US Army Corps of Engineers
Detroit District

FEASIBILITY STUDY FOR THE BOARDMAN RIVER

GRAND TRAVERSE COUNTY, MICHIGAN

DETAILED PROJECT REPORT

GREAT LAKES FISHERIES AND ECOSYSTEM RESTORATION PROGRAM

June 2014

US Army Engineer District, Detroit
477 Michigan Avenue
Detroit, MI 48226-2523

EXECUTIVE SUMMARY

The Feasibility Study of the lower Boardman River was conducted to address justification and desirability of restoring the limited resource, coldwater aquatic habitat in the Boardman River and improving ingress and egress of valued fish species to and from West Grand Traverse Bay of Lake Michigan. The Study evaluates opportunities to restore the Boardman River habitat, a Great Lakes tributary, by modifying or removing three dams along the waterway, singly or in combination. This study was undertaken as an Ecosystem Restoration Project under Section 506 authority (Great Lakes Fishery and Ecosystem Restoration) of the Water Resources Development Act of 2000. Great Lakes tributary habitats are a high priority of that legislation.

The Boardman River flows into West Grand Traverse Bay of Lake Michigan at Traverse City, Michigan. Grand Traverse County encompasses Boardman Lake, Sabin Pond, and Boardman Pond. Grand Traverse County is adjacent to Kalkaska County, which contains a large portion of the upper North and South Branches of the Boardman River. The majority of the Boardman River is a high-quality coldwater trout stream that has been degraded in its lower reaches as a result of habitat conversion resulting from the construction of dams formerly producing hydroelectricity. These dams have replaced the coldwater ecosystem throughout the lower reaches of the river through habitat fragmentation, habitat degradation, thermal disruptions, and thermally induced species disruptions. The dam-created impoundments and river hydraulics currently support a warmwater fishery and associated terrestrial species. The dams have also created a barrier between the river and West Grand Traverse Bay of Lake Michigan and preclude tributary spawning, foraging and protection for Great Lakes species.

The project objectives include reconnecting and restoring Great Lakes tributary habitat (i.e., the Boardman River), allowing movement of woody debris and sediment materials through the river system, negating thermal disruption, and restoring the natural balance between coldwater and coolwater species. These objectives shall be accomplished without transporting pollutants into West Grand Traverse Bay of Lake Michigan, losing flood protection, negatively impacting existing infrastructure, or allowing upstream migration of aquatic invasive species, particularly sea lamprey. Inherent in these objectives is a reduction in existing warmwater habitat in the impoundments. Compared to coldwater habitat, warmwater habitat is abundant in the area near the project; there are over 100 warmwater lakes in Grand Traverse County and Kalkaska County and more than 11,000 inland lakes in the State (MDNR 2012b) of which the vast majority are warmwater lakes. Conversely, less than 20 percent of rivers in Michigan's Lower Peninsula have coldwater characteristics (Seelbach et. al 1997). Conversely, less than 20 percent of rivers in Michigan's Lower Peninsula have coldwater characteristics (Seelbach et. al 1997). Coldwater streams naturally tend to have higher densities of game fish and other aquatic species and provide spawning grounds and nursery areas for Great Lakes species. These factors support the importance of protecting and restoring coldwater tributaries of the Great Lakes. Because there is an abundance of warmwater habitat in the surrounding areas, the opportunity to increase the rare, coldwater habitat takes precedence over the warm water habitat that is currently prevalent in the project area.

Eight alternative combinations of dam removal and modification measures- including a baseline No Action alternative- underwent Cost-Effectiveness and Incremental Cost Analyses based on their costs and their outputs in habitat quantity and quality in the Boardman River. Each alternative also underwent a habitat/species Trade-Off Analysis and other evaluations to determine a selected alternative. Habitat suitability index models were used to derive average annual habitat units for species, and the Michigan Rapid Assessment Method was used to evaluate wetland outputs.

The selected alternative consists of retaining the Union Street Dam to deny passage to the lamprey, creating a trap-and-transfer operation for transporting desirable fish from West Grand Traverse Bay of Lake Michigan further up the Boardman River, and modifying the existing fish ladder to include adult sturgeon in the downstream migration around the dam. In addition, the Sabin and Boardman Dams would be removed, allowing a free-flowing river to be restored upstream of the Union Street Dam.

The selected alternative would provide 8 miles of continuous stream habitat for coldwater species by eliminating dam impoundments and allowing for the movement of coldwater species throughout the length of the Boardman River upstream of the Union Street Dam. The conversion of the impoundments to riverine habitat would provide more usable habitat to various coldwater species, including the target species of brook trout, longnose dace, and lake sturgeon by lowering water temperatures and increasing the current.

The selected alternative is supported by Grand Traverse County and the City of Traverse City, the Michigan Department of Natural Resources, the U.S. Fish and Wildlife Service, and the Michigan Department of Environmental Quality.

At present, a Preliminary Finding of No Significant Impact (FONSI) is recommended, but a final decision regarding the need for an Environmental Impact Statement would be made after a review of all comments received during public review.

Total project costs are projected to be approximately $13,223,000. Planning, design, construction, and monitoring costs would be shared between the Federal and non-Federal sponsor up to a Federal cap of $10 million. All costs above this and the operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) would be the responsibility of the non-Federal sponsor.

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List of Acronyms and Abbreviations

˚F	degrees Fahrenheit
AAC	Average Annual Cost
AAHUs	Average Annual Habitat Units
ANS	aquatic nuisance species
BRDC	Boardman River Dams Committee
CE/ICA	Cost-Effectiveness / Incremental Cost Analysis
cfs	cubic feet per second
DCC	Direct Contact Criteria
DDR	Design Documentation Report
DO	dissolved oxygen
DWPC	Drinking Water Protection Criteria
ECT	Environmental Consulting & Technology, Inc.
EFS	Engineering and Feasibility Study
ESL	EPA Ecological Screening Level
FERC	Federal Energy Regulatory Commission
FY	fiscal year
GLEC	Great Lakes Environmental Center, Inc.
GSIPC	Groundwater/Surface Water Protection Criteria
HDPE	high-density polyethylene
HSI	Habitat Suitability Index
IDF	Inflow Design Flood
IT	Implementation Team
IWR	Institute for Water Resources
LERRDs	lands, easements, rights-of-way, relocations, and sediment placement areas
MCACES	Micro-Computer Aided Cost Estimating System
MDEQ	Michigan Department of Environmental Quality
MDL	method detection limit
MDNR	Michigan Department of Natural Resources
MiRAM	Michigan Rapid Assessment Model
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
OMRR&R	operations, maintenance, repair, replacement and rehabilitation
OSA	Office of the State Archaeologist
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	Probable Effect Concentration
PMF	Probable Maximum Flood
PPA	Project Partnership Agreement
SHPO	State Historic Preservation Office
TEC	Threshold Effect Concentration
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VE	Value Engineering
WRDA	Water Resources Development Act

1 Introduction

The following section provides information on the project study authority, background, study area, purpose and scope, and a list of prior studies and reports used to support this document.

1.1 Study Authority and Guidance

The Feasibility Study for the Boardman River was conducted under the authority of Section 506 (Great Lakes Fishery and Ecosystem Restoration Program) of the Water Resources Development Act (WRDA) of 2000 (Public Law 106-541), directing the Secretary of the Army to “plan, design, and construct projects to support the restoration of the fishery, ecosystem, and beneficial uses of the Great Lakes.”

Study guidance was provided in the memorandum Subject: Great Lakes Fishery and Ecosystem Restoration Program – Guidance for Implementation of Section 506 of the Water Resources Development Act (WRDA) of 2000, dated 12 December 2001. This guidance was further amended by Assistant Secretary of the Army (Civil Works), ASA(CW), memorandum date 10 June 2011: Subject: Implementation Guidance for the Water Resources Development Act of 2007 (WRDA 2007) – Section 5011, Great Lakes Fishery and Ecosystem Restoration Program.

The current Project Management Plan defines the scope of the decision document and the approval authority (URS Corporation 2012).

1.2 Study Background

The Feasibility Study for the Boardman River was conducted by the Detroit District, U.S. Army Corps of Engineers (USACE) in coordination with the non-Federal sponsor, Grand Traverse County. This study was first initiated as a Section 206, Ecosystem Restoration Project under the USACE Continuing Authorities Program; however, as a result of funding constraints within the Continuing Authorities Program, as well as the study’s strong emphasis on fisheries, the USACE and non-Federal sponsor determined that the study was best pursued under Section 506 authority (Great Lakes Fishery and Ecosystem Restoration) of the WRDA of 2000. A Preliminary Restoration Plan was subsequently prepared under that authority in fiscal years (FYs) 2005 and 2006, resulting in a determination that sufficient Federal interest exists to recommend that the study continue into the Feasibility Phase.

The Boardman River is a high quality coldwater trout stream that is degraded in its lower reaches as a result of the presence of dams. Restoration of the Boardman River and the disposition of the dams along its length have been the subjects of studies and planning efforts for nearly a decade. At the beginning of this study, there were four dams located in approximately 20 river miles, from the mouth of the Boardman River in Grand Traverse Bay to the Brown Bridge Dam, located at river mile 18.5. In 2005, Traverse City Light and Power determined that producing hydropower at the Sabin, Boardman, and Brown Bridge Dams was no longer economically feasible. The dams’ owners—the City of Traverse City and Grand Traverse County—organized the Boardman River Dams Committee (BRDC) to gather community feedback, encourage community involvement, and manage an Engineering Feasibility Study (EFS) to assess the environmental, economic, and social benefits and detriments of retaining, modifying, or removing the Boardman River dams. That study, concluded in 2009, recommended the removal of the Sabin, Boardman, and Brown Bridge Dams, and the modification of the Union Street Dam to enhance fish passage.

The BRDC is led by an Implementation Team (IT), which makes recommendations concerning the dams. The IT represents dam owners and interested organizations and agencies, including:

- Grand Traverse Band of Ottawa and Chippewa Indians
- City of Traverse City
- Grand Traverse County
- Michigan Department of Natural Resources (MDNR)
- Michigan Hydro Relicensing Coalition
- Traverse City Light and Power
- U.S. Fish and Wildlife Service (USFWS)
- Conservation Resource Alliance
- Grand Traverse Conservation District
- Grand Traverse County Road Commission
- Rotary Camps and Services
- Watershed Center Grand Traverse Bay

The current Boardman River Feasibility Study follows the Section 506 process to determine the most cost-effective alternative to meet project objectives. In its original conception, this study included in its project area the Brown Bridge Dam and its impoundment. However, in November 2011, Traverse City informed the USACE that the Brown Bridge Dam would be removed in 2012. Consequently, the project area was altered to include only the Union Street, Sabin, and Boardman Dams. The Brown Bridge Dam was removed in fall of 2012.

Restoration of habitat has been identified as a high priority for the entire Great Lakes Basin via the support plan for the Great Lakes Fishery and Ecosystem Restoration (GLFER) program. The presence of the dams and their resulting impoundments disrupt the natural thermal regime of the river and create warmwater habitat. Project objectives, discussed in detail in Section 3, include restoring coldwater habitat and restoring internal connectivity of habitat for coldwater species.

Implicit in these objectives is a reduction of warmwater habitat that exists in the impoundments. Compared to coldwater habitat, warmwater habitat is abundant near the project area. There are over 100 warmwater lakes in Grand Traverse County and Kalkaska County and more than 11,000 inland lakes in the State (MDNR 2012b) of which the vast majority are warmwater lakes.

Conversely less than 20 percent of rivers in Michigan's lower peninsula have coldwater characteristics (Seelbach et. al 1997).

1.3 Study Area

Located in the northwestern portion of Michigan's Lower Peninsula, the Boardman River originates in central Kalkaska County and flows southwest into Grand Traverse County where it turns north and flows into the West Grand Traverse Bay of Lake Michigan at Traverse City. The Boardman River Watershed drains 291 square miles of surface area and includes 179 lineal stream miles and 12 natural lakes. The Boardman River is designated a Natural River and considered among the "top ten" trout streams in Michigan, containing nearly 36 lineal miles of Blue Ribbon Trout Stream. This is a designation made by the State government or other authority identifying a recreational fishery of very high quality, considering criteria such as water quality and quantity, accessibility, spawning capacity, angling pressure, and specific species. The Boardman River Valley provides an attractive destination for outdoor recreation such as fishing, canoeing, hiking, camping, hunting, and wildlife viewing. These activities are enjoyed by area residents and are a major draw for tourists to the Traverse City region.

