A	In-stream: Construct a "W" shaped cross vane at the confluence as in-channel habitat.	0.13	$2,100	$15,534	
16	4A	In-stream: Construct vanes as in-channel habitats.	0.07	$1,419	$22,815	
17	3A	In-stream: Construct Newbury rock riffles as in-channel habitat.	0.08	$2,705	$30,530	
18	10	In-stream: Modify drop structures for fish passage.	1.79	$94,013	$52,549	

19	5ABC	In-stream: Construct a toe revetment (added to 5AC) for in-channel habitat.	0.05	$8,917	$180,579	These two plans are not cost-effective and not justified due to the high cost per unit of habitat output. The significant added cost per unit of habitat compared to plans 1 - 18 make these plans inefficient from a cost standpoint.
20	8A	In-stream: Modify concrete chute and restore natural channel in downtown reach.	3.09	$884,089	$286,651	

The No Action alternative is always an alternative that is considered, is a baseline for comparison of other alternatives, and also fulfills a requirement of NEPA. No action for this study is eliminated because it does not address the ecosystem problems or meet stud objectives.

Figures 24 and 25 show the 19 best buy plans graphically by showing the AAHU output on the x-axis and the incremental cost of each HU output on the y-axis. Based on these analyses and using the graphics provided below, the tentatively selected NER plan is plan 18, which is circled in red on each figure. Based on the amount of environmental benefits and costs to achieve those benefits, plan 18 is the NER Plan. The AA incremental cost per unit of habitat is $52,549, and would add site alternative 10 which includes modifying a drop structure to ensure fish passage and stream connectivity. Alternative 10 and Plan 18 is identified as incrementally justified because of the passage and connectivity it adds to the project. Alternative 5AC is shown as recommended, however Alternative 5ABC is not recommended. This is because the added increment of Alternative 5B is comparatively expensive at an incremental cost of $180,579/HU with minimal habitat benefit. Alternative 5B is a toe revetment, which is expensive and does not result in significant habitat benefits. Alternative 8A is not recommended due to cost. While there are significant benefits to restoring the downtown reach, the costs of this alternative exceed the cost limits of the Section 1135 program.

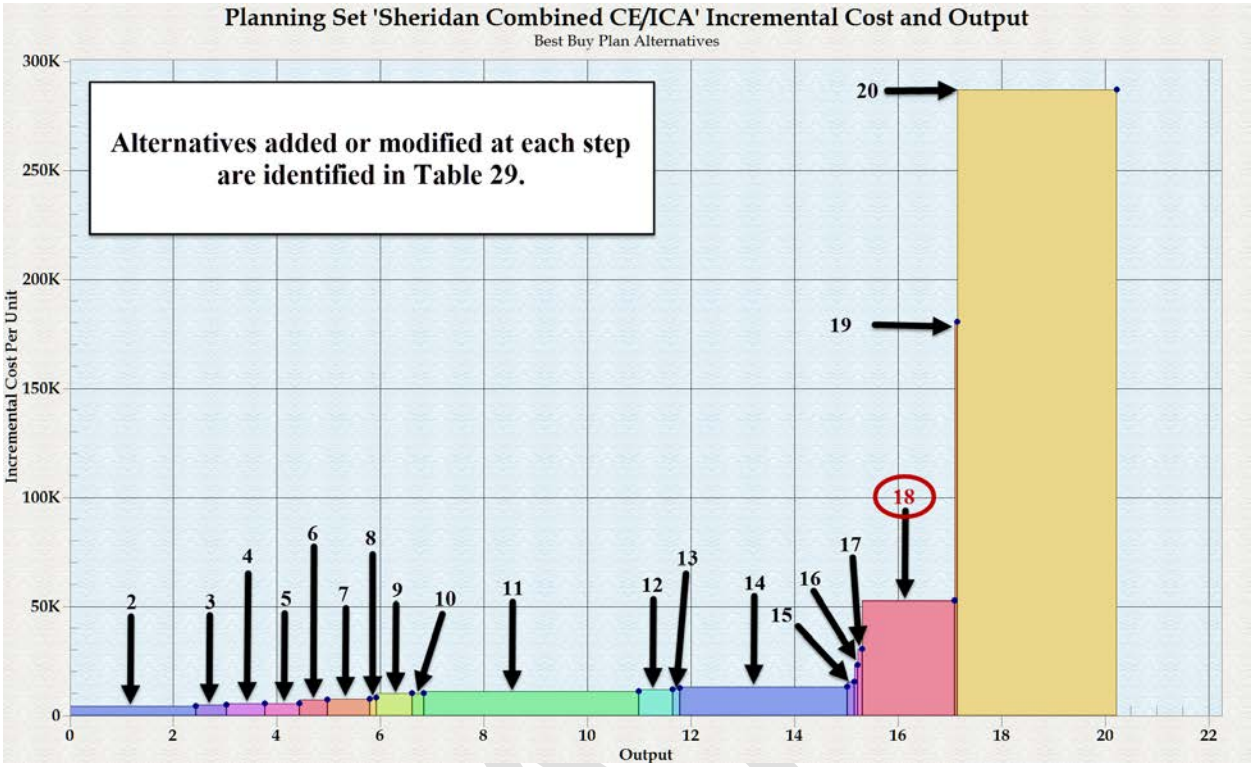


Figure 24. Cost-effective / incremental cost analysis

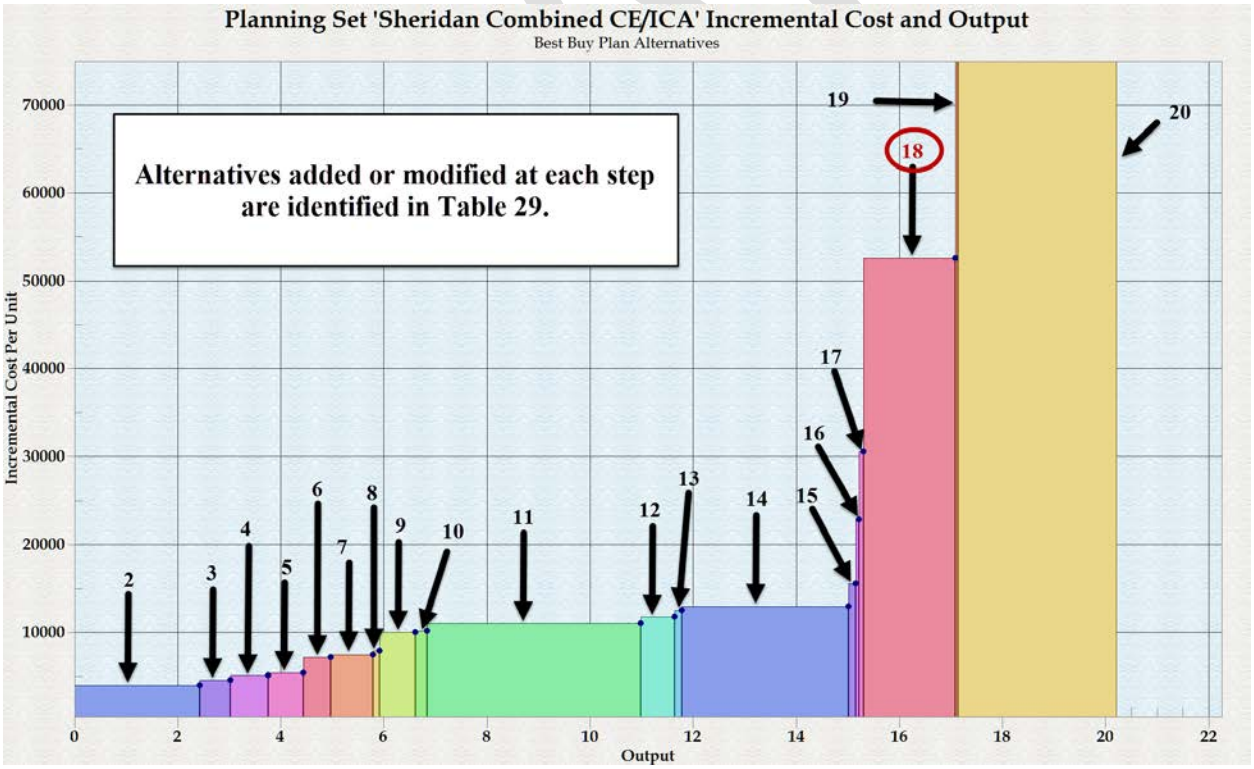


Figure 25. Cost-effective / incremental cost analysis (zoomed in)

Table 31 shows the acres of PEM and PSS wetlands in the project area resulting from the NER Plan, as well as the resulting amount of native upland habitat that results. Table 32 shows the amount of in-stream habitat that is improved as a result of the NER Plan.

Table 31. NER Plan riparian wetland and native upland habitat benefits

	Emergent Wetlands		Scrub-shrub Wetlands		Native Grasslands	
Alt. #	**Without Project Area (acres)**	**With-Project Area (acres)**	**Without Project Area (acres)**	**With-Project Area (acres)**	**Without Project Area (acres)**	**With-Project Area (acres)**
A1	0	0.89	0	0.23	0	0
B2	0.01	0.56	0	0.71	0	0
C2	0	0.3	0	0.06	0	0
F1	0.05	0.57	0	0.3	0	0.23
K1L1	1	2.8	0	5.61	0	0.34
M1	0.03	0.8	0	0.85	0	0
Total	**1.09**	**5.92**	**0**	**7.76**	**0**	**0.57**

Table 32. NER Plan in-stream habitat increases

Alt. #	Without Project Length of Low Quality Stream Channel (feet)	With-Project Restored Length of Stream Channel (feet)	Total Area of Restored Channel (acres)
1A	1,594	1,594	1.09
2AB	800	800	0.55
3A	200	200	0.14
4A	282	282	0.19
5AC	1,050	1,050	0.72
6B	1,900	1,900	1.31
7B	1,500	1,500	1.04
9A	260	260	0.31
10	510	510	3.61*
11C	3,970	3,970	5.47
12C	2,815	3,660	5.04
Total	**14,881**	**15,726**	**15.86**

*Note: The acreage footprint made accessible by passage improvements is included in the benefit calculation, as discussed in Section 3.14.1.

In Corps feasibility studies, alternative plans are formulated within the context of considering four fundamental planning criteria: *completeness*, *effectiveness*, *efficiency* and *acceptability*. Table 33 shows a comparison of the NER Plan and the no action alternative against the four planning criteria.

- *Effectiveness* is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- *Efficiency* is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
- *Completeness* is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.

- *Acceptability* is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations and public policies.

Table 33. Comparison of plans to planning criteria, objectives, and constraints

Plans	Effectiveness	Efficiency	Completeness	Acceptability	Planning Objectives
No Action	**No** Ecosystem restoration not likely to be implemented by others without federal assistance.	**No** No beneficial action is taken to improve environmental resources of significance in the Sheridan area.	**No** No action does not account for restoration of degraded in-stream or riparian habitat areas.	**No** Degraded environment and threat of future degradation does not align with city goal of increased open space and natural habitat areas.	**No** No ecosystem improvement in selected areas.
NER Plan	**Yes** Ecosystem restoration benefits create a net AAHU of 17.09. In-stream restoration outcomes result in benefits to 15,726 linear feet of channel, which translates to 15.86 acres. Riparian restoration outcomes result in benefits to 4.83 acres of emergent wetlands, 7.76 acres of scrub-shrub wetlands, and 0.57 acres of native upland.	**Yes** CE-ICA modeling is used to identify the most efficient best buy plans. The most efficient combination of best buy plans is selected as the proposed plan.	**Yes** The plan accounts for all necessary federal and non-federal investments.	**Yes** The plan is acceptable to the sponsor, the public and state resource agencies.	**Yes** The plan meets the project objectives and strikes a balance between effectiveness and efficiency that is acceptable to the study partners.

5.6 NER Plan Components

The NER plan (i.e. recommended plan) consists of six riparian restoration alternatives and 11 in-stream restoration alternatives. The recommendations encompass areas on the Little Goose Creek Reach, Big Goose Creek Reach, and Goose Creek Reach. Figures 26 and 27 show the restoration locations of the recommended plan. The green polygons indicate areas where riparian habitat restoration is proposed and the turquoise lines along the stream channel indicate the extents of the in-stream restoration alternatives. Figure 28 shows the connectivity that is created with the reference reaches previously discussed in this report. As noted previously and shown in the figure, the downtown reach is not restored in the recommended plan. The other area on Little Goose Creek that is shown as not being restored exhibits good bank stability and less degradation, which is why it is not included. Specific components of restoration occurring on each reach is provided in the following sections. Grading plans for the riparian alternatives, including for levee setbacks, are shown in Appendix B.

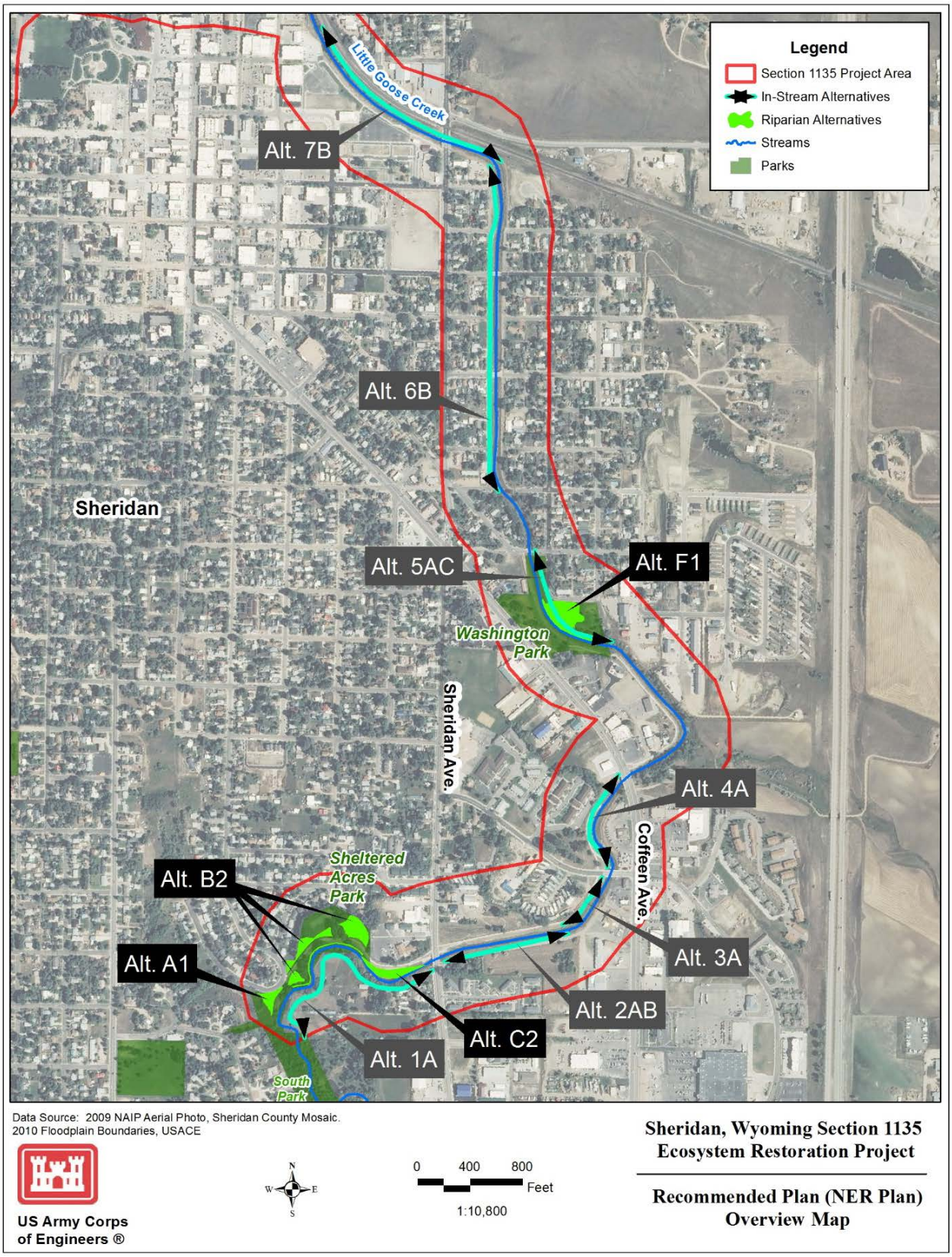


Figure 26. Recommended Plan (NER plan) restoration map (1/2)

Figure 27. Recommended Plan (NER plan) restoration map (2/2)

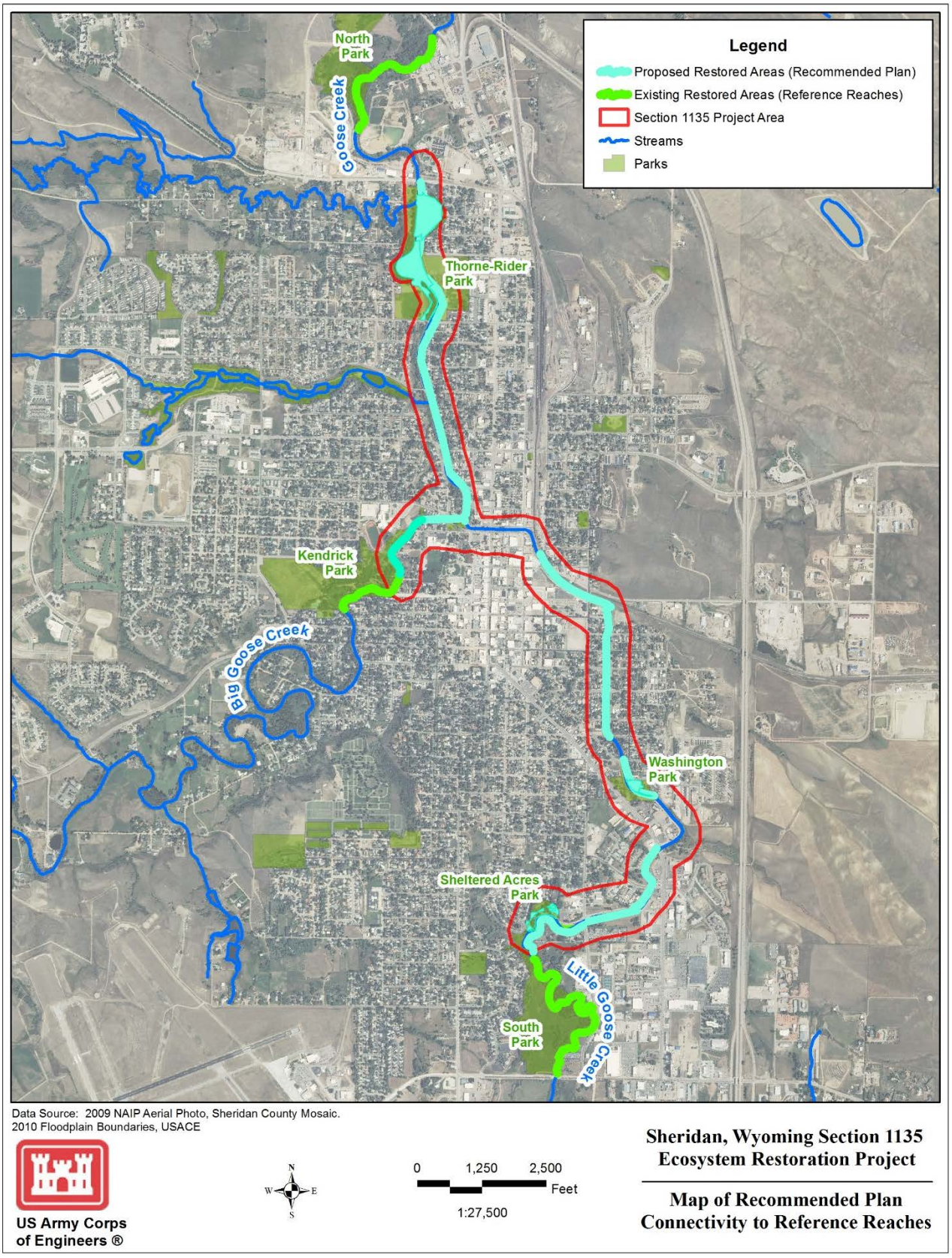


Figure 28. Recommended Plan connectivity with existing restored areas

5.6.1 Little Goose Creek Reach

Alternative A1 (Riparian)

A general description of the restoration work for Alternative A1 includes the following:

- Remove and dispose of non-native vegetation. Ensure topsoil infested with invasive species is disposed of properly. Bring in topsoil free from invasive vegetation as needed.
- Excavate and stockpile topsoil for reuse.
- Excavate to elevation range of 3,778 feet to 3,784 feet msl and dispose of approximately 480 cubic yards of material at an approved location.
- Seed and install plantings in accordance with the planting plan (Appendix A7).
- Water, fertilize and install shrub protection cages.

Ideally, the roots of all planted vegetation would be saturated for at least two consecutive weeks during the growing season. Alternative A1 and A2 were nearly the same with the exception of planting shrubs (A1) rather than trees (A2) around an emergent wetland vegetation near the center of the primary construction activity at Alternative A. A1 was selected as the most cost-effective method of restoring this area primarily because shrubs are less expensive to plant and facilitate similar habitat outputs when analyzed in the habitat models. Implementing A1 extends habitat availability westward and offer fauna nesting and foraging areas west of the pedestrian trail. Approximately 0.23 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetland and 0.09 acres of palustrine scrub-shrub temporarily flooded (PSSA) wetlands result from this alternative. Figure 29 shows the proposed plantings for this alternative.

Figure 29. Alternative A1 site plan

Alternative B2 (Riparian)

A general description of the restoration work for Alternative B2 includes the following:

- Remove and dispose of non-native vegetation. Ensure topsoil infested with invasive species is disposed of properly. Bring in topsoil free from invasive vegetation as needed.
- Excavate and stockpile topsoil for reuse for the area west of the pedestrian trail.
- Excavate to elevation range of 3,769 feet to 3,772 feet msl and dispose of approximately 1,525 cubic yards of material at an approved location.
- Seed and install plantings in accordance with the planting plan (Appendix A7).
- Water, fertilize and install shrub protection cages.

Ideally, the roots of all planted vegetation would be saturated for at least two consecutive weeks during the growing season. Eliminated Alternative B1 had forested plantings and less wetland and tree habitat. B2 was selected by eliminating tree plantings and some of the shrubs while expanding the size of the wetland. B2 was the most cost-effective method of restoring this area primarily because it cost less to plant herbaceous plants than woody species. Also, habitat output decline in the aviary species was less than the increase in suitable mink habitat which resulted in a more cost-effective method of restoring the environment at B. Implementing B2 would extend habitat availability northward and offer fauna nesting and foraging areas west of the pedestrian trail. Approximately 0.56 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetland and 0.71 acres of palustrine scrub-shrub temporarily flooded (PSSA) wetlands with some upland shrubs would be result from this alternative. Figure 30 shows the proposed plantings for this alternative.

Figure 30. Alternative B2 site plan

Alternative C2 (Riparian)

A general description of the restoration work includes the following:

- Remove and dispose of non-native vegetation in both areas. Ensure topsoil infested with invasive species is disposed of properly.
- Excavate to elevation range of 3,766 feet to 3,770 feet msl and dispose of approximately 120 cubic yards of material at an approved location. Bring in topsoil free from invasive vegetation as needed.
- Seed and install plantings in accordance with the planting plan (Appendix A7).
- Water and fertilize as needed.

Ideally, the roots of all planted vegetation would be saturated for at least two consecutive weeks during the growing season. Eliminated Alternative C1 did not have any woody vegetation and a larger wetland. This alternative did not provide any habitat improvement for both aviary species in the HEP models. Planting of a small area of woody vegetation as planned for in C2 allowed for some benefits to the yellow warbler

and brown thrasher. The ability to plant shrubs was constrained by the presence of the levee. ETL 1110-2-583 states that all woody vegetation must be at least 15 feet from the toe of the levee slope. Approximately 0.06 acres of shrubs have been proposed in C2 at least 25 feet from the toe of the levee slope. The remaining surface, approximately 0.30 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetlands has been proposed to be planted between the shrubs and the levee toe. C2 was the most cost-effective method of restoring this area primarily because it provided more benefits to the yellow warbler and brown thrasher at a slightly higher cost than the herbaceous plantings only as proposed in C1. Figure 31 shows the proposed plantings for this alternative.

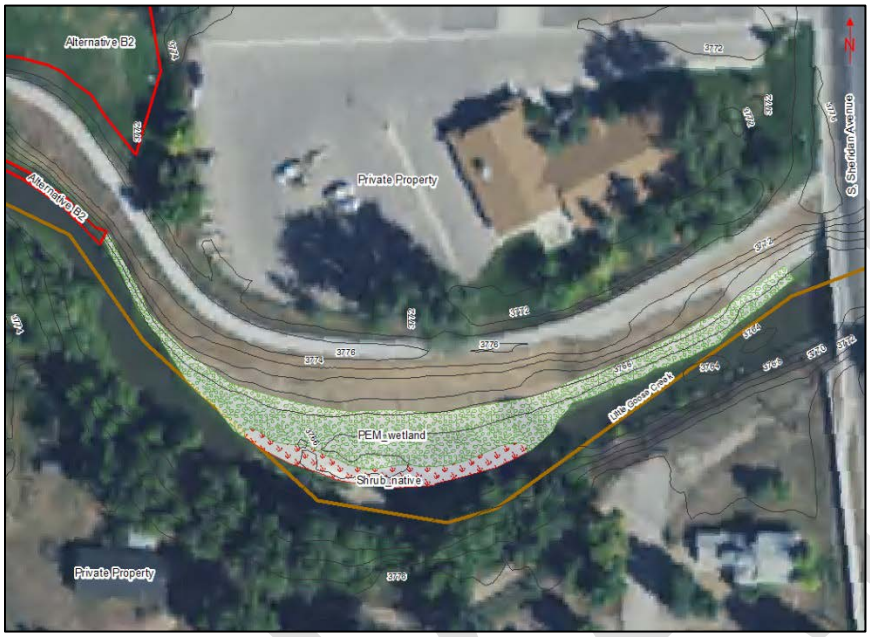


Figure 31. Alternative C2 site plan

Alternative F1 (Riparian)

A general description of the restoration for Alternative F1 includes the following:

- Remove and dispose of non-native vegetation in both areas. Ensure topsoil infested with invasive species is disposed of in the band of wetlands adjacent to Little Goose Creek. Bring in topsoil free from invasive vegetation as needed.
- Excavate to elevation range of 3,751 feet to 3,758 feet msl and dispose of approximately 3,535 cubic yards of material at an approved location.
- Stockpile topsoil for reuse for the area east of the pedestrian trail.
- Remove and dispose of existing concrete pedestrian trail.
- Excavate high ground from the edge of Little Goose Creek to setback high ground / new concrete pedestrian trail.
- Seed and install plantings in all areas in accordance with the planting plan (Appendix A7).
- Water, fertilize and install shrub protection cages.
- Re-build setback concrete pedestrian trail on top of new levee (high ground) and reconnect to existing bridge.

Ideally, the roots of all planted vegetation would be saturated for at least two consecutive weeks during the growing season. Approximately 0.57 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetlands is proposed to be planted adjacent to the creek and inland until transitioning into approximately 0.30 acres of shrub vegetation, some of which would be hydrophytic in nature. A band of

native grasses would abut the east side of the shrub planting to not impede on the 15-foot restriction adjacent to the new levee (high ground) and concrete pedestrian trail. Eliminated Alternative F1 alternative would not setback the levee and the area proposed for wetland and shrub seeding/plantings was reduced considerably by reducing the area (0.54 acres) available for restoration. F1 was the most cost-effective method of restoring this area primarily because it provided substantially more benefits to the modeled riparian species, albeit at a higher cost. Figure 32 shows the proposed plantings for this alternative.