For the purpose of this study, the "study area" and "project area" refer to two different expanses. The "study area" (**Figure 1**) represents the entire environmental and socio-economic context of the Grand Traverse County. The project area (**Figure 2**) includes three distinct areas that are within the lower 8 miles of the Boardman River's main stem. The three areas include the area immediately around Union Street Dam and the areas around Sabin and Boardman Dam that include the dam and impoundment. All three locations are within Grand Traverse County. This is the area that would be directly impacted by any action at the dams. Within the project area there are three dams along the waterway: the Union Street Dam at river mile 1.1, the Sabin Dam at river mile 5.3, and the Boardman Dam at river mile 6.1.

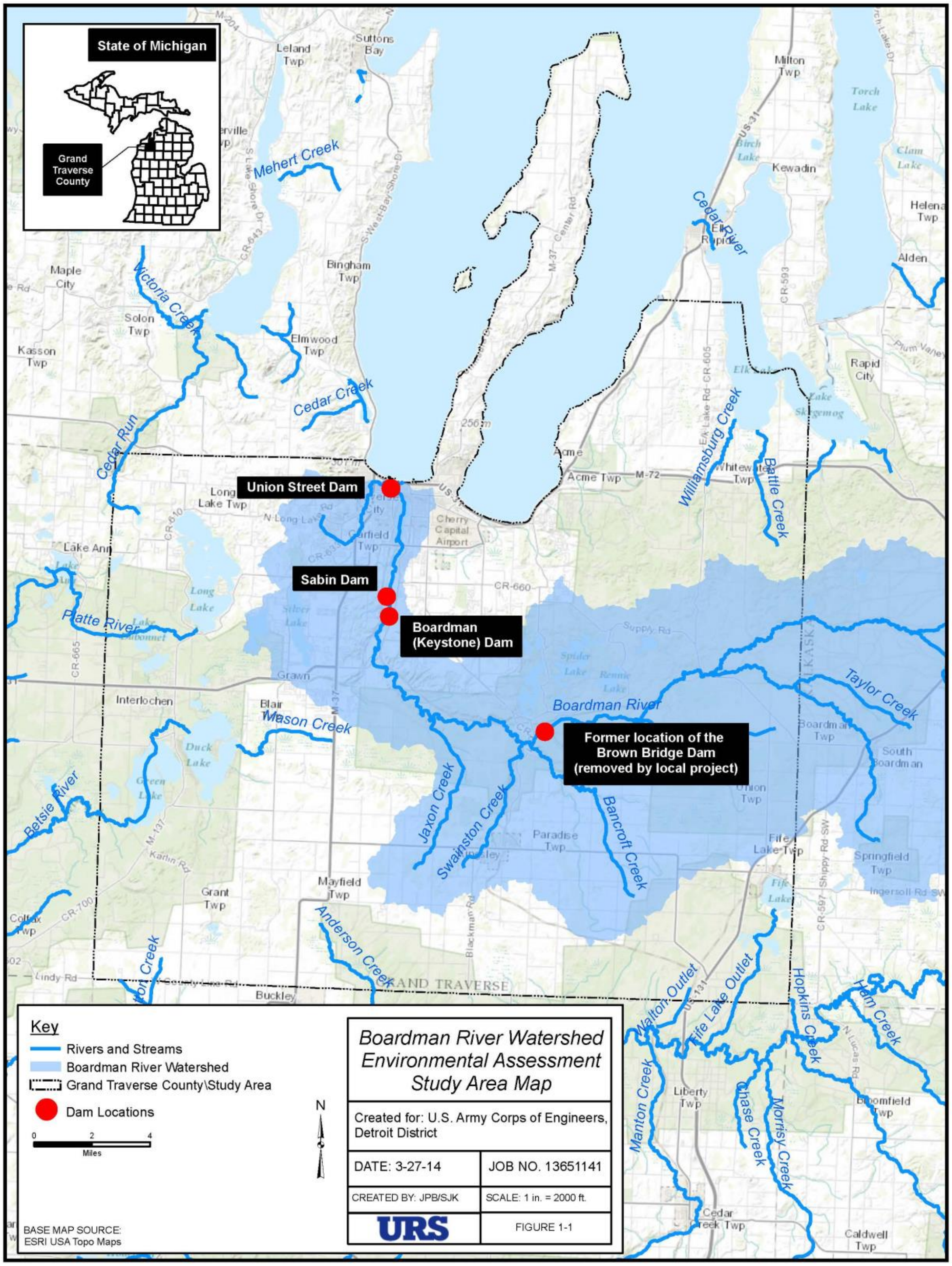

Figure 1: Boardman River Feasibility Study-Study Area

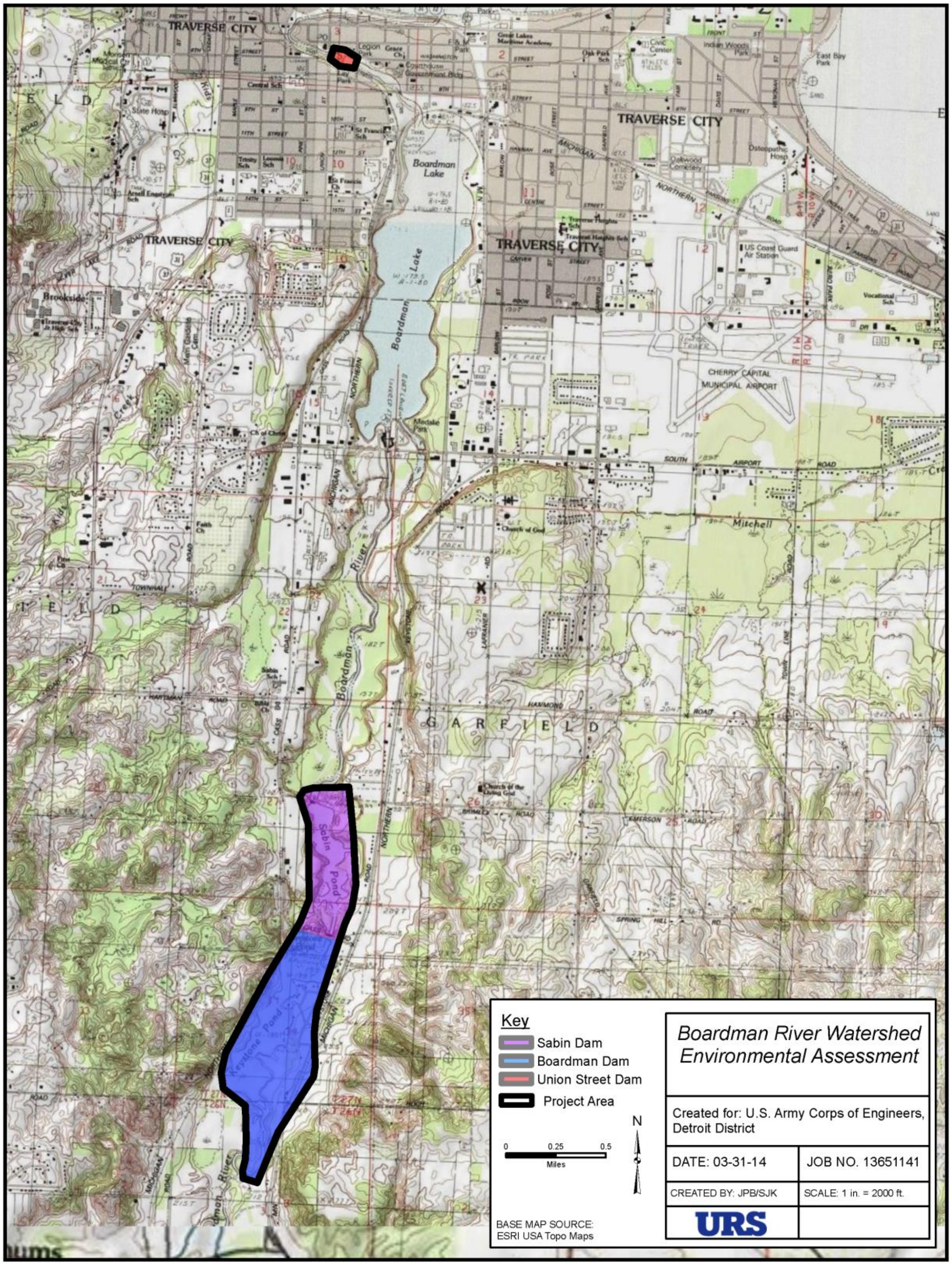

Figure 2: Boardman River Feasibility Study-Project Area

1.4 Study Purpose and Scope

This Feasibility Study—developed concurrently with an Environmental Assessment—addresses the need for and desirability of undertaking actions to restore coldwater aquatic habitat in the Boardman River. The purpose and scope of the Feasibility Study were to evaluate opportunities to restore tributary habitat for fish in the Boardman River by modifying or removing the dams, individually or in combination.

To supplement this Feasibility Study, there are six appendices attached to the Detailed Project Report. These appendices include: **Appendix A: Engineering**; **Appendix B: Economic Analysis**; **Appendix C: Cost Engineering**; **Appendix D: Real Estate Plan**; **Appendix E: Habitat Analysis**; and **Appendix F: Monitoring Plan**. These attachments are referenced throughout this document. This Detailed Project Report is also accompanied by an **Environmental Assessment**.

1.5 Prior Studies and Reports

The development of the Feasibility Study for the Boardman River was informed by numerous studies, reports, data sets, and other materials produced in recent years. This includes work under Section 506 authority, products associated with the separate and complementary Boardman River Dams Disposition project, and other relevant materials. The 2009 Boardman River Dams EFS completed by the BRDC was a primary data source. **Table 1** identifies 24 key documents reviewed for this study.

Table 1: Prior Studies and Reports

Publication	Date	Author	Component of BRDC Engineering Feasibility Study
Environmental Inspection Report for Sabin Dam	May 2002	Federal Energy Regulatory Commission	No
Grand Traverse Bay Watershed Protection Plan Update	December 2005	Watershed Center of Grand Traverse Bay	No
Preliminary Restoration Plan for the Boardman River Main Stem	February 2006	U.S. Army Corps of Engineers (USACE)	No
Boardman River Riparian Zone Wildlife Presentation	August 2007	Boardman River Dams Committee (BRDC)	No
Boardman River Hydraulic Model Report	April 2008	USACE	No
Economic and Social Analysis of the Boardman River Dams; Qualification of Existing Information	July 2008	Environmental Consulting and Technology, Inc. (ECT)	Yes
Public Opinion Survey Background	September 2008	BRDC	No
Safety Inspection of Brown Bridge Dam	September 2008	City of Traverse City	No
Safety Inspection of Union Street Dam	September 2008	City of Traverse City	No
Recommendations Concerning Alternative Futures for the Boardman River Dams	December 2008	BRDC	Yes
Boardman River Dams Breach/Drawdown Study	January 2009	Prein & Newhof	Yes
Boardman Dam Alternative Study	January 2009	Prein & Newhof	Yes
Detailed Analysis of the Effect on Wetlands	January 2009	ECT	Yes
Detailed Analysis of Alternatives	January 2009	ECT	Yes
Economic and Social Analysis of the Boardman River Dams; Evaluation of Available Information	January 2009	ECT	Yes
Preliminary Engineering Evaluation of Existing Structures	January 2009	ECT	Yes
Boardman River Fisheries Existing Data	January 2009	ECT	Yes
Boardman River Fisheries Habitat Survey and Data Collection	January 2009	ECT	Yes
Existing Sediment Chemistry Data	January 2009	ECT	Yes
Summary of Terrestrial Habitats in the Boardman River Watershed	January 2009	ECT	Yes
Wetland Determination Report	January 2009	ECT	Yes
Interim Report on Boardman River Wildlife Data	January 2009	ECT	Yes
Boardman River SIAM Modeling Base-case Scenario	May 2009	USACE	No
Brown Bridge Dam Removal Environmental Assessment	March 2012	U.S. Fish and Wildlife Service	No

2 Existing Conditions and Future Without-Project Conditions

Despite its attributes as an outstanding coldwater recreational fishery, the Boardman River System's ecological integrity is compromised by the presence of the three dams within an 8.5-mile section of the river's main stream that comprises the project area. The presence of these dams disturbs the Boardman River ecosystem through habitat fragmentation and degradation, sediment movement, and thermally induced disruptions that adversely affect overall species diversity.

This section of the report describes existing environmental and socioeconomic conditions in the study area and assesses likely future conditions if no project were undertaken to address the identified problems and opportunities in the proceeding sections.

2.1 Existing Conditions

The existing environmental and socioeconomic conditions descriptions represent conditions with all dams in place, which was the case as the evaluations were conducted. The Future Without-Project Conditions described in **Section 2.3** reflect the removal of the Brown Bridge Dam by local authorities.