Figure 32. Alternative F1 site plan

Alternative 1A (In-Stream)

In-stream Alternative 1 reach is the most upstream of the alternatives on Little Goose Creek. The reach covers 1,594 feet of stream length meander as the stream bends to easterly flow, and is bordered by private property on the right descending bank (inside bend) and a recreational trail from the city park on the left descending bank (outside bend). The existing stream banks are comprised of riparian forest with trees that appear to provide some shading over the stream, and appears to be the least channelized reach with the greatest degree of meander of the project in-stream reaches. Three habitat improvement alternatives were modeled to quantify the estimate of increased in-stream habitat suitability for brown trout. Alternative 1A was selected.

Alternative 1A is placement of Newburry riffles to restore a riffle-pool sequence habitat, which are well suited to adding habitat diversity to otherwise uniform reaches. This alternative is expected to provide thermal refuge as pools downstream of the riffle structure, as well as food production benefits to trout from primary production and periphyton attached to placed rock. Newburry riffles also provide value to the stream ecosystem as grade control to maintain the channel invert and water table stability during dry or low flow periods. The restoration will improve 1.09 acres of in-stream habitat, increasing the existing HSI score from 0.20 to 0.50 in year 1, and to 0.90 in year 50.

Alternative 2AB (In-Stream)

In-stream Alternative 2 reach is immediately downstream of Alternative 1 reach on Little Goose Creek, beginning at the South Sheridan Avenue Bridge. The reach extends 800 feet downstream along a straight

channelized stream immediately bordered by levee banks on each side, flowing easterly. The stream bed is uniformly shallow with no riffle or pool habitats, and no trees are present along the stream bank to provide shading; the reach is the beginning of the engineered flood control channel which extends downstream through the study area. The recommended alternative (2AB) is a combination of vanes to better channel flows and generate pool habitat, and placement of boulder clusters to provide shading and feeding habitat for trout. The restoration will improve 0.55 acres of in-stream habitat, increasing the existing HSI score from 0.20 to 0.80 in year one, and maintain as 0.80 to year 50. The beneficial effect of the restoration is expected to be immediately and fully realized during year one because the project can be built to final design and there is no anticipated maturation time for shading vegetation or periphyton growth. The habitat features will function as feeding and shading areas after construction when trout migrate to the area.

Alternative 3A (In-Stream)

In-stream Alternative 3 reach is immediately upstream of the Avoco Avenue Bridge and downstream of Alternative 2 reach on Little Goose Creek. It is a short reach (200 feet) with two alternatives proposed, each with a single structure to also serve as grade control along a straight reach of stream between two bends. The selected alternative (3A) is installation of a Newburry riffle to restore a riffle-pool habitat, and add habitat diversity to this otherwise uniform channelized reach. This alternative is expected to improve 0.14 acres of in-stream habitat by providing thermal refuge as pool habitat downstream of the riffle structure, as well as food production benefits to trout from primary production and periphyton attached to rock.

Alternative 4A (In-Stream)

In-stream Alternative 4 reach is 282 feet of stream in the channelized flood control project downstream of Avoco Avenue Bridge on Little Goose Creek. The selected alternative (4A) is a series of J-hook vane rock structures on the inside of the channel bend, and will improve 0.19 acres of in-stream habitat. J-hook vanes improve habitat at the site by concentrating flows towards a thalweg in the middle of the channel to facilitate habitat quality during low flow periods, and the "J" structures on the terminal end are intended to create scour pools for thermal refuge and improve substrate complexity. The scour usually results in tail out deposition of gravel (riffle-like) that may provide spawning habitat.

Alternative 5AC (In-Stream)

In-stream Alternative 5 reach is 1,050 feet of stream in the channelized flood control project flowing through Washington Street Park and extending to the East Heald Street bridge on Little Goose Creek. The existing stream channel is uniformly wide and shallow without a well-defined thalweg, no riffle-pool habitats, and no trees present along the stream bank or levee to provide shading. The selected alternative (5AC) is a series of J-hook vane rock structures on the inside of the channel bend and placed boulder clusters in the straight reach downstream of the channel bend, and will improve 0.72 acres of in-stream habitat. J-hook vanes improve habitat at the site by concentrating flows towards a thalweg in the middle of the channel to facilitate habitat quality during low flow periods, and the "J" structures on the terminal end are intended to create scour pools for thermal refuge and improve substrate complexity. The scour usually results in tail out deposition of gravel (riffle-like) that may provide spawning habitat. Boulder clusters provide shading and feeding habitat for trout, and increase the habitat diversity in the reach.

Alternative 6B (In-Stream)

In-stream Alternative 6 reach is 1,900 feet of straight stream with no bends or meander in the channelized flood control project flowing north from near King Street to near East Brundage Street on Little Goose Creek. The existing stream channel is uniformly wide and shallow without a well-defined thalweg, no riffle-pool habitats, and no trees present along the stream bank or levee to provide shading. Alternative 6B is placement of Newburry riffles to restore a riffle-pool sequence habitat, which are well suited to adding habitat diversity to otherwise uniform reaches. This alternative is expected to provide thermal

refuge as pools downstream of the riffle structure, as well as food production benefits to trout from primary production and periphyton attached to rock. Newburry riffles also provide value to the stream ecosystem as grade control to maintain the channel invert and water table stability during dry or low flow periods. The restoration will improve 1.31 acres of in-stream habitat, increasing the existing HSI score from 0.20 to 0.50 in year 1, and to 0.90 in year 50.

Alternative 7B (In-Stream)

In-stream Alternative 7 reach is 1,500 feet of straight stream with no meander along a gradual bend in the channelized flood control project flowing northwest from near the North Sheridan Avenue bridge to near East Alger Street on Little Goose Creek. The existing stream channel is uniformly wide and shallow without a well-defined thalweg, no riffle-pool habitats, and few trees present along the right descending bank (i.e., north stream bank) that provide only minimal shading, generally only during morning. The selected alternative (7B) was placement of Newburry riffles to restore a riffle-pool sequence habitat, which are well suited to adding habitat diversity to otherwise uniform reaches. This alternative is expected to provide thermal refuge as pools downstream of riffle structures, as well as food production benefits to trout from primary production and periphyton attached to rock. Newburry riffles also provide value to the stream ecosystem as grade control to maintain the channel invert and water table stability during dry or low flow periods. The restoration will improve 1.04 acres of in-stream habitat, increasing the existing HSI score from 0.20 to 0.50 in year 1, and to 0.90 in year 50.

5.6.2 Big Goose Creek Reach

Alternative 10 (In-Stream)

In-stream Alternative 10 is the only recommended restoration for Big Goose Creek. This alternative is 510 feet of stream at the terminal end of Big Goose Creek upstream of the confluence with Little Goose Creek at the Lewis Street Bridge. The reach is comprised of four engineered drop structures to control stream elevation and protect against head cutting. The channel is constrained by the Lewis Street bridge abutment on each bank, and the drop structures exceed the elevation drop criteria of 0.4 feet proposed by WGFD local fisheries biologists to allow fish passage. The existing condition blocks fish passage to previously restored in-stream habitat upstream near Kendrick Park. The selected alternative is installation of a series of drop structures such that each would not exceed 0.4 feet in elevation. The rock drop structures will also have plunge scour pools on their downstream end that will provide thermal refuge and give trout the necessary space to generate momentum to breach the water surface and jump up the 0.4 feet elevation rise if necessary to pass. The restoration will improve 0.41 acres of in-stream habitat at the drop structures themselves, and improve access to at least 3.20 acres of high quality habitat near Kendrick Park. Modeling indicates that habitat quality will increase from existing HSI score 0.20 to 0.50 in year 1, and to 0.60 in year 50.

Figure 33 shows a profile and plan view of the proposed drop structure for one drop. The distance between each drop is 22 feet and the depth of the pool between each drop will be about two feet during the low flow portion of the year. As shown in the structure plan in the figure, there will be gaps in the rocks to facilitate additional means of passage for smaller fish, and the pool between the drops will serve as a resting habitat for fish moving through the structure. A plan view and details of the entire structure is provided in Section 5.2.3 and Appendix C.

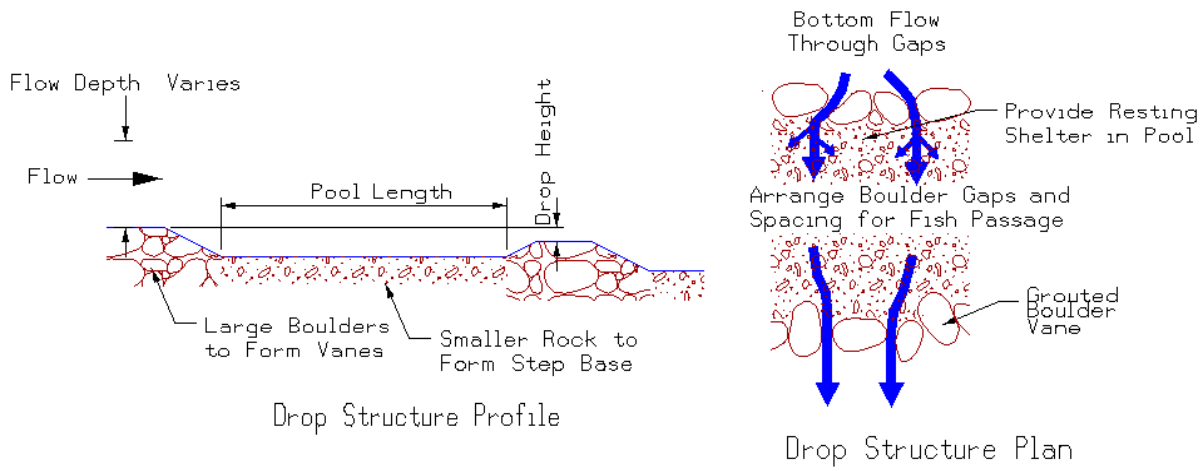


Figure 33. Profile and plan view of a drop structure drop

5.6.3 Goose Creek Reach

Alternative K1L1 (Riparian)

A general description of the restoration for Alternative K1L1 includes the following:

- Remove and dispose of non-native vegetation in both areas. Ensure topsoil infested with invasive species is disposed of in the band of wetlands adjacent to Little Goose Creek. Bring in topsoil free from invasive vegetation as needed.
- Excavate to elevation range of 3,706 feet to 3,716 feet and dispose of approximately 34,476 cubic yards of material at an approved location. Approximately 9,260 cubic yards of material would be used as fill in the existing channelized Goose Creek. Total excavation equals 43,736 cubic yards. Stockpile topsoil and reuse.
- Remove and dispose of existing concrete pedestrian trails.
- Remove portion of existing levee.
- Excavate a new meandering creek that extends Goose Creek into the floodplain.
- Dispose of material from the excavation into existing channelized Goose Creek.
- Construct the setback levee.
- Seed and install plantings in accordance with the planting plan (Appendix A7).
- Construct concrete pedestrian trails.

A plan view is shown in Figure 34. Ideally, for Alternative K1/L1 the roots of all planted vegetation, except native upland grasses, would be saturated for at least two consecutive weeks during the growing season. Approximately 2.8 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetlands is proposed to be planted at the low points in the meander bends and within the existing Goose Creek channel which transitions into approximately 5.6 acres of seasonally to temporarily flooded palustrine scrub-shrub (PSSA/C) wetlands, some of which would be hydrophytic in nature. A 0.35-acre band of native upland grasses is proposed to be planted on the west side of the levee from the toe where it transitions into shrub community and finally the emergent wetlands.

Sediment transport analysis was not included at this stage. Due to channel lengthening, final design would need to evaluate the potential for sediment impacts.

Figure 34. Alternative K1L1 site plan

Alternative M1 (Riparian)

A general description of the restoration work includes the following:

- Remove and dispose of non-native vegetation in both areas. Ensure topsoil infested with invasive species is disposed of in the band of wetlands adjacent to Goose and Soldier Creeks. Bring in topsoil free from invasive vegetation as needed.
- Excavate to elevation range of 3,709 feet to 3,713 feet msl and dispose of approximately 787 cubic yards of material at an approved location. Stockpile topsoil for reuse.
- Seed and install plantings in accordance with the planting plan (Appendix A7).
- Water, fertilize and install shrub protection cages.

A plan view is shown in Figure 35. Ideally, during higher runoff months (May/June) Soldier Creek would overtop into the newly created depression and keep the roots of all planted vegetation saturated for at least two consecutive weeks during the growing season. Opportunistic side channels may form over time from

these flows as they flood and recede the depression on the way to emptying into Goose Creek. Approximately 0.80 acres of palustrine emergent seasonally to temporarily flooded (PEMA/C) wetlands is proposed to be planted adjacent to the creek and inland until transitioning into approximately 0.80 acres of shrub vegetation, some of which would be hydrophytic in nature. Eliminated Alternative M2 was essentially the same habitat configurations, but M1 replaced shrubs with trees which was more expensive without getting a lot more HUs. M1 was the most cost-effective method of restoring this area primarily because it provided more benefits to all the modeled species for less cost.