2.1.1 Land Use and Recreational Resources

The main types of land cover found within the project area are water, wooded wetland, forest, and residential development (**Table 2**). Agriculture and commercial services account for a small fraction of the land use.

Grand Traverse County encompasses Boardman Lake, Sabin Pond, Boardman Pond and formerly Brown Bridge Pond. Grand Traverse County is adjacent to Kalkaska County, which contains a large portion of the upper North and South Branches of the Boardman River.

Table 2: Summary of 2012 Land Use for Boardman River Project Area

2012 Land Use/Cover	Area (Acres)	Percent of Project Area
Water	93.3	27.6
Wooded Wetland	62.5	18.4
Beach/Riverbank	42.5	12.5
Single Family/Duplex Residential	35.8	10.6
Broad Leaf Forest	30	8.8
Grass Shrublands	19.9	5.9
Coniferous Forest	15.6	4.6
Open Land Recreation	11.7	3.5
Mixed Broad Leaf/Coniferous Forest	11.2	3.3
Cropland	8.8	2.6
Transportation/Communications/Utilities	3.8	1.2
Non Wooded Wetland	1.7	0.5
Institutional	1.2	0.4
Multi-Family Residential	0.6	0.2
Commercial Services	0.1	0.03
Other Agricultural Lands	0.03	0.01
Total	338.7	100.0

Source: (Grand Traverse County 2012)

The dams and the land inundated by the impoundments are entirely owned by Grand Traverse County or the City of Traverse City. Much of the land immediately surrounding the impoundments is owned by the County. Residential properties are present along the river. Grand Traverse County owns all the land containing the Boardman and Sabin Dams and impoundment areas and the City of Traverse City owns Union Street Dam.

2.1.2 Recreation

The study area provides an attractive destination for outdoor recreation. Fishing, canoeing, hiking, camping, hunting, and wildlife viewing account for much of the outdoor recreation that occurs near the Boardman River watershed (MDNR 2007). About 36 lineal miles are designated as Blue Ribbon Trout Stream. The Boardman River is considered to be one of the top ten trout streams in Michigan (Huggler and Barfknecht 1995).

According to the Traverse City Convention and Visitor's Bureau, 36 percent of tourists visit the Traverse City area because of its waterfront, parks, and beaches (Traverse City Convention and Visitor's Bureau 2007). There are many recreational facilities surrounding the river that offer a diverse range of recreational opportunities for locals and tourists. The Boardman Valley Nature Preserve is located adjacent to Sabin Pond and includes over 100 acres for hiking, mountain biking, nature watching, hunting, and fishing. The Natural Education Reserve abuts the Boardman Valley Nature Preserve to the south and has 505 acres and 7 miles of trails along both banks of the Boardman River.

2.1.3 Demographic Setting

According to the U.S. Census Bureau, the 2010 population in Grand Traverse County was 86,986. The median age in years has increased by about 10 percent in the State of Michigan and Grand Traverse County since 2000. The total numbers of households increased by 16 percent in Grand Traverse County, and the county has also seen growth in the number of housing units. **Table 3** provides a detailed description of the study area demographics.

Table 3: Summary of 2010 Census Demographics

Description	Grand Traverse County	Percent Change*	State of Michigan	Percent Change*
Population	86,986	+12.0	9,883,640	-0.6
Persons Under 5 Years	4,907	+3.9	596,286	-11.3
Persons 18 Years and Over	67,791	+17.0	7,539,572	+2.7
Persons 65 Years and Over	13,028	+28.4	1,361,530	+11.7
Median Age in Years	41.3	+9.5	38.9	+9.6
Total Households	35,328	+16.2	3,872,508	+2.3
Number of Housing Units	41,599	+19.4	4,532,233	+7.0
Owner-Occupied Housing Units	26,489	+12.6	2,793,342	+0.0

Source: (U.S. Census Bureau 2010)
*Percent Population Change is calculated from the year 2000 to 2010.

2.1.4 Man-made Resources

The Union Street Dam is located in Traverse City at river mile 1.1. The dam was constructed in 1867 to supply power to a historical flour mill. Currently, the Union Street Dam raises the water level in Boardman Lake approximately 7 to 9 feet. Boardman Lake is natural and has a surface area of 339 acres. By raising the water level within Boardman Lake the Union Street dam adds approximately 80 acres to the lake's surface area. The MDNR Boardman River fish weir, officially named the James P. Price Trap-and-Transfer Facility, is located approximately 0.75 mile upstream from Grand Traverse Bay on the Boardman River and downstream of the Union Street Dam. The weir is owned by the City of Traverse City and operated and maintained by the MDNR. The MDNR operation includes harvesting salmon during their fall run and selling the eggs and fish for further processing. The weir is an MDNR backup egg collection site. If other

Great Lakes sites do not provide sufficient eggs for the hatchery, eggs from the Boardman weir are used to supplement those collected at other weirs.

The existing trap and transfer facility includes instream structures that support removable grates that can be used to block larger aquatic species while allowing passage of water and smaller aquatic species. The MDNR uses the grates to block passage of fish during the fall salmon run. At other times of the year, when grates are not in place, free passage upstream is possible. During periods when the grates are in place water is pumped through a fish ladder structure (appropriate for species with high burst speeds and jumping capabilities, such as salmonids) that directs fish into holding tanks where they are anesthetized and then sorted for harvest or return to the river.

The trap and transfer facility is comprised of a brick building and a loading dock. Associated with the structure are a weir structure and walkway, fish ladder, holding pens, sorting tanks and associated mechanical equipment for moving gates, grates and pumps. The entire site is approximately 9,800 square feet. Maintenance of the facility includes cleaning before, during and after harvesting operations; mechanical upkeep and exercising of equipment; building repairs; grate repair or replacement; and concrete repair of the fish ladder and holding tanks.

The proposed modifications to the trap and transfer facility would facilitate collection of sturgeon from the river for manual transfer above Union Street Dam.

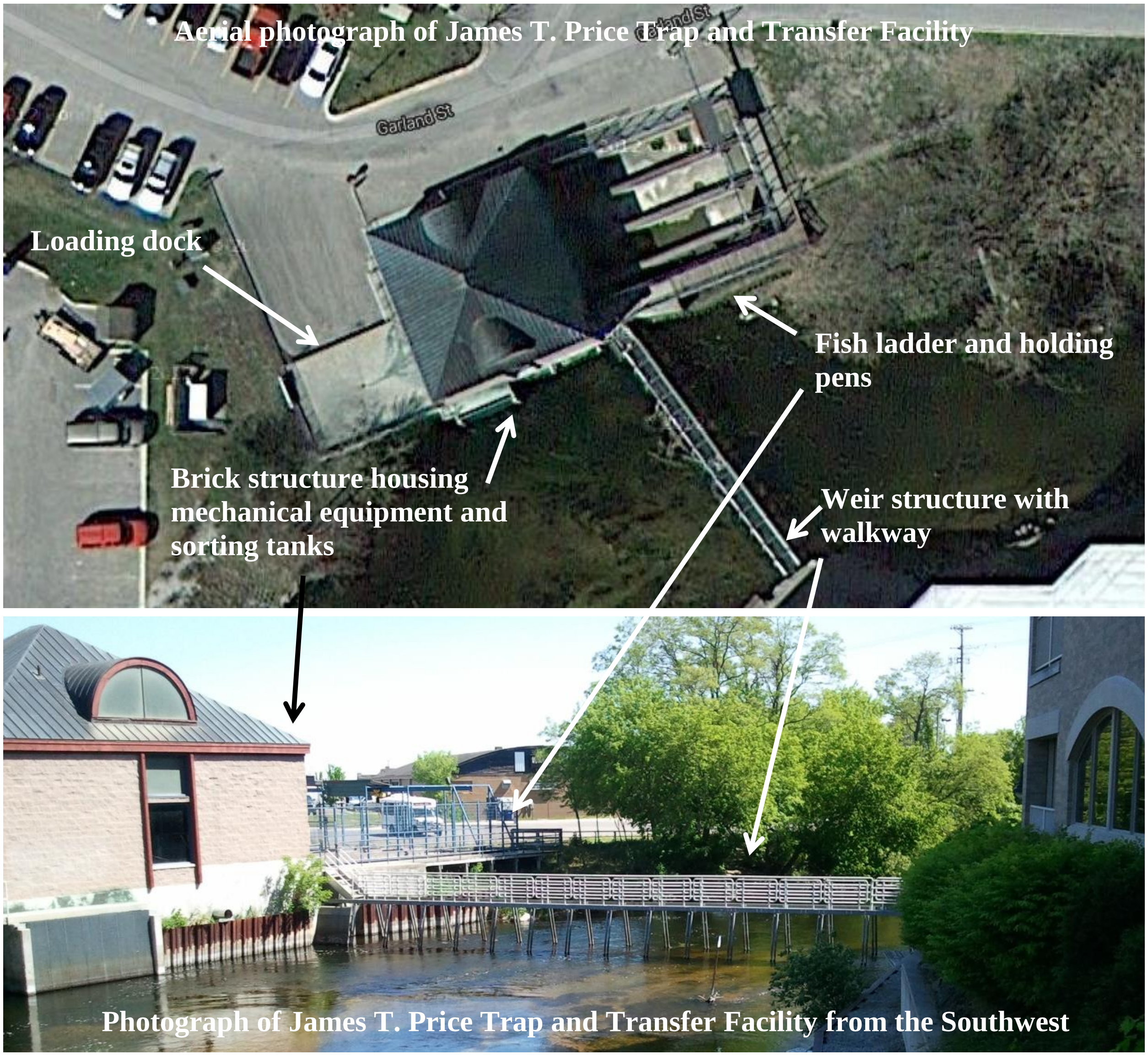

Figure 3. James T. Price trap and Transfer Facility

The Sabin Dam, located at river mile 5.3, was constructed in 1906 and completely rebuilt in 1930. Power generation ceased at the dam in 2006. The Boardman Dam was constructed in 1894 and rebuilt in 1930. This structure is located at river mile 6.1. Cass Road Bridge spans the intake works of Boardman Dam and is directly tied to this structure. The Union Street Dam is generally operated as a run-of-the-river dam. The moveable gates are left in an open position and maximum flows are allowed through the structure. The Sabin and Boardman Dams are operated as run-of-the-river dams, with the operational goal being no changes to the impoundment water surface elevation.

2.1.5 Business and Economic Setting

For the employed population 16 years and older, top industries in Grand Traverse and Kalkaska Counties are educational services, health care, and social assistance. In Grand Traverse County, other leading industries include retail trade, recreation, the arts, entertainment, accommodation, and food services. In Kalkaska County, other leading industries are manufacturing and retail trade, the arts, entertainment, recreation, accommodation, and food services.

A variety of recreational activities that substantially contribute to the local economy are offered in these counties. These activities include boating, fishing, camping, hiking, horseback riding, cycling, hunting, cross-country skiing, and wildlife viewing. These activities are particularly important in Grand Traverse County, as recreation is the second largest industry in that county.

2.1.6 Transportation

The local transportation network in the vicinity of the project area consists of county and local roads that serve the local residents and communities. County Route 611 (Garfield Road) is a primary connector roadway in the area and provides service from the City of Traverse City to various municipalities in the area. The Union Street Dam does not have any roads crossing over it, but it is bounded by S. Union Street to the west, E. State Street to the north, Cass Street to the east, and a few side streets to the south (i.e., Rivers Edge Drive, 7th Street, Lake Avenue). The Sabin Dam has no roads crossing over it, and is bounded by Cass Road to the east and Keystone Road to the west. Two access roads off of Cass and Keystone lead to the Sabin Dam; these are Birmley Road, and an unnamed road leading to the Boardman River Nature Center. The Boardman Dam is bounded by Keystone Road to the east and Cass Road to the west. Cass Road takes a slight curve to the west toward Keystone Road and crosses over the Boardman Dam.

2.1.7 Climate

The study area is located in a temperate zone, with four distinct seasons. Modeling of global atmospheric circulation patterns indicate that under a continuing global warming trend, air mass differences would become greater in the Great Lakes and upper Midwest regions during the fall and spring (transition) seasons, with stronger resultant atmospheric disturbances. This suggests future precipitation events in the region would be more frequent and more intense. As such, there is a possibility that river and stream systems in the Great Lakes region could experience more frequent events of intense rain falling during a short time, which would increase the potential for stream bank erosion, stream sediment loading, and flashiness of flood flows. The summer seasons are anticipated to be hotter and drier in this region in the years to come; less arctic air in the region would mean less winter snowfall and milder winter temperatures.