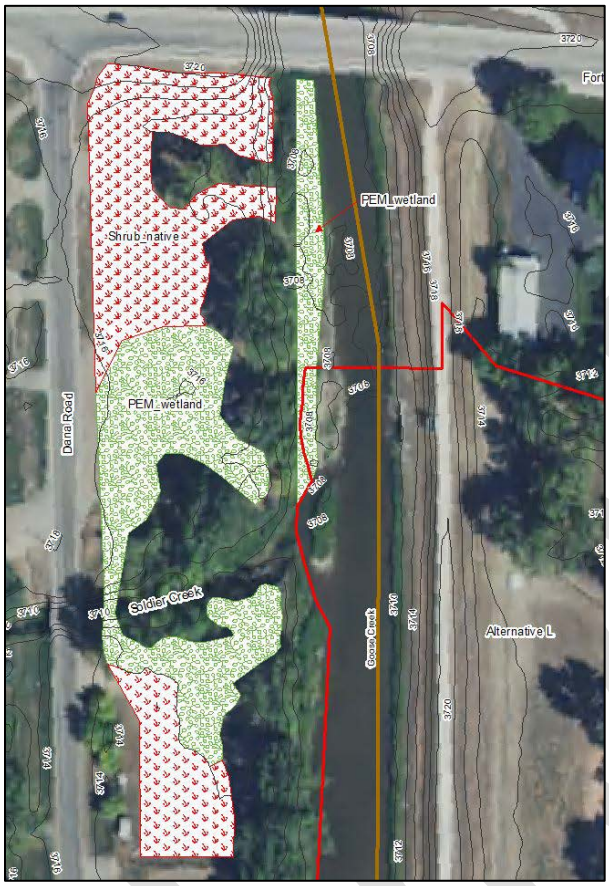


Figure 35. Alternative M1 site plan

Alternative 9A (In-Stream)

In-stream Alternative 9 reach is 260 feet of stream in the channelized flood control project flowing north at the confluence of Big Goose Creek and Little Goose Creek. The existing stream channel is uniformly wide and shallow without a well-defined thalweg, no riffle-pool habitats, and few trees present along the stream bank. The selected alternative was placement of a single W-vane to stabilize the confluence area and establish large deep pools for trout habitat. This alternative is expected to provide thermal refuge as pools downstream of the structure, and staging areas for trout preparing to move upstream through the concrete channel up Little Goose Creek or the drop structures up Big Goose Creek. Cross-vanes also provide value to the stream ecosystem as grade control to maintain the channel invert and water table stability during dry or low flow periods. The restoration will improve 0.31 acres of in-stream habitat, increasing the existing HSI score from 0.00 to 0.25 in year 1, and to 0.50 in year 50.

Alternative 11C (In-Stream)

In-stream Alternative 11 is 3,970 feet of stream along the straight channelized flood control project flowing north from the confluence downstream to the 11th Street Bridge. The existing stream channel is

uniformly wide and shallow without a well-defined thalweg, no riffle-pool habitats, and few trees present along the stream bank. The selected alternative (11C) is installation of a series of J-hook vane rock structures to improve in-stream habitat. J-hook vanes improve habitat at the site by concentrating flows towards a thalweg in the middle of the channel to facilitate habitat quality during low flow periods, and the "J" structures on the terminal end are intended to create scour pools for thermal refuge and improve substrate complexity. The scour usually results in tail out deposition of gravel (riffle-like) that may provide spawning habitat. The restoration will improve 5.47 acres of in-stream habitat, increasing the existing HSI score from 0.00 to 0.25 in year 1, and to 0.50 in year 50.

Alternative 12C (In-Stream)

In-stream Alternative 12 reach is 2,815 feet of stream in the channelized flood control project flowing north through Thorne Rider Park at the end of the study area on Goose Creek. The existing stream channel is uniformly wide and shallow without a well-defined thalweg and no riffle-pool habitats. The selected in-stream alternative (12C) compliments the riparian restoration plan in this area by meandering the stream channel through remnant oxbow channels associated with riparian Alternative K1L1 to increase the stream length to 3,660 feet. A series of J-hook vanes on the outside of the channel bends through the restored meanders concentrate flows towards a thalweg in the middle of the channel to facilitate habitat quality during low flow periods and protect the outside bank from erosion during normal and high flows. The "J" structures on the terminal end are intended to create scour pools for thermal refuge and improve substrate complexity. The scour usually results in tail out deposition of gravel (riffle-like) that may provide spawning habitat. Newburry riffle structures will also be installed to restore a riffle-pool sequence habitat, which are well suited to adding habitat diversity to otherwise uniform reaches. This alternative is expected to provide thermal refuge as pools downstream of riffle structures, as well as food production benefits to trout from primary production and periphyton attached to rock. Newburry riffles also provide value to the stream ecosystem as grade control to maintain the channel invert and water table stability during dry or low flow periods. Finally, it is expected that existing mature riparian forest areas through the meander bends will contribute to shading and provide additional thermal refuge. The restoration will improve 5.04 acres of in-stream habitat, increasing the existing HSI score from 0.00 to 0.36 in year 1, and to 0.72 in year 50.

5.7 Summary

There is great opportunity to increase the value of wetlands and other riparian habitat along the Goose Creeks in Sheridan, Wyoming project area and to establish healthy communities that will continue to improve and be sustainable throughout the life of the project. The establishment of a more natural stream with floodplain connectivity and a balanced riparian corridor could help the area thrive. In conjunction with ongoing local restoration efforts, the project area can individually, and as part of a riparian corridor along the Goose Creeks, provide benefits to many aquatic and riparian species, including migratory birds.

Restoring in-stream habitats to demonstrate benefit for brown trout improves overall ecological integrity of the aquatic system such that other species experience benefit as well, including secondary and tertiary benefits to avian, semiaquatic, and terrestrial species. As the stream system quality increases, the value to the community also increases by realized output of ecosystem services, such as improved water quality and reduced human use health risk (real and perceived), increased recreational and commercialized recreational opportunities, and community appreciation for value added in improved natural and green space.

Restoring this highly visible and culturally significant reach of urban stream is expected to have far reaching benefit and influence. The sponsor and local WGFD biologists anticipate this restoration will serve as a catalyst for addressing upstream issues identified within this study, but outside the scope of action alternatives, notable those issues related to withdrawals and water quality. The restoration actions

recommended in this study, combined with future solutions that address these upstream issues would further improve the ecosystem and in-stream habitat quality in the current Section 1135 project area.

Finally, these localized restoration efforts within the project area would have incremental positive effects on the overall health of the Goose Creek within the project area. If successfully implemented, the restoration measures described may serve as examples for future restoration projects throughout the greater Goose Creek watershed. Education, outreach, and watershed-based planning are likely to be the most effective measures for improving watershed condition in the Goose Creek watershed.

6.0 RECREATION PLAN FORMULATION AND RECOMMENDATION

Under the Section 1135 authority, the primary objective is aquatic ecosystem restoration. Within the context of the Section 1135 authority there is also an opportunity to address recreation features that provide further benefits to the community in relation to the project. Recreation components are added following selection of the preferred restoration plan. The following sections describe the planning process for evaluating the proposed recreation alternative. Recreation plan formulation was conducted on Goose Creek in the vicinity of Alternatives K and L. Recreation benefits were estimated in this area and the full analysis is presented below in Section 6.1. One area of the recommended plan, in the vicinity of Alternative F, involves setting back a trail. Recreation benefits were not calculated in this area because this was considered replacement in-kind. The existing trail will be impacted and rebuilt for a cost of about $3,000.

The goal of the recreation alternative plan is to provide recreational access to the NER project area, where recreational features do not already exist, that supports public education and enjoyment of the environment while maintaining the restored habitat. Related objectives include expanding upon the opportunities and experiences already provided by the existing Sheridan parks and recreation facilities, while expanding the nature-base recreation opportunity on designated trails and footpaths within the restored area and educating the public about the significance of the restored habitat areas.

Below highlights the opportunities within the project area. Note that the recommended NER plan does not include removing and restoring the downtown area (Alternative 8).

- Opportunity exists to incorporate riparian and in-stream habitat improvements in the vicinity of existing recreation trail and parks.
- Opportunity exists to supplement recent recreation improvements in downtown Sheridan (i.e. Mill Park near the confluence) with new recreational trails.
- Opportunity exists to enhance the quality of recreation on existing pedestrian and bike paths by improving nearby in-stream and riparian habitat.

The recreation alternative plan was developed through a collaborative process between the Corps and the city of Sheridan. Given that one of the goals of the recreation alternative is to provide ancillary recreation benefits through access to the restored area in a manner that minimizes impact to the restored habitat," multiple wide-ranging recreation alternatives were not evaluated. Rather a more focused approach was taken by looking for opportunity to complement existing city trails and recreation features. The proposed recreation alternative would provide reasonable access to the restoration areas, while limiting potential impact to the restored areas.

6.1 Evaluation of Alternative Plan

Recreational opportunities that provide further benefits to the community in relation to the project were evaluated at the north end of the project area at Alternatives K and L. There are currently trails providing access to K and L. During the environmental restoration and levee setback, portions of this trail would be removed, significantly affecting connectivity. There is approximately 2,000 linear feet of existing trails impacted due to the configuration of Alternatives K and L. The proposed trail within the area will replace the trails removed during the restoration and an additional path along the riverbank of K. The total length of proposed trail is approximately 2,230 linear feet. Note that the project would be developed on lands within the ecosystem restoration area so no lands, easements, rights of way, relocation or disposal areas (LERRDs) would be required in addition to that required for the NER alternative.

Figure 36 shows both the recreation and restoration features for Alternatives K and L. The recreation alternative plan is focused on sites K and L, and includes:

- nature trail, in addition to reconnecting city trail,
- two interpretive signs, and
- one bench near the interpretive signs.

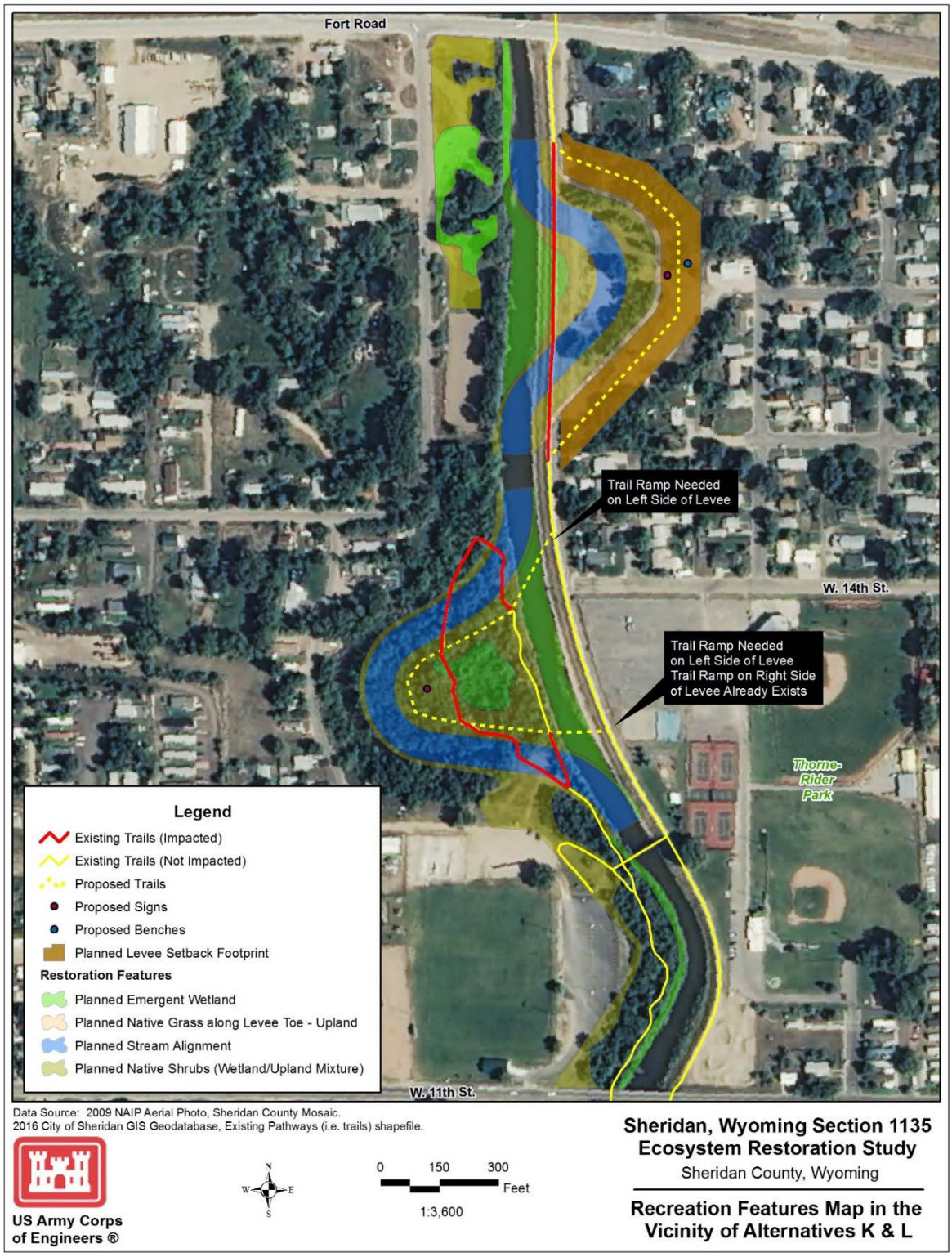


Figure 36. Recreation features map

6.2 Recreation Benefits

The recreation evaluation involves an analysis of the National Economic Development (NED) benefits from recreation opportunities created from the proposed recreation alternative. Benefits are compared to costs to inform decision-makers on the feasibility of the recreation facilities. As directed by the Planning Guidance Notebook (PGN) (ER 1105-2-100), recreation benefits should be measured as the recreation users 'willingness to pay' for the recreation opportunity. Since it is not possible to directly estimate demand for the proposed recreation facilities, nor are the proposed recreation facilities an integral part of project justification, the Unit Day Value (UDV) estimation technique is utilized for estimating recreation users' willingness to pay.

Based upon the criteria outlined in Figure E-10 in the PGN, Appendix E, the evaluation method selected for estimating recreation benefits is the UDV method. There is not a regional model available for estimating recreation benefits, nor are specialized recreation activities included in the alternative recreation plan. In addition, annual visits to the recreation features are not expected to exceed 750,000 visitors and the federal cost of a project including recreation will not exceed the federal cost of the project excluding recreation by more than ten percent**.**

As the name implies, the UDV is an estimate of the monetary value placed on each day of recreational use. The method considers both the quality of recreation experience and the number of recreationists, while utilizing an annually published 'unit day values for recreation' Economic Guidance Memorandum. For the purposes of the proposed recreation facilities, the category of 'general recreation' is utilized, and the guidelines for assigning points for general recreation (as directed in EGM 14-03) were followed.

An estimate of the number of trail recreationists was collected by the city of Sheridan. The annual visitor estimates for area KL are illustrated in Table 34 for the existing conditions, with the ER plan with no recreation features and with the ER alternative with recreation features. Since there would be no trails through the KL area, without the proposed recreation plan, it was assumed that recreation users decreased to 10 percent of existing use levels. The number of visitors for the project area of KL with the future with project condition was conservatively assumed to be the same level as the estimated number of visitors at the existing conditions.

Table 34. Annual visitor estimate for Alternatives K and L

Recreation & Ecosystem Restoration Area	Annual Visitors
Existing condition	36,431
ER Alternative- No Recreation Features	3,643
ER Alternative and Recreation Alternative	36,431

Unit day value quality scores were estimated for 'general recreation' and were developed using the criteria published in the Economic Guidance Memorandum (EGM) 17-03, including recreation experience, availability of opportunity, carrying capacity, accessibility, and environment. Visitor quality scores were developed in coordination with local experts from the city of Sheridan based on the criteria in EGM 17-3.

As shown in Table 35, the quality of the recreation experience was calculated for the three conditions or scenarios that was shown in Table 2: existing conditions, without project conditions (with the ER plan with no recreation plan) and with project conditions (with the ER tentatively selected plan and with the recreation plan) The existing condition has a higher unit day value score based on the connected trail

system, when compared to the without project condition. Likewise, the without project condition average annual benefits are lower because of the disconnected trail system through K and L, reducing the number of recreational visitors (note, it was assumed that ten percent of trail recreationists would still pass near areas K and L). The with-project condition quality score in significantly higher based on restoring the connectivity of the trail system, adding length to the trail system (300 feet of existing trail would be restored and 400 feet of trail added), along with the enhanced recreation experience of walking or biking near restored habitat, educational signage and pedestrian benches.

Table 35. Estimated recreation benefits (FY2017)

	Unit Day Points	General $/Day	Visitors	Average Annual Benefits
Existing Conditions	29	$5.79	36,431	$210,826
Without Project Condition (No Recreation, ER Alternative	4	$4.20	3,643	$15,301
With Project Condition (Recreation Alternative and ER Alternative)	42	$7.52	36,431	$273,815
Difference:			32,788	$258,514

6.3 Recreation Costs

Recreation alternative costs were estimated based upon the specific features included in the recreation plan. Trail cost estimates are based upon a per linear foot cost estimate and the estimated length of the trail proposed for each restoration area, while interpretive signs are estimated based upon the size and type of signage proposed, as well as the number of signs proposed for each restoration area.

Table 36 provides an overview of the recreation facility costs by area including the annualized investments cost, OMRR&R costs, and the total annual cost. A more detailed cost estimate is provided in the Cost Engineering Appendix.

Table 36. Recreation facilities cost estimate by area (FY2017)

Cost Line Item	KL
Construction Cost	$223,088
*E&D, S&A, Site Prep, and Contingency	$82,543
Estimated Total:	$305,630
IDC (1 yr, 2.875%):	$2,177
Investment Cost:	$307,808
Annualized Investment Cost:	$11,681
Annual OMRR&R:	$9,169
Total Annual Cost:	$20,850

*E&D – engineering and design; S&A – supervision and administration

6.4 Recreation Benefit Cost Analysis and Recommendation

Table 37 provides an overview of the benefit cost ratio (BCR) by restoration area. The BCR is well over 1.0 at 10.8 for the proposed recreation plan.

Table 37. Benefit cost comparison by area

	KL
Total Annual Cost	$20,850
Annual Recreation Benefits	$258,514
Benefit-Cost Ratio	**10.8**

The federal share of recreation cost, estimated at approximately $189,000, would increase federal costs approximately 5.3 percent over the federal share of ecosystem restoration cost, estimated at approximately $3,700,000. In summary, increased access would further public understanding and appreciation of nature and the ecosystem restoration project. Trails and associated recreation facilities would help encourage visitors to the restored area to respect the restored habitat, while providing them an opportunity to enjoy and appreciate the restored area.

7.0 RECOMMENDED PLAN

The recommended plan consists of six riparian restoration alternatives, 11 in-stream restoration alternatives, and recreation features on Goose Creek. The six riparian alternatives that are part of the recommended plan are referred to as Alternatives A1, B2, C2, F1, K1L1, and M1 and consist of improvements to wetlands and the riparian environment adjacent to Little Goose Creek and Goose Creek. The 11 in-stream alternatives are referred to as Alternatives 1A, 2AB, 3A, 4A, 5AC, 6B, 7B, 9A, 10A, 11C, and 12C and consist of aquatic habitat improvements in Little Goose Creek and Goose Creek, modification of a drop structure for fish passage on Big Goose Creek, and a stream realignment on Goose Creek. Figures 26, 27, and 28 show the locations of the recommended plan alternatives in the city of Sheridan (see Section 5.7). The recommended plan consists of nature trail modifications, interpretive signage, a bench along the trail, which is all associated with the ecosystem restoration improvements.

Ecosystem restoration recommendations are described in detail in Chapter 5 and recreation recommendations are described in detail in Chapter 6.

7.1 Recommended Plan Costs

A summary of the recommended plan implementation costs is provided in Tables 38 and 39. Economic costs shown under the Lands and Damages line item (see Table 38) represent the estimated value of LERRDs required for implementation, including LERRDs that are part of the FRM project. The non-federal sponsor will only receive financial credit in the cost-share for LERRDs which were not part of the existing FRM project.

Table 38. Recommended Plan economic costs (FY17 price levels)

Item	Ecosystem Restoration	Recreation	Total
Fish and Wildlife Facilities	$ 4,162,000	$ 342,000	$ 4,504,000
Lands and Damages	$ 1,095,746	$ -	$ 1,095,746
Relocations	$ -	$ -	$ -
Adaptive Management	$ -	$ -	$ -
Subtotal	$ 5,257,746	$ 342,000	$ 5,599,746
Design	$ 842,000	$ -	$ 842,000
Construction Management (E&D, S&A)	$ 338,000	$ -	$ 338,000
Total Economic First Cost	$ 6,437,746	$ 342,000	$ 6,779,746

Table 39. Economic costs and benefits of recommended plan (FY17 price levels)

Item	Ecosystem Restoration		Recreation		Total	
	Allocated Costs	Benefits	Allocated Costs	Benefits	Allocated Costs	Benefits
Investment Cost						
First Cost	$ 6,437,746		$ 342,000		$6,779,746	
IDC	$ 153,535		$ 2,492		$ 156,027	
Total	$ 6,431,535		$ 344,492		$6,935,773	
Annual Costs						
Interest and Amortization	$ 186,291		$ 4,908		$ 191,199	
OMRR&R	$ 63,835		$ 8,165		$ 72,000	
Total	$ 250,126		$ 13,073		$ 257,137	

Monitoring Costs (Year 1-5)	$ 10,000		$ 0		$ 10,000	
Annual Benefits						
Non-monetary (Ecosystem)		17.096 AAHU				
Net Annual Recreation Benefits						$ 234,653
Recreation Benefit to Cost Ratio						10.83
Recreation Benefit to Cost Ration (at 7%)						7.18

7.2 Public Input on the Recommended Ecosystem Restoration Plan

A public meeting was held on March 23, 2017 in Sheridan to gather input on the proposed plan for restoring degraded aquatic habitat in the vicinity of the existing flood control project. During the meeting it was conveyed to the public that the preferred plan consists of in-stream habitat structures in over three miles of the creeks, which would improve fishery habitat in a similar fashion to previously constructed projects throughout the city. All of the habitat improvements would be implementable while maintaining the current levels of protection provided by the flood control project. The meeting was attended by 50 members of the public. A summary of comments received during the meeting is listed below.

- Comment received supporting the project. Concerns were expressed about ice jams in the creek as a result of placing rock structures in the stream that may impact velocity and turbulence. Concerns on whether frazil ice could form on cold nights, develop hanging dams and anchor ice that can choke the channel and cause water to spill onto the flood plain. One recommendation is that reducing turbulence (drop) and velocity might be a good thing if it helps the stream to ice over and stay capped.
- Comment was received expressing disappointment over the abandonment of the work along the south side of 1st Street, but otherwise supporting the project. Further, removing the existing concrete channel and replacing it with a more "people-friendly" area (such as something analogous to a San Antonio Riverwalk) was by far the most appealing part of the project. Regarding possible fisheries improvements associated with the currently proposed project, the sections of Big Goose and Little Goose Creeks immediately upstream of the current flood levee system are not really notable fisheries, so making improvements within the levee system for that purpose are questionable. A few years back Trout Unlimited planted fingerlings in Little Goose Creek just upstream of the levee against the recommendations of the WGDF, primarily because this state agency did not view the creek in that reach as suitable trout habitat.
- Comment received supporting the project. Also, the commenter posed the following question. If the city and county could enhance the floodplain upstream of the project, could that give you additional flexibility to manage floods and allow for additional restoration and trees in the project area?
- Comment received regarding cultural resources. Commenter noted that some limited cultural resource work was completed for this project but questioned plans to fulfill National Historic Preservation Act obligation for areas outside the concrete channel.
- Comment received supporting the project. A kayak enthusiast would like to see a three-foot wide path down the middle of the channel on Big Goose Creek where the proposed drop-structure modification would be constructed.
- Comment received supporting the project. Commenter recommended that the Corps introduce more sinuosity to Little Goose Creek between South Sheridan Avenue and Coffeen Avenue. Also recommended that the Corps clean up the east bank above Washington Park and Coffeen Avenue. Finally, the commenter recommended that the Corps consider creating a public interface

at Coffeen and Avoca area to introduce some aesthetic and recreational draw along the busiest corridor in town.

A summary of public and agency involvement and the input that was received during the scoping phases is provided in Section 2.3.

7.3 Design and Construction Considerations

7.3.1 No Net Rise Hydraulic Modeling

Hydraulic modeling will occur during the design phase to ensure that no net rise occurs as a result of a Section 1135 project. Depending on how the selected alternative might affect flood water surface profiles and floodplain boundaries, a Conditional Letter of Map Revision (CLOMR) may need to be obtained as part of the project.

2-dimensional modeling (RAS) was performed on the stream realignment on Goose Creek that shows no rise hydraulic condition. The concrete channel was eliminated primarily due to an inability to model a no rise alternative within the available geometry that was cost-effective. A no rise analysis will be performed on the modified Big Goose Creek drop structure in the design phase once the design is finalized and should be easy to attain. Similarly, the in-stream habitat structures will be evaluated in detail during the design phase, but discussion with engineering team members indicates that certain structures will not result in a net increase in flood stages. The Newbury rock riffles are assumed to have a very slight increase in stage, but this increase can be offset by excavation of small areas along the channel next to each structure if needed, resulting in a no net rise.

7.4 Real Estate Plan

The purpose of this Real Estate Plan is to support the feasibility study. It will identify and describe all lands, easements, relocations, rights-of way, and disposal areas (LERRDs) for the construction, operation, and maintenance of Section 1135 modification to an existing FRM project. The Section 1135 project is recommending construction of ecosystem restoration features around the system creeks in Sheridan, Wyoming as described in this feasibility report. The Real Estate Plan is tentative in nature. It is for planning purposes only and both the final real property acquisition lines and the real estate cost estimates provided are subject to change even after approval of the feasibility report.

Nearly all of the project footprint is already owned by the city of Sheridan. Sheridan County ownership information showed some lands with no specific parcel or owner and these areas are still pending clarification and were interpreted for purposes of this planning document. The city of Sheridan (i.e. non-federal sponsor) will need to obtain title certifications or proof of ownership for all project lands prior to the design and implementation phase of the project. Locations for access, staging areas, and construction easements have not been specifically determined yet, however, the city's ownership in most locations provides area excess to the project footprint which could allow for access, construction, and staging with minimal need to secure such rights from other neighboring landowners.

The Section 1135 project will require a total of 55 acres of fee-owned land. The project footprint in relation to the real estate parcels is shown in Appendix J. The number of tracts with the acreage for each fee acquisition required for the project will be determined during the design and implementation phase. Estimated total base economic cost for LERRDs is $924,000, plus a 14 percent contingency to account for inflation or market increases in land and other possible unknown factors and conditions in relation to the project footprint, for a total estimated cost of $1,053,800. However of the total LERRDs, the local sponsor will not receive credit for approximately 12 acres located within the existing FRM at an estimated

value of $159,000. These lands are assumed to have been part of the initial FRM project and therefore not eligible as credit under the Section 1135 project.

During the agency technical review of costs by the Cost Engineering Center of Expertise the contingency was changed to 20 percent. That contingency was applied to the costs of LERRDs less the amount that the sponsor has already received credit for ($924,000 - $159,000 = $765,000) for a total LERRD cost of $936,000 to be included in the Total Project Cost Summary.

7.5 Levee Setbacks

Levee setbacks are located in the area of Alternative KL1 and Alternative F. Feasibility level analysis shows that these do not impact flood protection for structures currently afforded protection by the FRM project. Detailed design and hydraulic modeling in the design phase will occur to confirm. Grading plans for these areas are shown in Appendix B.

It is assumed the setback location subsurface conditions are similar to the existing levee location and underseepage will not be an issue. An assessment will be made after completion of the boring and design, if needed, will be per EM 1110-2-1913 Design and Construction of Levees. The levee in area L1 would be analyzed for underseepage and settlement. The setback levee in area F1 is basically a freeboard levee and is not of a height great enough to warrant a design.

At least one boring will be performed for the L1 levee setback to assess foundation conditions. There is the potential that the levee would require mitigation for underseepage (berms, wells, cutoff).

7.6 Operation, Maintenance, Repair, Replacement, and Rehabilitation

The sponsor is responsible for OMRR&R of ecosystem restoration features. The OMRR&R activities were estimated by the PDT using professional judgment, taking into account prior experiences with other constructed projects. The project biologist estimated expenditures for OMRR&R for each riparian alternative including costs per acre for management of noxious weeds and invasive species. OMRR&R costs for in-stream alternatives were collaboratively estimated by the engineering and biologist team members.

Annual OMRR&R for riparian alternatives is estimated at $4,300. For riparian alternatives the following OMRR&R activities are expected:

- Weed management for such species as Canada thistle, teasel, Russian olive, crack willow, and reed canary grass on an annual basis.
- Maintaining the protection of plantings from beaver and deer, for a number of years.
- Fence replacement and repair over the economic life of the project.