2.1.8 Flood Events

Available data on flood history for the Boardman River reveal that no recent flood events have occurred. Since 1998, the peak water level crest was recorded at 5.44 feet. To be considered at flood level, the water needs to crest at or above 7 feet (NOAA 2013). The hydraulic simulation was a steady-state computation which calculates water surface elevations along the entire study area under a given discharge. The Kalkaska soil that comprises the riverbed plays a key role in the absence of flood events within the watershed. It is a sandy, permeable soil that drains quickly and helps keep the river from flooding during heavy rains.

The dams situated along the Boardman River were constructed as power generation structures, and were not intended to be used for flood risk management.

2.1.9 Structural Condition of Dams

The three dams in the project area have all undergone structural inspections in the last 3 years, focusing on major safety concerns and the maintenance necessary to keep the dams in place. All of the dams have been given a high hazard potential classification[1]. This classification reflects the potential hazard the dam poses to downstream populations, property and infrastructure and is not a reflection of the structural integrity of the dams. The results of those structural inspections are summarized below. Note that this Feasibility Study does not address or evaluate specific actions made by Grand Traverse County, the City of Traverse City or TCLP to maintain the dams. Routine maintenance is beyond the scope and authority of this study.

Union Street Dam. The Union Street Dam is 10 feet high and consists of 250 lineal feet of earthen embankment, two spillways, and a fish ladder. The spillways consist of two 48 inch corrugated metal pipe outlets that receive flows from a concrete overflow section with five 10.5-foot-wide bays. The fish ladder is designed to assist the passage of salmon and trout while preventing upstream travel of sea lamprey and it appears to be structurally sound. A partially exposed City water main runs across the top of the dam.

Per the latest dam safety inspection performed by the Michigan Department of Environmental Quality (MDEQ) in December 2012, the overall condition of the Union Street Dam was deemed “satisfactory” with no deficiencies noted.

Recommended regular or near term maintenance activities include:

- Continue weekly inspections, continue slope maintenance (trimming grass and keeping embankment clear of woody vegetation, and keep trash racks free of debris.
- Lubricate and exercise all principal spillway gate operators.
- Review and update the Emergency Action (EAP) and Operation and Maintenance Plans.
- Inspect principal spillway pipes and submit a report to the DEQ on their condition.
- Install a toe drain upstream of the principal spillway headwall.

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1 A “high hazard potential classification” is defined by the Natural Resources and Environmental Protection Act 451 of 1994 as “any dam located in an area where failure may cause serious damage to inhabited homes, agricultural buildings, campgrounds, public utilities, main highways, or Class I carrier railroads; where environmental degradation would be significant; or where danger to individuals exists with the potential loss of life”. A dam’s classification is not a reflection of the dam’s structural condition. No laws or regulations exist that would require removal or repair of Union Street, Sabin or Boardman Dams in the future without project condition.

- Evaluate spillway capacity.
- Mount a staff gage to the dam to monitor reservoir elevation.

Longer term maintenance recommendations include replacement of the corrugated metal pipes and relocation of the water main that runs across the top of the dam.

A copy of the December 2012 MDEQ Union Street Dam Safety Inspection Report is on file at the Detroit District USACE office.

- In 2011, the USFWS surveyed the extent of the sea lamprey presence in the Boardman River. This inspection identified several gaps between the stop logs and concrete sill that were large enough to pass sea lamprey. These gaps were subsequently repaired by the City of Traverse City.

Figure 4: Union Street Dam and Fish Ladder

Sabin Dam. The Sabin Dam is 30 feet high, and consists of earthen embankments, a powerhouse, a stop-log spillway, and a tainter gate spillway. Power generation ceased at the Sabin Dam in 2006. A 1917 map shows a fish ladder just east of the powerhouse; this feature is no longer extant. The structure exhibits minor cracks in the powerhouse superstructure, concrete deterioration on the downstream side of the powerhouse, a leaking roof, and minor corrosion at brick mortar joints and window lintels. No major rehabilitation appears necessary to maintain dam safety, but routine maintenance, such as exercising the gates, repairing spalled concrete, removal of woody vegetation, and building repairs, is required. No laws or regulations exist that would require the future removal or repair of Sabin Dam. The dam is shown in **Figure 5**.

Per the latest dam safety inspection performed by the MDEQ in December 2012, the overall condition of the Sabin Dam was deemed “satisfactory” with no deficiencies noted.

Recommended maintenance activities include:

- Review and update the EAP.
- Remove trees and brush from the embankment as they develop.

A copy of the December 2012 MDEQ Sabin Dam Safety Inspection Report is on file at the Detroit District USACE office.

Figure 5: Sabin Dam Showing Spillway and Powerhouse

Boardman Dam. The Boardman Dam is 60 feet high and consists of earthen embankments, an emergency spillway, and a concrete structure and penstock intake. Power generation ceased at the Boardman Dam in 2007. The dam exhibits significant cracking in the walls of the structure (which also serve as substructural supports for the bridge). The concrete beams that form the bridge superstructure are cracked and there is significant spalling on the fascia beams, exposing steel girders. The bridge barrier railing is in significant disrepair, and the bridge deck has been patched multiple times. Many of the door and window frames on the powerhouse are corroded, the roof is leaking, and cracks in the grout around the brickwork were observed. Also, seepage was noted in multiple locations along the earthen embankment in previous reports. The dam is shown in **Figure 6**.

Per the latest dam safety inspection performed by the MDEQ in December 2012, the overall condition of the Boardman Dam was deemed “poor due to lack of spillway capacity, but is stable since the impoundment was drawn down.” There were no deficiencies observed that would lead to the dam’s immediate failure. Because of the lack of capacity the County and State have entered into a consent decree that indicates the dam needs to be modified in such a way to meet spillway requirements or be removed.

Recommended maintenance activities include:

- Review and update the EAP.
- Maintain the dam’s water level at the current elevation in accordance with the 2007 consent agreement between county and DEQ.
- Continue to plan for the dam’s modification or removal in accordance with the consent agreement and the County Board of Commissioners resolution.
- Remove trees and brush from the embankment as they develop.

A copy of the December 2012 MDEQ Boardman Dam Safety Inspection Report is on file at the Detroit District USACE office.”

Figure 6: Boardman Dam

2.1.10 Dam Hydraulics

The hydraulic conditions of the Boardman River dams were assessed during a site visit in April 2011 to examine functionality. The Boardman Dam is the only structure that does not have sufficient spillway capacity to meet the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act 451 of 1994, as amended.

In 2006, Grand Traverse County lowered the water level of Boardman Pond approximately 17 feet to address the deficient spillway capacity. The deficient spillway capacity is a reflection of the dam’s condition. The reduction in normal pool elevation stabilizes the dams. Thus, the reduction in pool elevation would be maintained until the spillway deficiency is corrected or the dam is removed. **Table 4** summarizes hydraulic conditions of the existing Boardman River dams, current and historic regulatory requirements, their corresponding flows, and the existing spillway capacities.

Table 4: Hydraulic Conditions of the Boardman River Dams

Dam	0.5 percent chance flood event (cfs)	PMF (cfs)	Regulatory Requirements (cfs)		Flood of Record (cfs)	Existing Spillway Capacity (cfs)	Meets FERC Spillway Criteria?	Meets MDEQ Spillway Criteria?
			FERC (IDF)*	MDEQ				
Union Street	2,000	N/A	N/A	2,000 (200-year)	1220 (9/14/61)	2,000	N/A	Yes
Sabin	2,000	11,600	2,000	2,000 (200-year)	1220 (9/14/61)	3,650	Yes	Yes
Boardman	1,900	11,600	11,600	6,100 (1/2 PMF)	1220 (9/14/61)	4,550	No	No

cfs = cubic feet per second
PMF = Probable Maximum Flood
FERC = Federal Energy Regulatory Commission
IDF = Inflow Design Flood
MDEQ = Michigan Department of Environmental Quality
*FERC requires the use of the IDF for the required spillway capacity.
Source: (ECT 2009d).

2.1.11 Thermal Impacts of Groundwater Flows

Hydrologic soil types in the watershed provide good rainwater infiltration and have deep formations of sand, gravel, and coarse-textured till materials. A significant portion of the river’s flow volume is derived from groundwater discharge through these permeable glacial outwash soils. The Boardman River watershed contains over 22 streams that contribute to approximately 130 lineal miles of river and tributary waterways (MDNR 1976). Twelve lakes drain into the Boardman River, influencing warmer water temperatures for a short distance downstream; however, in the upper portions of the watershed, groundwater seepage soon cools the water sufficiently to support a variety of cold water fish species throughout the river expanse. The dams located within mainstem flow also elevate surrounding water temperatures, especially in the lower 8 miles of the river. These sustained higher temperatures compromise the cold water habitat in this portion of the watershed.

2.1.12 River Profile

Figure 7 shows the Boardman River profile including elevations from West Grand Traverse Bay of Lake Michigan to the former Brown Bridge Dam location. The river elevation drops approximately 200 feet over this distance.

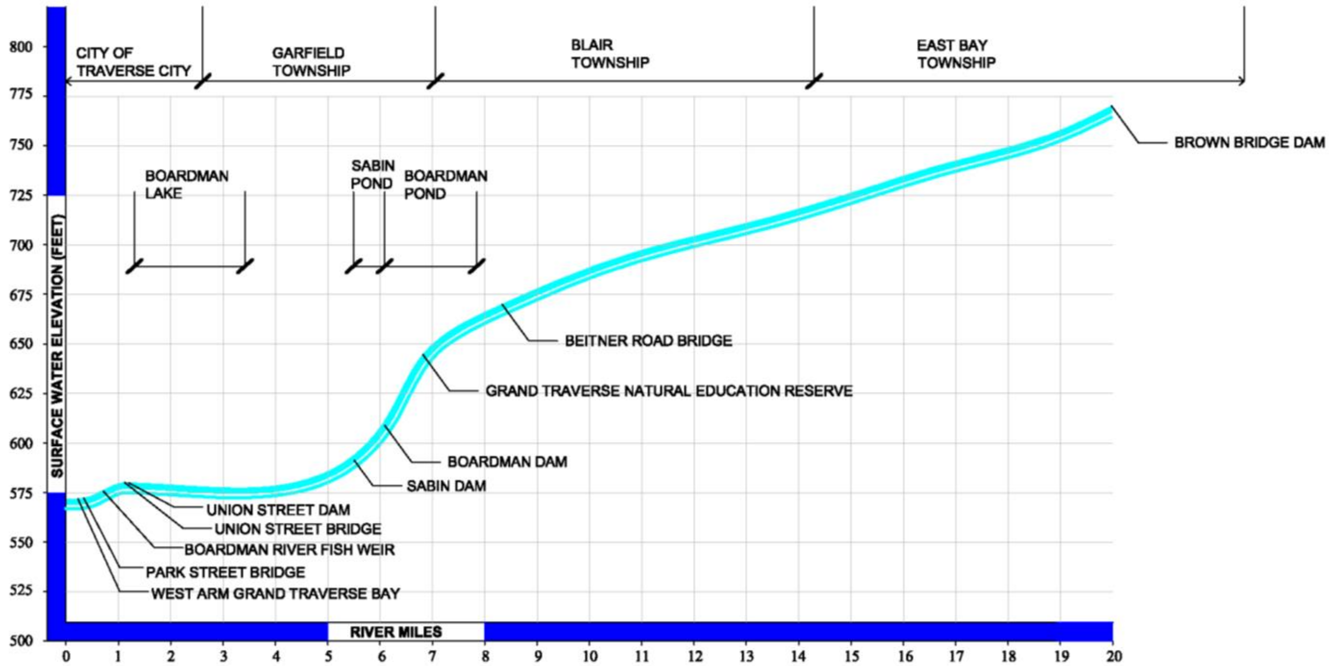

Figure 7: Boardman River Profile

2.1.13 Sediment

Multiple sediment sampling efforts have been conducted within the impoundments by the MDEQ, Great Lakes Environmental Center, Inc. (GLEC), and Environmental Consulting and Technology, Inc. (ECT). These sampling efforts took place in 1997, 2010, and 2012.

Based on a review of prior sediment sampling activities and lab analytical data, the following criteria were used to evaluate the impoundment sediments: EPA Ecological Screening Levels (ESLs), Threshold Effect Concentrations (TECs), Probable Effect Concentrations (PECs), and MDEQ Michigan Default Background Levels, Drinking Water Protection Criteria (DWPC) , Direct Contact Criteria (DCC) , and Groundwater / Surface Water Protection Criteria (GSIPC). A TEC is a concentration where harmful effects on sediment-dwelling organisms are not expected to occur, and the PEC is a concentration where harmful effects to sediment-dwelling organisms are expected to occur frequently (USEPA 2003). A detailed description of these criteria screening levels can be found in the **Environmental Assessment**.

The MDEQ Surface Water Quality Division, in conjunction with the EPA, conducted sediment sampling in 1997 in Boardman Lake and the Boardman River extending to the Union Street Dam. As a result of the 1997 MDEQ study, GLEC conducted additional sediment sampling as well as toxicity testing on samples from the northern portion of Boardman Lake and the Boardman River halfway up to the Union Street Dam. Sediment samples were collected from Boardman and Sabin Ponds by GLEC in late fall 2010.

Given the potential for contaminated sediments within the impoundments, GLEC was retained once more to conduct sediment sampling upstream of the Boardman and Sabin Dams in regards to the proposed action. Sampling took place in May 2012.

No organochlorine pesticides, polychlorinated biphenyls (PCBs) or semi-volatile organics were detected in any of the samples collected from the Boardman River ponds.

Union Street Dam and Boardman Lake. The initial 1997 sampling by MDEQ revealed many contaminants above the threshold levels including polynuclear aromatic hydrocarbons (PAHs), arsenic, cadmium, chromium, copper, iron, mercury and manganese. These results initiated an additional sediment sampling process that included toxicity screening on samples from the northern portion of Boardman Lake and the Boardman River halfway up to the Union Street Dam. The toxicity screening concluded that existing levels of PAHs have the potential to negatively impact the benthic organisms within the lake and river.

Sabin Pond. GLEC collected sediment samples from Sabin Pond in late fall 2010 to comply with MDEQ and USACE quality assurance standards and dredging guidance (ECT 2009a). The samples were analyzed for pesticides, PCBs, PAHs, and 10 trace metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc). All metals were below the TEC and ESL levels, and none exceeded MDEQ-established background sediment concentrations for wadeable streams. In summary, arsenic was detected at levels above the EPA-established ESLs which are identical to the EPA-established TECs. No metals within the impoundment were found to be above the EPA-established PECs. The following metals were detected at levels well above the MDEQ-established Michigan Default Background Levels: arsenic, barium, lead, manganese, and selenium.

Arsenic and manganese were above the MDEQ-established residential DWPC, and arsenic, mercury, selenium, and silver exceeded the MDEQ-established GSIPC. No metals exceeded the MDEQ-established nonresidential DCC. This criterion is applicable to the proposed onsite upland sediment management and disposal locations.

Additional sediment sampling within Sabin Pond was conducted by GLEC in May 2012. The samples were analyzed for pesticides, PCBs, PAHs, and 10 trace metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc). Selenium was detected at concentrations exceeding the EPA-established ESL, but no metals were detected at concentrations above the EPA-established TECs or PECs. Arsenic and manganese were detected at concentrations exceeding the MDEQ-established Michigan Default Background Levels. However, none of the metals analyzed exceeded the Michigan background sediment concentrations as reported in *Sediment Report for Wadeable Streams* (MDEQ 1999).

Arsenic, selenium and manganese were detected at concentrations exceeding the MDEQ-established residential DWPC. Arsenic, mercury and silver were detected at concentrations exceeding the MDEQ-established GSIPC, but no metals were detected at concentrations above the MDEQ-established nonresidential DCC. No PAHs or PCBs were detected above the MDLs reported by the analytical laboratory.

Boardman Pond. GLEC collected sediment samples from Boardman Pond in late fall 2010 to comply with MDEQ and USACE quality assurance standards and dredging guidance (ECT 2009a). The samples were analyzed for pesticides, PCBs, PAHs, and 10 trace metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc). Arsenic and cadmium were found in the samples slightly above the TEC but below the PEC. Barium, manganese and selenium exceeded MDEQ-issued background sediment concentrations for wadeable streams in a few sample locations within Boardman Pond.

The 2010 samples showed that arsenic and cadmium were detected at levels above the EPA-established ESLs which are equivalent to the TECs. No metals were detected at levels above the EPA-established PECs. The following metals were detected at levels above the MDEQ-established Michigan Default Background Levels: arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, and zinc.

Arsenic and manganese were above the MDEQ-established residential DWPC; arsenic was above the MDEQ-established residential DCC; and arsenic, mercury, selenium, and silver were above the MDEQ-established GSIPC. This criterion is applicable to sediment management and disposal. None of the samples exceeded the MDEQ-established nonresidential DCC.

Additional sediment sampling within Boardman Pond was conducted by GLEC in May 2012. The samples were analyzed for pesticides, PCBs, PAHs, and 10 trace metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc). Arsenic was detected at concentrations exceeding the EPA-established ESLs, TECs, and MDEQ-established Michigan Default Background Levels, residential DWPC, residential DCC, and GSIPC. Selenium was detected at concentrations exceeding the EPA-established ESL. No metals were detected at levels above the PECs or MDEQ-established nonresidential DCC.

Arsenic, manganese and selenium were detected at concentrations exceeding the MDEQ-established Michigan Default Background Levels; however, there were not any metals analyzed that exceeded the Michigan background sediment concentrations. Arsenic and manganese were detected at concentrations exceeding the MDEQ-established residential DWPC, and only arsenic was detected at concentrations exceeding the MDEQ-established residential DCC. Arsenic, mercury, selenium and silver were detected at concentrations exceeding the DEQ-established GSIPC. No PAHs or PCBs were detected above the method detection limits (MDLs) reported by the analytical laboratory.

Contaminated Sediment Summary

Previous studies show that the types and levels of contamination that occur upstream of each dam varies. The Boardman Lake and river to Union Street Dam have the highest and most diverse levels of contamination. This reflects the historical industrial use of the area, while the impoundments of Boardman and Sabin Dam reflect accumulation of naturally occurring substances that have likely been concentrated as fine material has settled out in the impoundments.

2.1.14 Aquatic Habitat and Fisheries

The presence of the Boardman River dams has disturbed the natural, free-flowing coldwater habitat along the Boardman River and has created an environment more suitable to warmwater species both upstream and downstream of the dams. To present the existing data in a framework useful for identifying essential data and evaluating alternative fates of the Boardman River dams, the study area was divided into 10 segments. These segments are based on the spatial extents of impacts of the dams. **Table 5** describes the segments, which are shown in **Figure 8**.

Table 5: Boardman River Habitat Analysis Segments

Segment Number	Location	Length (miles)
1	From Union Street Dam downstream to West Grand Traverse Bay of Lake Michigan, and Hospital (Kids) Creek	1.14
2	Union Street Dam impoundment, better known as Boardman Lake	2.14
3	From Sabin Dam downstream to Boardman Lake	2.15
4	Sabin Dam impoundment, also known as Sabin Pond, upstream to Boardman Dam	1.04
5	Boardman Dam impoundment, also known as Boardman Pond or Keystone Pond	1.34
6	From former Brown Bridge Dam, downstream to Boardman Pond	12.03
7	Former Brown Bridge Dam impoundment, also known as Brown Bridge Pond	1.63
8	From the confluence of the North and South branches of the Boardman River, also known as the Forks, downstream to the former Brown Bridge Pond	6.95
9A	North Branch of the Boardman River	3.00
9B	South Branch of the Boardman River	3.00

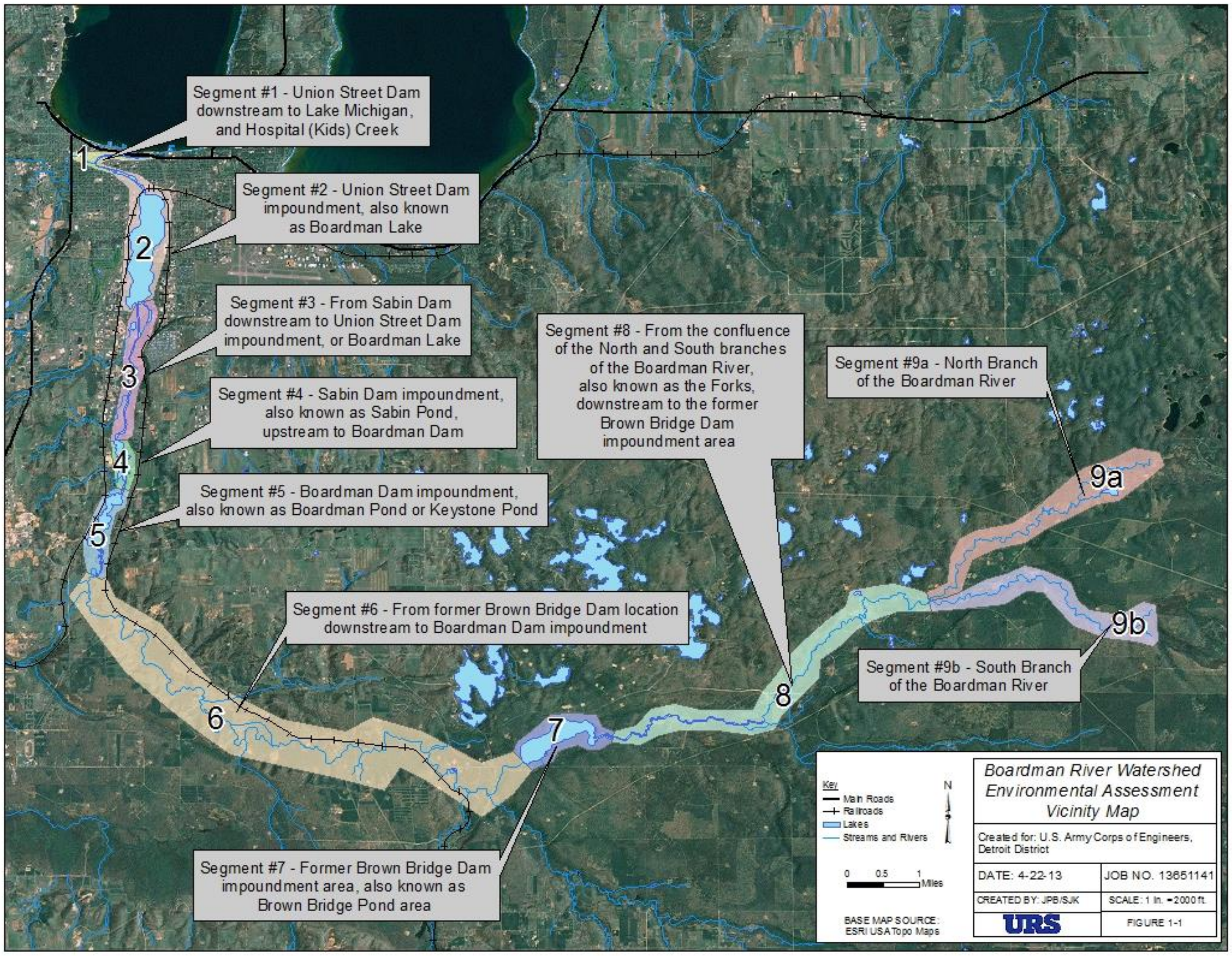

Figure 8: Boardman River Analysis Segments

The data in this section are drawn from ECT 2009b. The data found in this study are extracted from various other studies performed at different times, using different methodologies for each segment. Due to these variables in obtaining data, the information available is not consistent across each segment. In addition, the analysis was initially performed with the Brown Bridge Dam in place, but the dam has since been removed and the impoundment is no longer present.

The project area impacts the first six segments of the river as shown in **Figure 8**. As such, the habitat for only the first six segments is described in detail below. The segments located further upstream were used in habitat modeling as described in **Appendix E: Habitat Analysis**. A general description of aquatic habitat in each of these six segments follows:

Segment 1. From the Union Street Dam downstream to West Grand Traverse Bay of Lake Michigan (**Figure 9**), habitat quality is generally good, with slight impairment and water temperatures warmer than in other river segments. This segment is approximately 1.14 miles in length with an average width of 68 feet. Approximately 96 percent of the segment contains run habitat, four percent contains pool bedforms, and 56 percent of the stream provides water depths of 2.5 feet or greater. The percentage of stream containing wood material is low, at four percent. The percentage of the stream covered by aquatic vegetation is 24 percent and the average composition of streambed substrates, from qualitative observations, are zero percent clay, zero percent silt, 32 percent sand, 45 percent gravel, 16 percent cobble, and six percent boulders. Similar to river segment 3, this segment is quite wide and dominated by gravel, cobble, and boulders. The stream in this segment has been impacted by the impoundment effects from Lake Michigan, impeded sediment transport due to the Union Street Dam, and channelization via vertical side slopes, concrete-lined banks, and loss of floodplains. Consequently, river segment 1 can be viewed as impaired from natural conditions over its entire length (ECT 2009b). Segment 1 is accessible to fish from West Grand Traverse Bay of Lake Michigan. Thus, it receives runs of fish including salmon, steelhead, sea lamprey, and sometimes lake sturgeon. This river segment flows through downtown Traverse City and is channelized along its entire course.