Annual OMRR&R for in-stream alternatives is estimated at $60,000, which is equivalent to four percent of the first costs of the structures. For in-stream alternatives the following OMRR&R activities are expected:

- Reshaping of rock riprap and/or material replacement resulting from major disturbances.
- Periodic removal of large woody debris that has accumulated on or around the in-stream rock structures. In particular, if it is deemed to be disturbing to the structural or ecological function, it should be removed to reduce the risk of failure.
- Rock riprap may require occasional refurbishment due to normal settling or wear and tear on the rock structure.

Annual OMRR&R for recreation features is estimated at $8,165, which is equivalent to three percent of the first costs of the features. For recreation features the following OMRR&R activities are expected:

- Periodic replacement or repair of damaged trails, particularly the trails that are crossing the high flow channel of Goose Creek.
- Periodic removal of large woody debris that has accumulated on or around the new trails.

7.7 Summary of Plan Effects across Four P&G Accounts

Corps civil works decision documents evaluate, display, and compare alternative plans effects across all four Principles and Guidelines (P&G) accounts. The four accounts are: national economic development (NED), regional economic development (RED), environmental quality (EQ), and social well-being (other social effects, OSE). The following sections provide a discussion of the likely effect of the proposed plan on the four accounts.

7.7.1 National Economic Development

The National Economic Development (NED) account considers increases in the net value of the national output of goods and services, expressed in monetary units. They are the direct net monetary benefits that accrue in the planning area and the rest of the nation. Recommended ecosystem restoration measures and associated alternative plans do not need to exhibit net NED benefits, but are evaluated based on non-monetary outputs compatible with the P&G selection criteria. Although it is likely action alternatives would produce incidental NED benefits, for this study the main focus of increasing national value is by contributing to the nation's ecosystems through restored habitat. In addition, the net benefits associated with the proposed recreation alternative were evaluated and could be considered part of the national economic benefits associated with ecosystem restoration. The net annual recreation benefits associated with the proposed recreation plan are $234,653.

7.7.2 Regional Economic Development

Regional Economic Development (RED) account considerations are factors affecting the Sheridan regional economy while not necessarily affecting national economic development. For the purposes of the Sheridan Section 1135 Study, RED impacts have not been quantified, however it is expected that the proposed ecosystem restoration and recreation plans would have a positive impact on the regional economy due to both the direct construction activities associated with the proposed plan, as well as the on-going positive effect the restored area would have on improved quality recreation opportunity, and the overall environmental quality and desirability of the adjacent Sheridan urban area. For example, a positive impact on RED could be an increase in construction employment and income during the period of construction for the proposed ecosystem and recreation plans. There could also be a positive RED impact from an increase in local recreation activity and associated recreation expenditures, once the project is complete. In addition, habitat restoration on the system of creeks in Sheridan will add attractive aesthetics to the urban area increasing the desirability and livability of the nearby community.

7.7.3 Environmental Quality

An Environmental Quality (EQ) account evaluation was done, including defining resources, inventorying and forecasting resource conditions, and assessing and evaluating effects on those resources. No significant adverse effects would occur to significant EQ resources. Significant beneficial effects would occur to riparian habitat and in-stream habitat providing increases in habitat connectivity and benefiting international migratory birds and native species. These and other effects are described in Section 7.1 and Chapter 8.

7.7.4 Other Social Effects

The recommended plan would be a substantial financial commitment for the sponsor. The proposed recreational features would complement local plans and existing recreation features and would enhance community recreation experiences.

8.0 ENVIRONMENTAL COMPLIANCE AND SOCIAL EFFECTS

Corps civil works studies and projects should be in compliance with all applicable federal environmental statutes and regulations and with applicable state laws and regulations where the federal government has clearly waived sovereign immunity. The NEPA requires federal agencies, including the Corps, to comply with a process that includes the inventory and assessment of the environmental resources within the study area. The NEPA also requires the evaluation and comparison of alternatives to determine the impacts to those ecological, cultural, and aesthetic resources identified and investigated. Involvement by resource agencies and the general public during the study process is also required. Corps NEPA guidance can be found in ER 200-2-2. The NEPA process will be integrated with the Corps' six-step planning process. This should also include all measures required for compliance with other applicable environmental statutes, such as the ESA, the Clean Air Act, the Clean Water Act, the Fish and Wildlife Coordination Act, and the Historic Preservation Act, among others. This integration is intended to reduce process overlap and duplication. The integrated process helps assure that well-defined study conditions and well-researched, thorough assessments of the environmental, social, and economic resources affected by the proposed activity are incorporated into planning decisions.

This section addresses the ecosystem restoration components of no action and preferred action alternative, and assesses potential impacts to existing resources. There would be little difference between the environmental impacts of the recommended action and the alternatives that were eliminated as they propose the same types of activities, such as excavating, spreading topsoil, planting vegetation, sowing seeds, adding stream restoration features, enhancing fish passage, and restoring floodplain connectivity among other environmentally beneficial activities. Refer to prior sections of this report for a detailed description of the recommended plan.

8.1 Ecosystem Restoration Effects

In the description below all work being done to complete in-stream and riparian restoration will be collectively referred to as "ecosystem restoration." The ecosystem restoration measures with ancillary recreation features would be implemented in primarily urbanized areas. Therefore, the analysis of environmental consequences on individual resources (grouped together where logical) is broken out by resource below.

<u>Geology and Soils</u>
No action
Because no work would be completed, it is anticipated that no change to the geology of the area would occur under the no action alternative. Areas near the upstream end of Little Goose Creek, the disc golf course and Washington Park soils may be permanently disturbed and the surfaces may be converted into future development if no action is taken to restore the proposed areas. Increased soil erosion may occur during the developments of these hypothetical projects.

Proposed action – No effect anticipated to geology and soils.
Excavation associated with the implementation of the NER Plan would only disturb near-surface soils and is not anticipated to have any effect on the geology of the project area. Soil disturbance would result from site clearing, excavation and restoration activities throughout the project area. None of the areas proposed to be restored are considered prime farmland. All of the ecosystem restoration areas involve some excavating to increase the ability of hydrophytes to persist on restored wetland areas through groundwater interaction or the collection and slow conveyance of precipitation and runoff back to the Goose Creeks. Excavated topsoil would be stockpiled and spread out and revegetated with native plants. Areas that included monocultures of cattails, purple loosestrife, reed canary grass, phragmites and other invasive species would have to have the topsoil through the root zone removed and disposed of offsite in order to

successfully eradicate these species. Some topsoil may have to be hauled in if there is not at least 12 inches available from excavation at any given site.

There is the possibility as with any construction activity of spilling fuel, hydraulic fluid, or other unnatural materials. Care would be taken to inspect machinery, repair leaks and refuel at approved locations to minimize the likelihood of such accidents. A measurable loss in soil productivity and a contribution to air or water degradation would not occur as a result of implementing the proposed action.

Sediment Transport

No action

Because no work would be completed, the only changes to sediment transport would be those that are already occurring naturally or are caused by human intervention unrelated to the project (development, sediment removal, etc.).

Proposed action – No effect anticipated to sediment transport.

Proposed actions at all areas generally consist of restoring historically wet areas (in the floodplain) via excavation, removing invasive species, and planting native species. The impact to overall sediment transport due to these alterations is expected to be minimal. Best construction practices (use of silt fences, coir rolls, etc.) would be used to deter any inadvertent sediment moved during construction to enter the Goose Creeks. Some localized deposition may occur in the excavated areas during infrequent floods, but the magnitude of sediment deposition expected in these areas is negligible.

Fisheries and Water Quality

No action

It is anticipated if areas proposed for restoration are not restored, then they may be susceptible to residential, commercial, agricultural or industrial development. Depending on the exact type of land use these areas develop into, especially riparian areas A and B, increased impervious surfaces and hazardous fluids and other pollution associated with any development may enter the river and further degrade water quality. Non-point source pollution, in particular, is one of the leading causes of water quality degradation in the United States (EPA, 2005). Finally, an increase in stormwater runoff from more impervious surfaces inevitably contributes to continued water quality degradation. Some aquatic species that currently inhabit the river may not be able to tolerate further degraded conditions.

Proposed action – No effect anticipated to fisheries and wildlife.

All of the riparian restoration will be completed above the top of the banks of the Goose Creeks. However all of the in-stream restoration alternatives involve placing engineering structures below the banks of the Goose Creeks. These include typical vanes, J-hook vanes, cross-vanes, Newbury riffles and random boulder clusters. Depending on where they are in the creeks, the structures vary widely based on engineering design to optimize aquatic habitat without reducing the project's flood protection. Physical construction of each structure would probably take less than a day to complete. Impacts to the water column, substrate, turbidity and fish are not anticipated to be significant and would only be temporary in nature. It can be assumed fish would react to avoid the construction area of where the engineering structure is being placed in the creek.

Although not specifically formulated for, some incidental increases in water quality would likely occur as a result of restoring riparian wetland habitats that filter nutrients from upland stormwater runoff through both rural and urban areas. The in-stream measures would improve the water quality increasing DO, reducing temperature, providing depth diversity, creating low-flow channels for fish to pass during low water events and allow connectivity between Big Goose Creek and Goose Creek.

There is the possibility, as with any construction activity of spilling fuel, hydraulic fluid, or other unnatural materials, that they may drain into the river. Care would be taken to inspect machinery, repair leaks and refuel at approved locations to minimize the likelihood of such accidents.

Adverse effects to fisheries as a result of implementing the proposed project are not expected. This project should have positive effects on the fisheries in Goose Creeks.

Riparian Habitat, Vegetation and Wetlands

No action

If no action is taken to restore the prospective areas, it is likely that invasive and ornamental vegetation species will continue to out compete and take over these areas due to their ability to tolerate extreme variations in climate. Invasive and ornamental species provide little to no habitat value for wildlife that currently inhabit the areas. It is also anticipated if areas proposed for restoration are not restored, they may be susceptible to residential, commercial, agricultural or industrial development. An overall decrease in riparian habitat, vegetation and wetlands is likely to occur in order to facilitate this development.

Proposed action – No effect anticipated to riparian habitat, vegetation, and wetlands.

The purpose of ecosystem restoration is to improve the riparian habitat within the study area through the primary means of removing noxious, invasive and non-native vegetation and restoring it to a more natural condition by planting native species. The proposed project would increase emergent wetlands from 1.09 acres to 5.92 acres and scrub-shrub wetlands from zero acres to 7.76 acres. An additional 0.57 acres of native grasslands would be planted around proposed recreational amenities. Most of the lands being restored consist of introduced upland non-native grasslands. The floristic quality and associated beneficial functions of wetlands, such as filtering pollutants, nutrients, pesticides, trapping sediment, and stabilizing soils would increase throughout the project area. Temporary impacts may occur to existing wetlands as excavation occurs to remove invasive species and grade to target elevations that are needed to provide adequate hydrology to support planted native hydrophytes. This work would be completed under Section 404 Nationwide Permit #27, which allows the Corps to complete ecosystem restoration work under certain regional and special conditions. The state of Wyoming inherently certifies this action under its 401 water quality certification for all work completed under Nationwide Permits as long as the work is *not* being completed in a Class 1 waterway or riparian area. There are no Class 1 waterways within the project area.

No significant negative impacts to the riparian habitat, vegetation communities, including wetlands, are expected as a result of implementing the proposed ecosystem restoration project.

Wildlife

No action

It is anticipated that if areas proposed for restoration are not restored, they may be susceptible to residential, commercial, agricultural or industrial development. This would have the most negative impacts to wildlife in the non-developed proposed restoration areas A, B, L and M. If these areas were to be developed, the availability of *any* riparian habitat along the river within the project area would be reduced and wildlife would likely relocate to more suitable locations within the Front Range of the Big Horn Mountains.

Proposed action – No effect anticipated to wildlife.

One of the primary objectives of restoring the ecosystem at the proposed locations is to increase the availability of suitable habitat within the project area. Replacing invasive species with natives and planting more trees, shrubs and emergent vegetation will provide the habitat wildlife needs to forage, breed and rear their young. Temporary construction impacts to wildlife resulting from noise, disturbance

and displacement would occur during excavating and planting activities. All construction activities would take place outside of nesting seasons of migratory birds in order to minimize any impacts to nesting birds. No significant negative impacts to wildlife would occur as a result of implementing the proposed action.

Federally- and State-Listed Species (Biological Assessment)

No action

No federally-listed species are known to inhabit the project area and no direct or indirect effects are anticipated. Several state species of concern are noted as potentially being present in the project area. Environmental consequences would be similar to those described under the wildlife no action heading above.

Proposed action – No effect anticipated to federally or state listed species.

No direct or indirect effects on federally and state threatened, endangered or state special concern species would result from implementing the ecosystem restoration project.

One species, the black-footed ferret (*Mustela nigripes*), is listed as only existing in experimental areas in Wyoming and Section 7 consultation with the USFWS would only be required if the project were to occur on these lands owned by the USFWS and the National Park Service (NPS) for conducting these experiments. As the project area lies well outside these lands no effect is anticipated. See Appendix A8 for a letter from the USFWS stating no threatened, endangered or species being considered for listing are present within the project area.

Land Use

No action

All of the restoration alternatives are located on lands currently owned by the city of Sheridan. Areas A, B, F, K, L and M could be developed to accommodate residential, industrial and commercial interests. However, it is unlikely due to the high probability that residents would not accept development of these small green spaces. Area F, Washington Park, would likely remain a city park. Area C is a floodplain bench that is not suited for any type of habitable development. Areas L and M have the highest likelihood of potentially being developed for the previously mentioned interests. If the levee is not setback at Area L, the likelihood of anthropogenic development dramatically increases. If no action is taken to restore these areas, commercial, residential or industrial development may occur as the "open" areas are in Sheridan and are located in a desirable setting next to the river. If left undeveloped, the existing vegetative communities would likely further degrade by the formation of monocultures of invasive vegetation.

Proposed action – No effect anticipated to land use.