Figure 9: Boardman River Segment 1

Segment 2. Segment 2 is Boardman Lake, upstream of the Union Street Dam. The lake is a natural lake, with water levels raised by the dam. Currently, Boardman Lake encompasses 339 acres. The little available habitat data for the Boardman Lake (**Figure 10**) suggest that aquatic macrophytes are common and zebra mussels are prevalent. This water body does provide an average fishery for sport fish such as walleye, smallmouth bass, and northern pike.

Figure 10: Boardman River Segment 2

Segment 3. This segment stretches approximately 2.15 miles and includes the portion of the Boardman River from Boardman Lake to the Sabin Dam (**Figure 11**). It generally has good habitat conditions supporting brown trout, smallmouth bass, and Chinook salmon. However, water in this segment can reach temperatures that are harmful to coldwater species. Impacts to aquatic habitat and natural hydrological conditions were observed for a distance approximately a ½ mile downstream of the Sabin Dam. At that point, impoundment effects on habitat were evident from the Union Street Dam (ECT 2009b). Consequently, this entire river segment was determined to be impacted by the Boardman River dams. A small coldwater trout stream enters the Boardman River approximately 0.1 miles below the Sabin Dam in Segment 3.

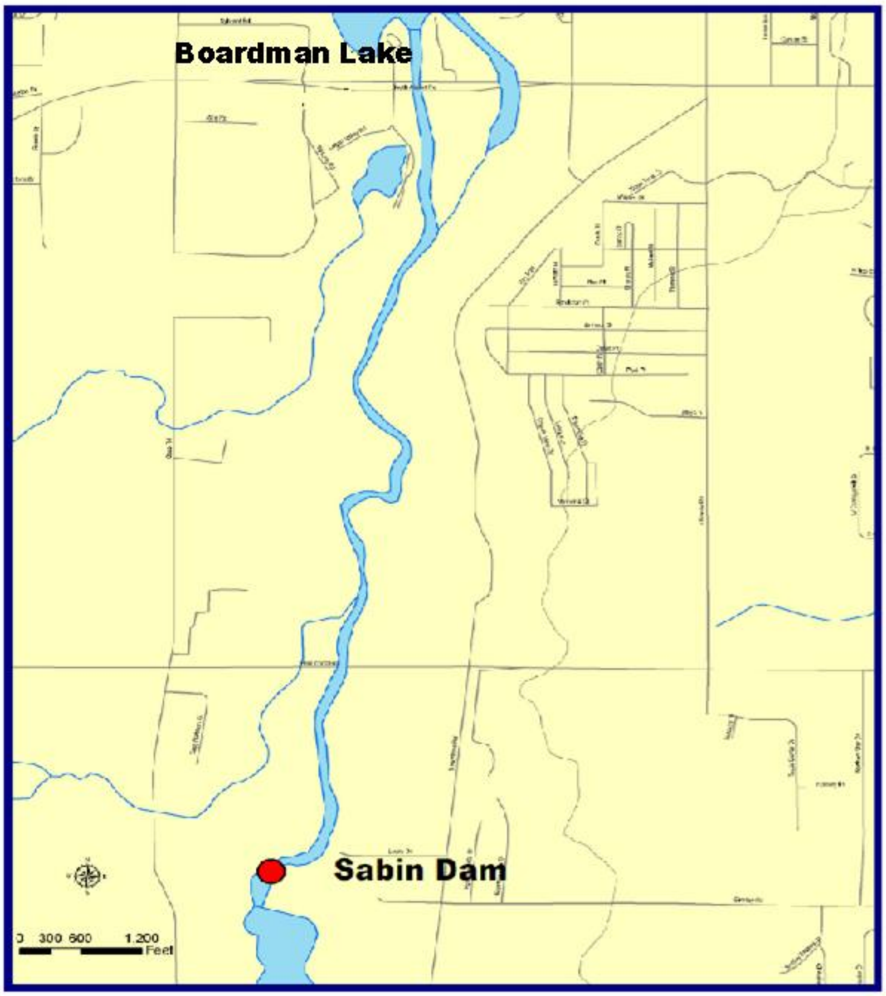

Figure 11: Boardman River Segment 3

Segment 4. Sabin Pond (**Figure 12**), located at river mile 5.7, encompasses approximately 40 acres and constitutes river Segment 4. It provides a poor fishery for coldwater fish species. High water temperatures are due to the warming effect of the impoundments from the presence of the Sabin and Boardman Dams and are suboptimal for coldwater fishes.

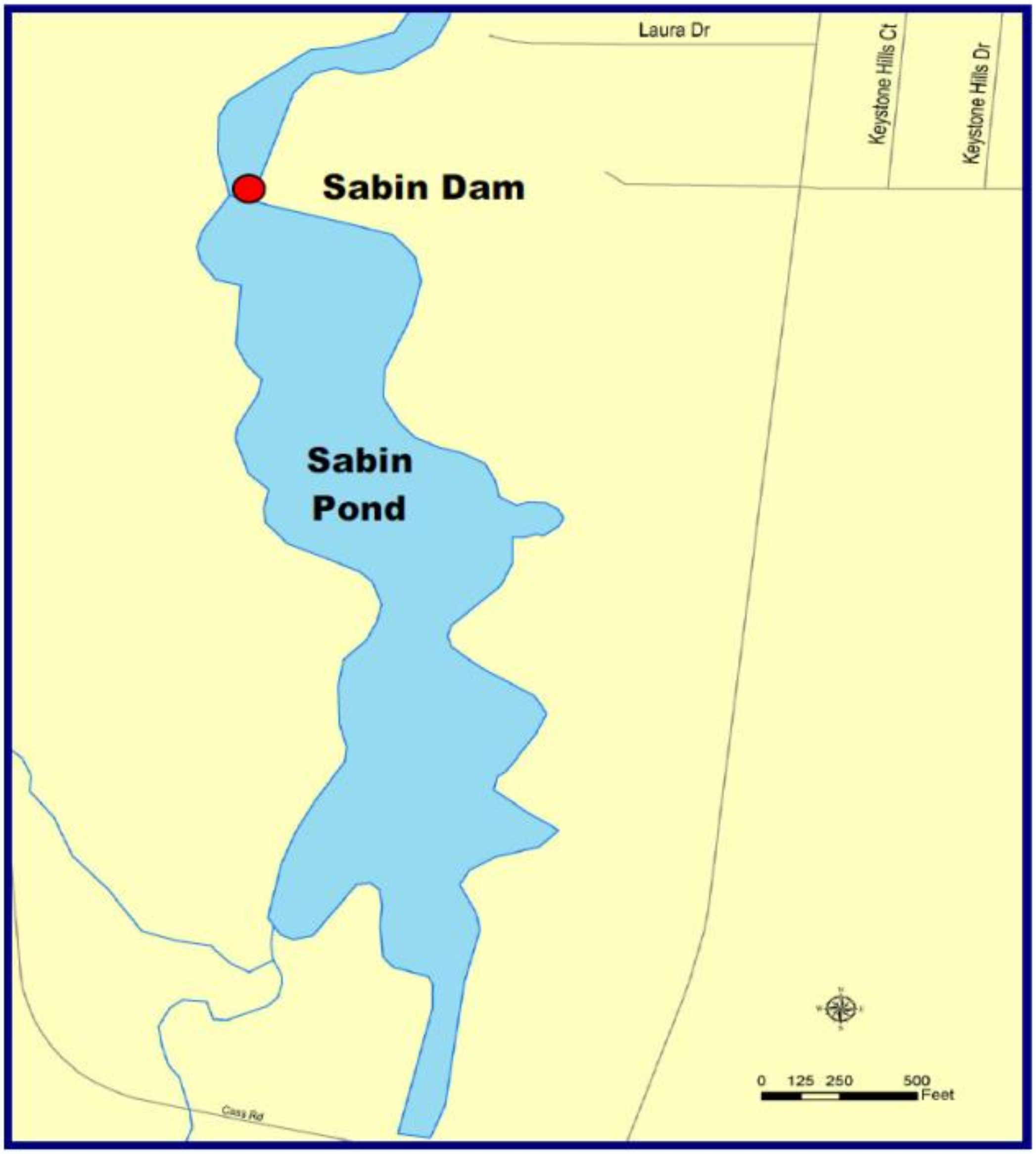

Figure 12: Boardman River Segment 4

Segment 5. Boardman Pond, shown in **Figure 13**, supports a fair-to-poor warmwater fishery. Rock bass and white sucker are the most abundant species present. Smallmouth bass and northern pike are common and bluegill, yellow perch, largemouth bass, and pumpkinseed sunfish are also present in low relative abundance. Although there is higher species diversity within this segment, Boardman Pond does not support coldwater fish species. The fish species present are adapted to the warmer water temperatures within the impoundments that result from the presence of the dams.

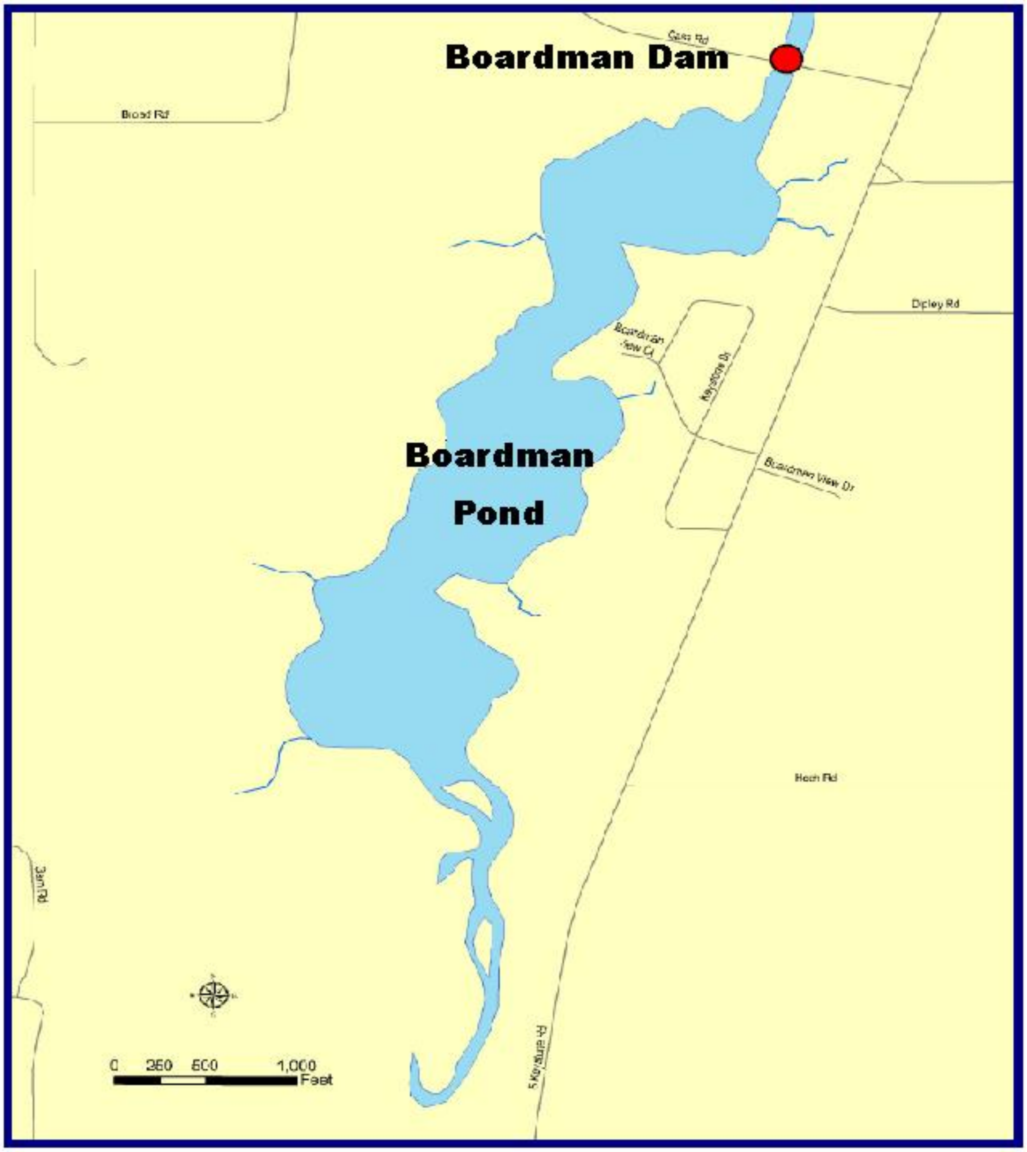

Figure 13: Boardman River Segment 5

Segment 6. In this segment, upstream of the Boardman Dam to the former Brown Bridge Dam location (**Figure 14**), the mean summer water temperature was raised by the presence of the Brown Bridge Dam by 8.2 degrees Fahrenheit (°F), a high level of impact. Water temperatures recorded at three fish sampling sites in this segment reveal monthly maximum summer temperatures greater than 70° F, a suboptimal temperature for coldwater species such as trout. Brown trout are found here in moderate densities, and brook trout in low densities.

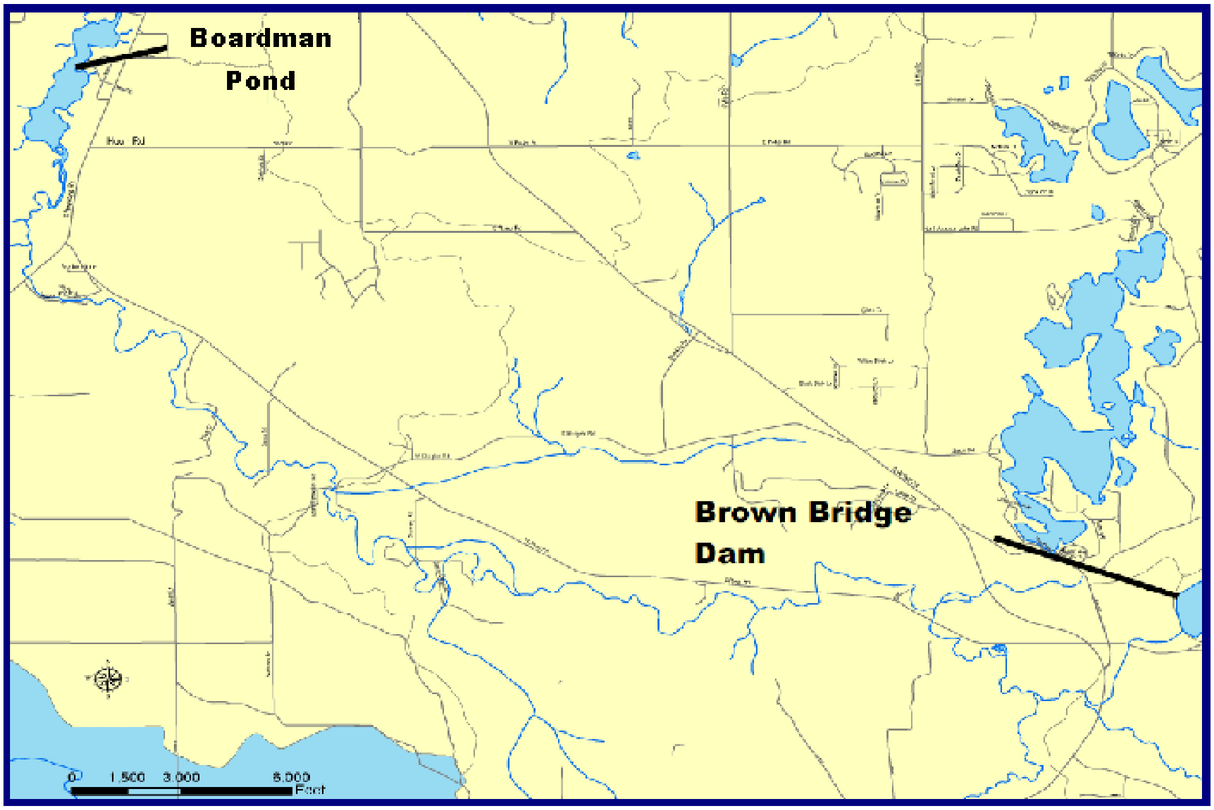

Figure 14: Boardman River Segment 6

Table 6 summarizes available habitat and fisheries data in the study area. Note that coldwater species are present primarily in segments 1, 3, and 6. The other segments reveal conditions that do not support habitat for coldwater species.

Table 6: Summary of Aquatic Habitat and Fisheries

Segment*	Macroinvertebrate Community Conditions*	Habitat Conditions*	Abundant Species*	Year Information was Obtained*
1	acceptable tending towards poor	good/marginal	sea lamprey, salmon and steelhead	2003
2	dominated by zebra mussels	not assessed	walleye, smallmouth bass, and northern pike	2003
3	acceptable, neutral	good	brown trout, smallmouth bass, white sucker, rainbow trout, and Chinook salmon	2003, 2006
4	not assessed	not assessed	northern pike and white sucker	2007
5	not assessed	not assessed	rock bass, white sucker, smallmouth bass, and northern pike	2007
6	good	excellent	moderate densities of brown trout, low densities of brook trout	2004, 2005

*Data drawn from the *Boardman River Feasibility Study: A Report on the Boardman River Fisheries Habitat Survey & Data Collection*, which includes varying and inconsistent data across the river segments.

2.1.15 Wetlands and Wetland Habitat

The BRDC Engineering Feasibility Study completed in 2009 included an extensive effort to identify and characterize wetlands and associated habitat in the study area. According to ECT (2009e), “the Boardman River valley is composed of flat, sandy outwash plains, ranging from 6 to 14 miles wide and pitted by small, shallow depressions.” Within the study area, wetlands are typically located around impoundments, with “lower elevations adjacent to the impoundments generally including palustrine (inland wetland) forested, palustrine scrub shrub, and palustrine emergent wetlands.” Within the impoundments, there are lacustrine (lake related) emergent, floating-leaved, and submergent wetlands. **Table 7** characterizes the wetlands within, near, or adjacent to the impoundments of each dam. In general, existing wetland conditions within the impoundments are characterized by submerged aquatic and floating wetland types with relatively low floral and faunal species and structural diversity. Additionally, as the “majority of rare species reported in the Michigan Natural Features Inventory database for the Boardman River Watershed utilize wetland habitats,” threatened and endangered species are also identified.

While a majority of the riparian corridor consists of wetland habitat, there are riparian upland areas adjacent to the impoundments and the Boardman River that are predominately forested and may include these community types from Region II, Northern Lower Michigan (ECT 2009f):

- Mixed riparian upland forest dominated by jack pine (Pinus banksiana) and northern pin oak (Quercus ellipsoidalis)
- Mixed riparian upland forests generally dominated by quaking aspen (Populus tremuloides), red maple (Acer rubrum), and Eastern white pine (Pinus strobus)
- Northern hardwood forest communities dominated by American beech (Fagus grandifolia), sugar maple (Acer saccharum), eastern hemlock (Tsuga canadensis), American basswood (Tilia americana), northern red oak (Quercus rubra), and Eastern white pine
- Black oak (Quercus velutina), white oak (Quercus alba), and bigtooth aspen (Populus grandidentata) communities

Table 7: Wetland Characteristics

Impoundment	Total Impoundment Size	Type of Wetland Within, Near, or Adjacent to Impoundment	Total Wetland Size	Threatened or Endangered Species Present
Boardman Lake	339 acres	-Aquatic -Palustrine Scrub-Shrub -Palustrine Emergent/Palustrine Scrub-Shrub	145.24 acres	-king rail (*Rallus elegans*) -common loon (*Gavia immer*)
Sabin Pond	40 acres	-Aquatic -Palustrine Emergent -Palustrine Emergent/Palustrine Scrub-Shrub -Palustrine Forested -Palustrine Forested/Palustrine Scrub-Shrub -Palustrine Forested/Palustrine Scrub-Shrub/Palustine Emergent/Open Water	32.3 acres	-wood turtle (*Glyptemys insculpta*) -Blanding's turtle (*Emys blandingii*)
Boardman Pond	128 acres	-Newly Formed Emergent -Palustrine Emergent -Palustrine Emergent/Palustrine Scrub-Shrub -Palustrine Scrub-Shrub -Palustrine Forested/Palustrine Scrub-Shrub	39.7 acres	-common loon (*Gavia immer*) -red-shouldered hawk (*Buteo lineatus*) -wood turtle (*Glyptemys insculpta*) -Blanding's turtle (*Emys blandingii*)

2.2 Future Without-Project Conditions

Without any action to remove or modify the Boardman River dams, the dams would continue to fragment the Boardman River into discontinuous segments, leading to continued loss of genetic diversity in the trout populations, blockage of migratory Great Lakes fish at the Union Street Dam, as well as continued habitat degradation, thermal disruptions, and induced species disruptions. Trout populations, biomass, and individual fish size would be expected to remain artificially low, coolwater fish populations would continue to experience negative effects and species such as the lake sturgeon would not have access to the river, although limited fish passage would remain possible at the Union Street Dam. Consequently, under "Future Without-Project" conditions, restoration of the Great Lakes tributary habitat—a high priority of the Great Lakes Fishery and Ecosystem Restoration program (Section 506, WRDA of 2000)—would not be achieved.

The future condition of the Boardman River, absent Federal investment, is defined by several key assumptions:

- **Dam maintenance.** As dam owners, Traverse City and Grand Traverse County would have various responsibilities related to dam maintenance and regulatory requirements. In the future, the City and County would likely address those requirements by maximizing conveyance through the dams by removing electric generating equipment and opening the gates to the extent possible.
- **Impoundment water levels.** During the fall of 2006, Grand Traverse County lowered the water level of Boardman Pond approximately 17 feet to meet spillway capacity required by Michigan Dam Safety Regulations. These drawn down levels would likely be kept stable in "Future Without-Project" conditions.
- **Cass Road Bridge Reconstruction.** The existing bridge is in poor condition and needs to be replaced. The Grand Traverse County Road Commission has secured funding from the Michigan Department of Transportation to support the reconstruction of the bridge and approach roads. The Grand Traverse County Road Commission would upgrade the Cass Road crossing of the Boardman River consistent with the future condition of the Boardman Dam. Construction or removal of the Cass Road Bridge is not included as part of the proposed restoration project.

The Non-Federal Sponsor, Grand Traverse County, has expressed its support for improving coldwater habitat in the Boardman River. In addition, the City of Traverse City has expressed support for improving coldwater habitat. Both jurisdictions have cooperated with the USACE and other partners in studying the disposition of the dams. In November 2011, Traverse City informed the USACE that the Brown Bridge Dam would be removed in a project separate and distinct from the outcomes of this Feasibility Study. The decision was made to begin the process of removing the Boardman River dams as quickly as possible. As such, the removal of the Brown Bridge Dam was completed in fall of 2012, and is part of the "Future Without-Project" conditions for this Feasibility Study. According to the EFS, removing the dam was expected to create an estimated 156 acres of new wetland area and return the river to a more natural channel.

Figure 15 and **Figure 16** illustrate the anticipated footprint of the river once the channel has settled into its expected location. It is predicted that the removal of the dam would negate thermal disruptions downstream of the former dam location to Boardman Pond, and extend the existing coldwater fishery downstream to River Segment 6. To date the non-federal sponsor has not been able to identify sources of financial support that would allow it to remove Boardman and Sabin Dams without a federal partnership.