Implementing all of the riparian restoration measures in these undeveloped areas may prevent certain personal land uses with the exception of Area C and Area F, which is unsuited for habitable development and is a city park, respectively. Setting back the levee at Area L would deter any interest in developing this area and would reconnect this portion of the project with the floodplain of Goose Creek. Restoring all of these undeveloped areas provides certainty that they will remain undeveloped which will provide the citizens of Sheridan open green spaces that provide aesthetics, educational opportunities and potential recreational benefits within the city limits.

Environmental Justice

No action

Low-income, minorities or subsistence populations would experience no more adverse effects from the no action plan than any other human that may benefit from the restored areas. The universal impact would likely be the lack of being able to enjoy the restored areas. This may prevent all citizens from feeling connected to the river or caring about the riparian ecosystem.

Proposed action – No effect anticipated to environmental justice.
The human health or environmental effects to the residents in the proposed project area have not been identified to be disproportionately high or adverse on minority and low-income communities and Native American groups. The proposed action would not displace any residents. Although there are relatively low-income and high-minority populations in parts of Sheridan, they would not be expected to be disproportionately affected by the proposed ecosystem restoration.

Cultural Resources
No action
Cultural Resource Survey for the Sheridan, WY Section 1135 study (project) consisted of reviews of the National Register of Historic Places (NRHP), Wyoming Cultural Resource Information System database (WYCRIS), and a phone call to Wyoming SHPO staff. WYCRIS showed 11 recorded sites within the area of potential effects for the project. The no action alternative is not expected to have any effect on these areas. Additional information on the cultural resource assessment conducted for this study is located in Appendix E.

Proposed action – No adverse effect anticipated to cultural resources.
The proposed project in Sheridan, Wyoming will cause no adverse effect to historic properties. One property, eligible for listing on the National Historic Register of Historic Places, contains a segment of the river in downtown Sheridan and Little Goose Creek. The property which meets the criteria for listingis the concrete chute and associated structures, built by the Corps of Engineers for flood control,. There is no work planned these structures, therefore the project would not adversely affect the eligible property.

There are no other known eligible archeological sites or historic structures within the project area. The project area soils are greatly disturbed due to natural (floods, river meanderings), and human (rechanneling and development) activities, therefore any historic properties that may have been there will not contain the necessary criteria for significance. A letter to the Wyoming State Historic Preservation Office dated February 2, 2018 requested concurrence with the agency determination of No Adverse Effect to Historic Properties for the cultural portion of the proposed actions.

Air Quality and Noise
No action
Air quality and noise would remain at current levels if no action is taken to restore the ecosystem within the project areas because the level of human activity is not influenced by the proposed action.

Proposed action – No effect anticipated to air quality and noise.
Some minor and temporary impacts associated with construction machinery would occur through emissions from exhaust and noise associated with these machines. Weld County was designated as a non-attainment area for 8-hour ozone requirements in 2008; however, it has not recently exceeded these thresholds. The temporary operation of construction machinery (scrapers, front-end loaders, all-terrain vehicles, trucks, etc.) would not negatively attribute to the overall air quality. All construction would take place during regular work hours, Monday through Friday so impacts to noise levels should be negligible.

Flood Protection
No action
Flood protection levels provided by the existing FRM project would remain unchanged if no action is taken to restore the ecosystem in the Section 1135 project because no modifications to existing FRM infrastructure would occur.

Proposed action – No effect anticipated to flood protection.

2-dimensional modeling (RAS) was performed on the stream realignment on Goose Creek that shows no rise hydraulic condition. The concrete channel was eliminated primarily due to an inability to model a no rise alternative within the available geometry that was cost-effective. A no rise analysis will be performed on the modified Big Goose Creek drop structure in the design phase once the design is finalized and should be easy to attain. Similarly, the in-stream habitat structures will be evaluated in detail during the design phase, but discussion with engineering team members indicates that certain structures will not result in a net increase in flood stages. The Newbury rock riffles are assumed to have a very slight increase in stage, but this increase can be offset by excavation of small areas along the channel next to each structure if needed, resulting in a no net rise.

8.2 Recreation Effects

The recreational features developed as part of the Corps' recreation alternative are oriented towards providing trail access to the restored areas, compatible with the ecosystem restoration objectives. Trails within NER areas would be designed to minimize human disturbance to plant and animal communities. Trail surface materials will be appropriate for the type of trail use the city prefers (pedestrian, bicycle, and/or equestrian use). These trail uses may differ by reach or location, to accommodate tie-ins to other nearby trails, thus materials such as a packed earthen trail and crusher fines path are planned for the trail. No negative effects to the human environment are anticipated. See Appendix H for more information regarding the recreation component of the project.

8.3 Environmental Statute Compliance

Rivers and Harbors Act
According to Corps Wyoming Regulatory Field Office, the Big Goose Creek, Little Goose Creek and Goose Creek are not jurisdictional waterways under Section 10 of the Rivers and Harbors Act. No further compliance is required and no effect would occur to any waters regulation by the Rivers and Harbors Act.

Fish and Wildlife Coordination Act (FWCA)
A scoping letter was sent to the USFWS on August 1, 2014 requesting the assistance of experts within the agency with regards to fish and wildlife resources within the project area as required under the USFWS. The Corps offered to fund their expenses to consider these resources. No response was received from the USFWS. A USFWS staff member called the Corps biologist on December 4, 2014 and stated that a letter with regards to ESA and FWCA would be drafted and mailed. No letter or further contact was received. Another follow-up phone call was made in December 2015 to again request that the USFWS provide comments on compliance with the FWCA. A final phone call was made in August 2017 again requesting any comments with regards to USFWS. Both follow-up attempts did not produce any documentation of comments or concerns. The Corps made a good-faith effort to offer funding and allow the USFWS to provide information with regards to the FWCA, but no feedback was received.

Section 401, 402 and 404 of the Clean Water Act (CWA)
Section 404 of the CWA governs the placement of dredged or fill material into waters of the United States. The restoration work would be completed above and below the OHWM of the Goose Creeks. Engineering structures (primarily rock) would be placed within the Goose Creeks to enhance and restore the modified system to establish a more natural fishery within the project area. This work is authorized under Nationwide Permit (NWP) #27. NWP #27 is a Section 404 permit revised by the Corps every five years which authorizes work to restore aquatic ecosystems, if completed in accordance with the general and special conditions attached to it. Further, the NWP specifically states the types of activities the Corps plans to undertake while completing this project as identified in the bullets below.

- Installation of current deflectors (e.g. vanes)
- Enhancement, restoration or establishment of riffle and pool stream structure

- Placement of in-stream habitat structures
- Modifications of the stream bed and/or banks to restore or establish stream meanders
- Backfilling of artificially made channels
- Installation of structures or fills necessary to establish or re-establish wetland hydrology
- Activities needed to re-establish wetland vegetation

In the state of Wyoming, Section 401 Water Quality Certifications are attached to any Nationwide Permit that a project is completed under. No additional permit application or documentation is needed to meet Section 401 requirements. Discharge of storm water resulting from construction activities that would disturb more than one acre of surface area requires a National Pollutant Discharge Elimination System permit under Section 402 of the CWA. A Stormwater Pollution Prevention Plan would be prepared prior to commencement of construction activities. The plan would address practices and measures required to control and reduce the amount of pollutants in storm water runoff.

Endangered Species Act

The proposed project would have no effect on federally-listed species or species considered for federal listing in the area of the project because none exist. These findings are described in further detail in Appendix A8 (correspondence from USFWS).

Wild and Scenic Rivers Act

Essentially, the Wild and Scenic Rivers Act protects and preserves wild and scenic rivers from development that would substantially change their wild or scenic nature. No wild and scenic rivers are within or near the project area. The closest wild and scenic rivers are west in the Yellowstone National Park. As such, no significant impacts would occur as a result of implementing the proposed action.

Clean Air Act

Air quality in the Sheridan area is "good," which means for all pollutants measured the air quality index is less than 50. Air quality is projected to remain the same or degrade slightly due to increases in urbanization and associated commercial/industrial construction over the 50-year period of analysis. The proposed action and all alternatives would have minimal and temporary adverse effects on air quality, due to exhaust from mobile construction equipment, over a period of one year.

Hazardous, Toxic, and Radioactive Waste Considerations

In accordance with USACE policy (ER 1165-2-132), construction of civil works projects in HTRW contaminated areas should be avoided where practicable. Additionally, the response to address contamination is the responsibility of the sponsor, not the government. An environmental investigation was completed by the USACE, Omaha District in 2015 in support of the Section 1135 Ecosystem Restoration Study. The investigation activities included a review of public records, interviews with city officials, and a visual survey of the project area. There are four total reaches within the project area. No concerns of HTRW impacts were found in three out of four reaches, including the Little Goose Creek Reach, Big Goose Creek Reach, and Goose Creek Reach. However, two areas were identified in the Downtown Reach. Since the downtown alternative was eliminated and there is no proposed work in that reach there are no known issues with HTRW for the recommended plan.

National Historic Preservation Act (NHPA)

Cultural Resource review for the Sheridan, WY Section 1135 study consisted of searches of the National Register of Historic Places (NRHP), formal file searches requested from the Wyoming State Historic Preservation Office and two Class III intensive cultural resource surveys covering: Goose Creek Reach, Big Goose Creek Reach, Little Goose Creek Reach, and the Downtown Chute Reach. A combined total of 58.42 acres were surveyed. One historic isolated resource and 20 historic sites were recorded. Nine of the

historic sites were previously identified and eleven were newly identified. Three of these sites, 48SH1444, 48SH1588, and 48SH1868, were recommended as eligible for inclusion in the National Register of Historic Places.

The planned project activities, to be completed in and near the creeks, will cause no adverse effect to any of the properties eligible or non-eligible.

Noise Control Act

According to EPA (2011), "the traditional definition of noise is 'unwanted or disturbing sound'." The units used in identifying noise are decibels (dB) on a logarithmic scale. Since human hearing is not equally sensitive to all sound frequencies, certain frequencies are given more "weight." These frequencies for human hearing are measured on the A-weighted scale (dBA). The EPA has set values that should not be exceeded. While the primary responsibility of regulating noise was transferred from the EPA to state and local governments in 1981, the Noise Control Act of 1972 and the Quiet Communities Act of 1978 are still in effect. The EPA published its *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* in 1974 to provide state and local governments with information to develop their own ambient noise standards.

The construction of the proposed project would be conducted during typical working hours and is expected to cause temporary increases in ambient sound within and adjacent to the project area. The use of heavy equipment or trucks would be the primary noise source during construction and excavation. The level of impact would vary by equipment type, duration of construction activity and the distance between the noise source and the receptor. No significant impacts are expected to occur as a result of implementing the proposed action.

Bald and Golden Eagle Protection Act

The National Bald Eagle Management Guidelines provide recommendations for avoiding disturbance to nesting sites consistent with the BGEPA and the MBTA. In this area, the nesting season runs from November 1st to July 31st. Accordingly, during this period, construction would avoid active nests by a maximum distance of 660 feet if the activity would be visible from the nest (USFWS, 2007b). A qualified biologist would coordinate with the USFWS Wyoming Ecological Services Field Office in Cheyenne, Wyoming, to survey the area prior to clearing and construction efforts, as well as if a nest is suspected in the project area. No adverse impacts are anticipated.

Farmland Protection Act

According to the U.S. Department of Agriculture (2017), area soils are poorly drained and may be considered prime farmland if they are drained, or protected from floods during the growing season, or irrigated. No prime farmlands exist within the project area; therefore, no negative impacts to farmland would occur.

Executive Order 11988 Floodplain Management

An Executive Order 11988 review has been conducted and completed on 07 November 2016 and is located in Appendix I. Continued reviews will occur in the design and implementation stages of the project. The Section 1135 Feasibility Study selected alternative will be located in and adjacent to the Special Flood Hazard Area. Coordination of project features and local floodplain management criteria must occur before project construction begins. Hydraulic modeling will occurring during the design phase to ensure that no net rise is obtained from pre-Section 1135 project conditions to post-Section 1135 project conditions. Depending on how the selected alternative might affect flood water surface profiles and floodplain boundaries, a Conditional Letter of Map Revision (CLOMR) may need to be obtained as part of the project.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (16 U.S.C. 703-712: Ch. 128 as amended) provides protection to migratory birds and prohibits the destruction of their active nests or nestlings. There are 23 birds on the migratory bird species list provided by the USFWS (see Appendix A8) for more information. Construction activities that would otherwise result in the taking of migratory birds, eggs, young, and/or active nests should be avoided and be completed outside the primary nesting season.

The active nesting season for most migratory bird species in Wyoming is between April 1st and August 15th, which coincides with the peak construction season. However, some birds are known to nest outside of the primary nesting period, and construction activities may occur any time of the year. Specific Wyoming nesting seasons to consider include the bald eagle (November 1st – July 31st), cliff nesting raptors (February 1st – July 31st), burrowing owls (March 15th – October 31st), osprey (March 15th – September 10th) and ground nesting birds (May 1st – July 31st).

Care would be taken during construction to avoid any disruption to migratory birds. Clearing and grubbing would be scheduled to occur outside the primary nesting period, August 16th to March 31st. If construction of the project has to occur during the primary nesting season or at any other time that may result in the taking of nesting migratory birds, a qualified biologist would conduct a field survey of the affected habitats to determine the absence or presence of nesting migratory birds. Surveys would be conducted during the nesting season and immediately preceding the proposed construction activities. Should nests or nestlings of migratory birds be identified, construction activities would be modified to avoid disturbance and the USFWS Wyoming Ecological Services Field Office in Cheyenne, Wyoming, would be contacted immediately for further guidance and assistance. If nests are active, activities that would directly impact the nest, or that would encroach close enough to cause adult birds to abandon the nest during the breeding season, would be restricted. No significant impact is anticipated, and in fact this is a major focus area of anticipated benefits with the potential of an overall, long-term benefit to migratory birds in this area.

Environmental Operating Principles (EOPs)

The proposed project integrated EOPs, as required, and affirms the Corps' commitment to ecosystem restoration. The integrated EOPs are:

- Strive to achieve environmental sustainability. Environmental sustainability will be advanced here by increasing the ability of the river corridor to perpetually inundate and form new habitat on flood plain lands, enabling plant community regeneration. Monitoring and adaptive management plans have been included to help achieve success.
- Consider environmental consequences. This feasibility study has considered environmental consequences not only by proposing restoration of past habitat values, but also through NEPA evaluation of any potential adverse effects of the final array of alternatives. This report contains a complete integrated environmental assessment of the proposed action and primary alternatives.
- Seek balance and synergy. The ecosystem restoration project would seek balance and synergy by restoring hydrologic connectivity between the river and its floodplain riparian community, so that it can interact beneficially with the riparian community.
- Accept responsibility. Accountability has been established by stating clear and measurable objectives to be met for each proposed project measure, by identifying the respective responsibilities of the Corps and the sponsor in this report, and by providing for monitoring and adaptive management which allows the Corps' action to ensure project success.
- Mitigate impacts. The proposed ecosystem restoration project has been formulated to require no formal mitigation. The ecosystem restoration project would instead improve environmental conditions at the site.

- Understand the environment. Improved understanding of environmental and cultural conditions was obtained from coordinating with a variety of expert resources such as the USFWS, WGFD, local experts, city of Sheridan staff, and others. The proposed ecosystem restoration and recreation project would increase public understanding of the environment.
- Respect others views. The study effort respected others views by inviting input from the general public and from affected agencies, and by incorporating to the extent feasible the input of those agencies and public who did provide input to this study.

8.4 Socioeconomic Impacts and Environmental Justice

Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations*, requires federal agencies to make achieving environmental justice part of its mission by identifying and addressing disproportionally high and adverse human health or environmental effects on minority and low-income populations. For this report, minority populations are defined as ethnic origins that include African Americans, American Indians or Alaska Natives, Asians, Hispanics or Latinos, and Native Hawaiian or other Pacific Islanders. Low-income populations are people living below the national poverty level.

The proposed project would not permanently displace any residents and would not disproportionately, adversely affect low-income, minority, or subsistence populations.

8.5 Cumulative Effects

Cumulative impacts are those that result from the added incremental effects of an action when taken in the context of the past, present and reasonably foreseeable future actions within a region. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. For this discussion, the cumulative impact assessment area (CIAA) includes the riparian area of the Goose Creeks from where it descends into the front range of the Big Horn Mountains until it reaches its confluence with the Tongue River.

<u>Effects of Past and Present Land Use</u>
The dominant past and present land uses include farming, grazing, rural and urban development, industrial operations and recreation. These uses have affected the following resources in the past or currently: soils, water resources, wetlands, threatened and endangered species, vegetation and invasive species, socioeconomics, wildlife, noise, cultural resources, and recreation.

Waterways, soils, vegetation and wetlands of the area have been disturbed by past and present farming, ranching, urban development and commercial / industrial operations. These activities have led to elimination or degradation of the riparian habitat by converting natural herbaceous, shrub and forested communities into farms, ranches and urban environments. More specifically, farms and ranches remove native vegetation, drain wetlands, apply chemicals, contribute to pollution (manure) in the river and overall contribute to declines in water quality and habitat availability. The primary impact of urbanization is the conversion of natural vegetation communities to impervious surfaces. These impervious surfaces nearly abut the river and provide conduits for sources of urban pollution to directly enter the river because of the lack of any riparian vegetative buffer. These intense land uses and conversions remove the diversity of habitat needed to support the foraging, breeding and rearing young habitat desired by many species known to inhabit riparian areas within the CIAA.

The Goose Creek system has been channelized within urban areas, and water from the river has been diverted to irrigate agricultural fields upstream of Sheridan, Wyoming. These modifications coupled with agricultural, ranching, wastewater treatment, flood control (concrete channel in downtown Sheridan),

recreation (concrete trails located immediately adjacent to river), pollution (contaminated runoff in urban areas, trash and debris disposal) associated with urban environments have reduced the water quality of the river and the overall availability of suitable riparian habitat within the CIAA. A decline in the presence of native fish species is probably attributed to increases in water temperature, degradation of water quality, altered flow regimes, loss of spawning habitat and the presence of migration barriers (WYGF, 2014). Riparian habitat is generally unavailable to wildlife within the urbanized areas due to the conversion of natural habitats to impervious surfaces and buildings. Agricultural use in rural areas has further fragmented suitable habitat by draining wetlands and removing native vegetation in order to plant crops. This has likely caused local population declines or shifts for some native wildlife and plant and animal species that prefer disturbed habitats.

Noise levels have risen commensurate with the level of farming, urban development and recreation within the CIAA, and encroached into what used to be relatively quiet riparian habitats. Socioeconomics have benefited from development activities and recreational opportunities in the area.

9.0 IMPLEMENTATION

9.1 Design and Implementation Phase Overview

The feasibility study phase was cost-shared 50-50 between the Corps and the city of Sheridan as the non-federal study sponsor. After final report approval, study cost-share accounts are balanced and closed.

Design and implementation require new authorization and cost share sponsorship. Sheridan is the intended design and implementation sponsor. Sheridan has provided a Letter of Intent attesting that it is ready, willing, and able to sponsor the projects. Sheridan also provided a Statement of Financial Capability (see Appendix X), stating that it is aware of the financial obligations of sponsorship for the projects and would have the financial capability to satisfy those obligations.

The Corps would be responsible for all design plans and specifications, with potential work in-kind by the sponsor. The Corps would advertise the construction contract, most likely using full and open invitation for bids. The Corps would supervise all construction; except that portions of the construction could be performed by the sponsor as work-in-kind, credited toward its cost share, if specified in the project partnership agreement (PPA) and preapproved by the Corps.

As the prospective sponsor, the city of Sheridan would agree to comply with applicable federal laws and policies, including performing the following items of local cooperation:

a. Provide 25 percent of total ecosystem restoration costs as further specified below:
    1. Provide 25 percent of design costs allocated by the government to ecosystem restoration in accordance with the terms of a PPA entered into prior to commencement of design work for the ecosystem restoration features of each project.
    2. Provide all lands, easements, and rights of way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements on lands, easements, and rights of way needed to enable the disposal of dredged or excavated material as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features.
    3. Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 25 percent of total ecosystem restoration costs.

b. Provide 50 percent of total recreation costs as further specified below:
    1. Provide 50 percent of design costs allocated by the government to recreation in accordance with the terms of the PPA entered into prior to commencement of design work for the recreation features.
    2. Provide all lands, easements, and rights of way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights of way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the recreation features.
    3. Provide, during construction, any additional funds necessary to make its total contribution for recreation equal to 50 percent of total recreation costs.

c. Provide, during construction, 100 percent of the total recreation costs that exceed an amount equal to 10 percent of the federal share of total ecosystem restoration costs.

d. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project unless the federal agency providing the funds verifies in writing that such funds are authorized to carry out the project.

e. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights of way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function.

f. Not use the ecosystem restoration features or lands, easements, and rights of way required for such features as a wetlands bank or mitigation credit for any other project.

g. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms.

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights of way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

i. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government.

j. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project.

k. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors.

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20.

m. Comply with all the requirements of applicable federal laws and implementing regulations, including, but not limited to: Title VI of the Civil Rights Act of 1964, Public Law 88-352, as amended (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant

thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Army Regulation 600-7 issued pursuant thereto; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*).

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights of way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction.

o. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights of way that the federal government determines to be required for construction, operation, and maintenance of the project.

p. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

9.2 Implementation Schedule

Upon Northwestern Division USACE approval of the feasibility study report, a PPA would be executed for the design and implementation phase of the project, and design and implementation would commence. The estimated schedule for design and implementation is based on the assumption that the feasibility report is approved by Northwestern Division USACE in FY17, and the PPA is signed by the Corps and city of Sheridan in FY17. Table 40 identifies the estimated schedule for implementation.

Table 40. Estimated implementation schedule

Design period	11/1/2017 - 10/30/2018
Contract award	11/30/2018
Construction start date	12/1/2018
Estimated construction end date	5/1/2020
Estimated construction duration	~515 calendar days

9.3 Costs and Cost-Sharing

A summary of the financial cost-sharing for the Recommended Plan is provided in Table 41. The real estate costs in the table are only lands for which the sponsor has not received credit in the past.

Table 41. Recommended Plan financial costs, federal and non-federal (FY17 Price Level)

Item	Federal Cost	Non-Federal Cost	Total Cost
Feasibility Study	$ 425,000	$ 325,000	$ 750,000
Ecosystem Restoration (ER)			
Design	$ 631,500	$ 210,500	$ 842,000
LERRD*	$ 0	$ 936,000	$ 936,000
Ecosystem Restoration Features	$ 4,223,750	$ 276,250	$ 4,500,000
ER Subtotal (75:25 cost-share)	$ 4,708,500	$ 1,569,500	$ 6,278,000
Recreation (REC)			
Design	$ 0	$ 0	$ 0
LERRD	$ 0	$ 0	$ 0
Recreation Features	$ 171,000	$ 171,000	$ 342,000
REC Subtotal (50:50 cost-share)	$ 171,000	$ 171,000	$ 342,000
Total Financial First Cost (ER and REC)	$ 4,879,500	$ 1,740,500	$ 6,620,000

*Land values estimated at $239,500 within the existing FRM project was credited to the sponsor for providing real estate when the initial project was built in the 1960's. These lands are not creditable for a second project within the same project footprint.

9.4 Monitoring and Adaptive Management

After initial construction activities are complete, monitoring and adaptive management are necessary to address uncertainties and ensure project success. Success criteria were defined based on specific hypothesis, which were formed based on the goals of the project. Monitoring activities were identified to determine whether the project met these success criteria, and adaptive management actions were designed to redirect the restoration effort in the event that the restored areas do not perform as predicted.

The goal of monitoring is to assess project performance and to determine if the goals of the project are being attained. Monitoring methodology, measures for ecological successes, and other information are located in Appendix A9. Monitoring occurs following construction and will occur annually for up to five years. It will include hydrologic monitoring and vegetation monitoring. Monitoring is estimated to cost $10,000 per year for the monitoring period. This is part of the total project cost shared between the Corps and the sponsor. Implementation responsibilities for the monitoring plan will be identified in the PPA.

It is a Corps requirement that ecosystem restoration projects include monitoring, for assessing performance and determining whether adaptive management is needed to attain project benefits. The purpose of adaptive management is to make changes to the project after construction in order to better achieve the project objectives. Omaha District in consultation with the sponsor, federal and state agencies, and the Corps Division office will determine any adaptive management that may be needed. Adaptive management would need concurrence from the sponsor and would be cost shared with the sponsor. Monitoring and adaptive management are not the same as inspections or operation and maintenance for which the sponsor would be responsible even during the monitoring period.

10.0 RECOMMENDATIONS

I recommend implementation of the recommended plan described in this integrated Feasibility Report and Environmental Assessment for the Sheridan, Wyoming Section 1135 Ecosystem Restoration Project. The recommended plan consists of six riparian restoration alternatives and 11 in-stream restoration alternatives. The recommendations encompass areas on Little Goose Creek, Big Goose Creek, and Goose Creek. Specific components of restoration recommended for implementation include in-stream habitat structures to benefit the aquatic environment in the system of creeks, modification to a drop structure to allow for improved fish passage between Goose Creek and Big Goose Creek, and riparian habitat restoration adjacent to the creeks. The project restores depth diversity and geomorphic substrate to palustrine wetlands located in the floodplain of the creeks. The ecosystem restoration plan calls for placement of rock habitat structure in the creeks, excavation, grading, plantings, and seeding, at a first cost of $6,620,000, including real estate interests.

Stream restoration benefits include restoration of 14,881 feet of existing low quality stream channel to a higher quality and creation of 845 feet of stream channel through improvement to channel sinuosity. Wetland restoration benefits include restoration of 4.83 acres of palustrine emergent wetland habitat and 7.76 acres of scrub-shrub wetland habitat. The recommended plan also opens up a migratory pathway connection for fish by improving the gradient of the existing drop structure from having drops from one to three feet high to drops of 0.4 feet across the entire length of the structure. The recommended plan provides 17 net total average annual habitat units. The average annual cost per unit of habitat is $52,549. This plan is recommended with full support from the non-federal sponsor. It also carries wide ranging support from local and state agencies and the public.

Recreation features ancillary to the ecosystem restoration component complement restoration work. Recreation features resulting from the recommended plan include 2,200 feet of trails providing new access, two interpretive educational signs, and one bench near the proposed trails. These recreational features provide connectivity to existing recreational facilities in the community. These features will provide recreation benefits to this community of 17,000 with a benefit to cost ratio of approximately 10.8 to 1.

The estimated cost-shared total for project implementation is $6,620,000. Of the total cost, $936,000 is for land, easement, rights-of-way, relocation, and disposal costs, for which credit will be given to the sponsor. Of the total cost, the federal portion is approximately $4,879,500 and the non-federal portion is approximately $1,740,500. Of the total non-federal portion, approximately $804,500 will be provided in cash and $936,000 will be provided in land, easement, rights-of-way, relocation, and disposal costs. Estimated average annual cost for operations, maintenance, repair, replacement, and rehabilitation is $63,835 for ecosystem restoration and $8,165 for recreation.

I have given consideration to all significant aspects in the overall public interest. Aspects considered include environmental, social, and economic effects, engineering feasibility, the unique capabilities and strengths of the Corps to study, design, and implement such a project, capabilities and interests of the cost-share sponsor, and other elements. The non-federal sponsor, the city of Sheridan, has stated that prior to implementation it will, through signing of the Project Partnership Agreement, agree to perform the required items of cooperation including provision of all needed real estate interests, provision of cash as needed beyond real estate values to constitute its share of total costs, and post-construction operation and maintenance of the project.

I recommend that the plan proposed herein for aquatic ecosystem purposes and related recreation purposes be approved and implemented through the Section 1135 program. This recommendation reflects

the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch.

John L. Hudson, P.E.
Colonel, Corps of Engineers
District Commander

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