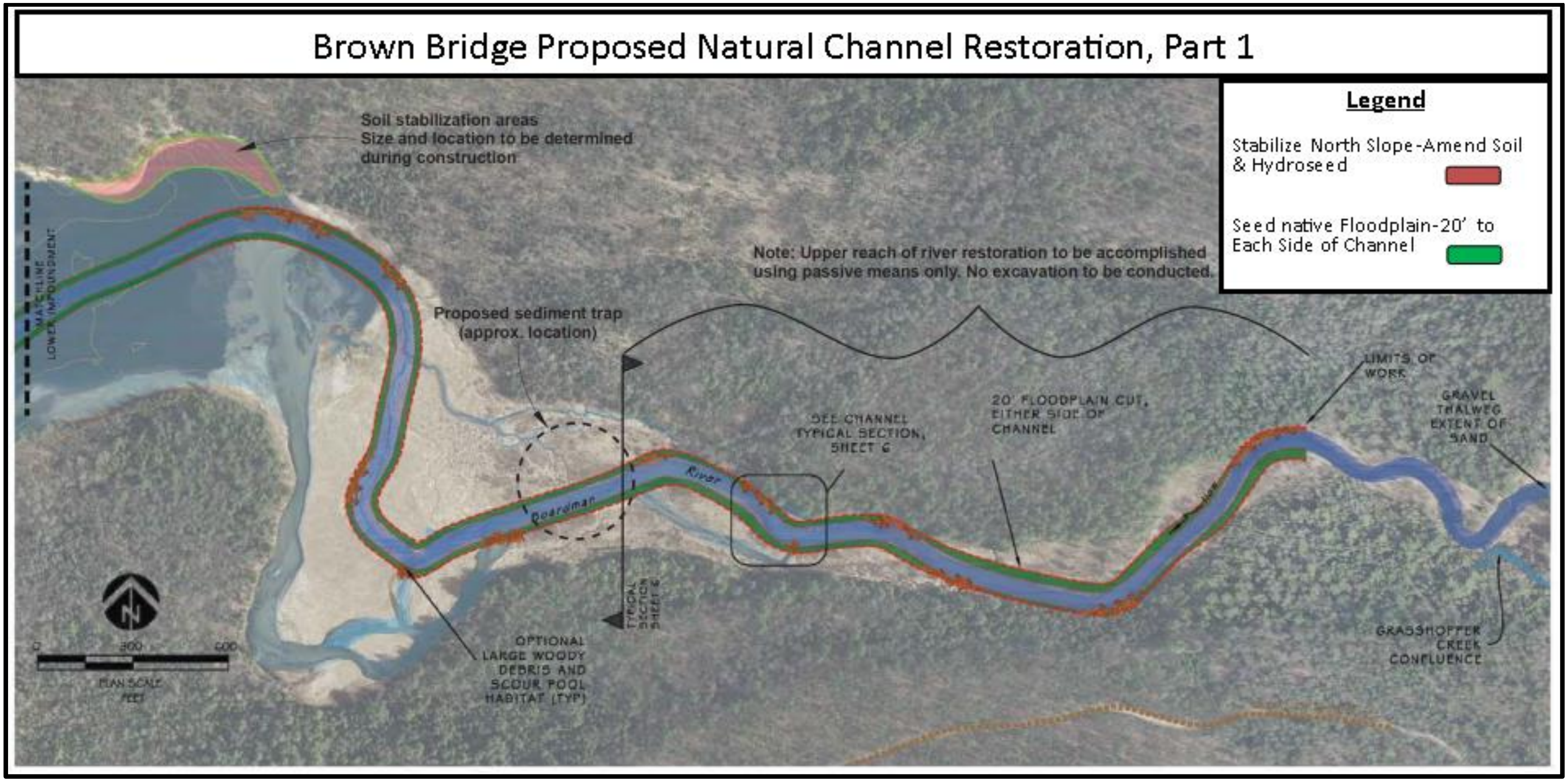

Figure 15: Estimated Floodplain Following Removal of Brown Bridge Dam, Part 1

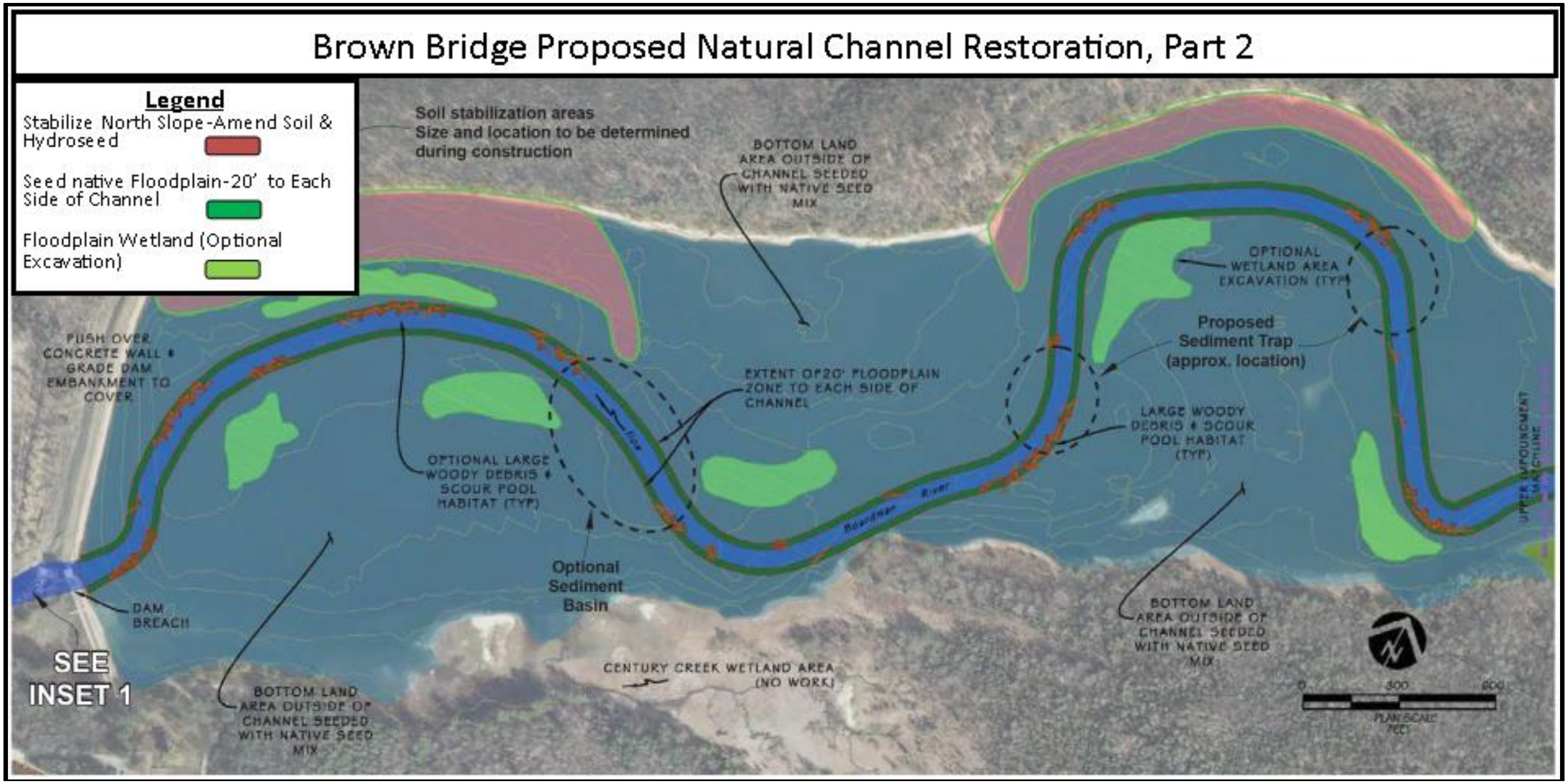

Figure 16: Estimated Floodplain Following Removal of Brown Bridge Dam, Part 2

3 Specific Problems, Opportunities, Objectives, Constraints

This section introduces the problems, opportunities, goals and objectives, and planning constraints taken into consideration before developing the alternatives found in **Section 4**.

3.1 Problems

Coldwater streams are a limited resource in the lower peninsula of Michigan, making up fewer than 20 percent of stream segments. These streams naturally tend to have higher densities of game fish and other aquatic species and provide spawning grounds and nursery areas for Great Lakes species. These factors support the importance of protecting and restoring coldwater streams in Michigan.

The dams on the Boardman River damage the ecosystem of the study area through habitat fragmentation, habitat degradation, thermal disruptions, and thermally induced species disruptions. The result is a reduction in populations of trout and other coldwater species immediately upstream and downstream of the Boardman River dams. The dams were constructed to produce hydropower for the area, but no longer serve this function. The impoundments currently support a warmwater fishery and associated terrestrial species. Lentic environments are common throughout the lower peninsula of Michigan; glacial geology resulted in numerous inland lakes with warmwater ecosystems. Coldwater, steep gradient streams are a comparatively rare resource. Specific problems related to the presence of the dams include:

Habitat Fragmentation. The presence of the Boardman River dams segments the river system into four discontinuous reaches. Such segmentation has a particularly adverse impact on resident brook and brown trout by increasing their vulnerability to adverse environmental conditions (e.g., pollution, habitat degradation, wetland filling) while decreasing their genetic diversity. Fragmentation also limits access to areas with suitable spawning habitat, optimal food availability, and protection from predators.

Habitat Degradation. Related to and exacerbated by fragmentation, habitat degradation has multiple dimensions with adverse impacts on aquatic species mix, diversity, and populations. The presence of the dams limits downstream transport of woody debris, sediment, and vegetation critical to sustaining healthy populations of trout and other desirable fish and invertebrate species, particularly in impoundments and the downstream segments of the project area. Woody debris provides food, refuge, and channel diversity to fish and invertebrate species, as well as protection from excessive riverbank erosion. Riparian vegetation provides similar benefits while also stabilizing banks and filtering pollutants and excess nutrients to the river. The presence of the dams decreases the diversity of such vegetation by limiting the downstream dispersal of reproductive material. The presence of the dams also compromises sediment transport, “starving” downstream areas by reducing sediment loads and increasing bank and riverbed erosion in those downstream reaches. Impoundments trap and immobilize sediment as a result of decreased flow velocities and in so doing compromise spawning areas for invertebrates and fish species. Sediment deposition in the impoundments also widens the river in areas upstream of the dams, decreasing depth, raising temperatures and, in general, compromising the quality of the habitat.

Thermal Disruptions. Sampling and analysis by the MDNR Fisheries Division has documented the adverse impacts of the Boardman River dams on water temperature, a critical consideration for the health and sustainability of coldwater fish species such as brook and brown trout. For example, studies of the Brown Bridge Dam impoundment discharges in June to August 2002 found waters in the impoundments to be an average of 6° F warmer than flowing channel waters; significantly in excess of the 2° F difference allowed under the State's Water Quality Standards (Rule 75, Part 4, Natural Resources and Environmental Protection Act, 1994 Public Act 451). The presence of the Boardman River dams has also been observed to adversely affect diurnal water temperature fluctuations, resulting in temperatures that are lower at night than during the day. These thermal disruptions have a variety of impacts on coldwater species that can include compromised growth rates, alteration of metabolism and timing of spawning and hatching, reduced populations and, in some instances, temperatures lethal to fish.

Induced Species Disruptions. Associated with thermal impacts on specific coldwater species (e.g., brook and brown trout) are thermally induced disruptions that adversely affect overall species mix and composition. Elevated water temperatures due to the presence of the Boardman River dams, for example, induce competition from coolwater species that would not otherwise have a significant presence in those river reaches. The MDNR Fisheries Division has documented 17 such species in the dam impoundments, and noted that unnatural warming of downstream reaches can induce such species to migrate out of the impoundments and compete with coldwater species for food, cover, and related habitat characteristics.

3.2 Opportunities

The Boardman River is a designated Natural River under the State of Michigan Natural Rivers Program. Outside of the project area, it features 36 lineal miles of Blue Ribbon Trout Stream designated by the MDNR Fisheries Division. The upper reaches of the river are considered one of the top 10 best trout streams in Michigan and support self-sustaining populations of brown, brook, and rainbow trout. The river also has the potential to provide foraging and spawning habitat for sturgeon, a species that is currently blocked from passage up the river by the dams.

The lake sturgeon is a State-listed species that generally uses large, hard-bottom rivers to spawn and has been observed migrating up the Boardman River to the Union Street Dam. Historically, lake sturgeon have spawned in the Boardman River, but are now unable to pass above Union Street Dam because they are unable to navigate the existing fish ladder due to poor burst speeds and inability to navigate through the high velocities and barriers that comprise the fish ladder. If sturgeon were able to pass through the Union Street Dam via a new type of fish passage structure or via a trap-and-transfer approach, and the upstream dams were removed, sturgeon would gain access to an enormous amount of new potential spawning habitat. While the need to block sea lamprey prevents opening up the spillway in this manner, there are other practical means of moving sturgeon upstream as would be explained in the Alternatives Development section (4.0) of this report.

In addition to the opportunities related to restoring the natural resources, the existing dams no longer serve their intended purpose. Boardman and Sabin Dam were built as hydroelectric projects and served an important historical function by providing electricity to the Traverse City area. However, since TCLP stopped generating electricity at the dams in 2005 and sold the generating equipment, this purpose is not currently being fulfilled.

Mitigating the ecosystem disruption to the study area by removing the Boardman River dams would provide 8 continuous miles of top quality trout stream, restore internal habitat connectivity and coldwater characteristics of the Boardman River, and potentially increase the diversity of species moving between the Great Lakes and the river. Restoring coldwater habitat on the lower reaches of the Boardman River would replace regionally common lentic habitat with a river type that is relatively rare in the lower peninsula of Michigan. Restoration of the coldwater characteristics of the river would contribute to the objectives of the Great Lakes Fisheries and Ecosystem Restoration Program as well as comply with local planning for the future of the Boardman River.

3.3 Planning Goal and Objectives

The goal of this Feasibility Study was to determine whether actions can be undertaken to restore coldwater aquatic habitat in the Boardman River. This study evaluated alternatives for restoring tributary habitat and internal connectivity of the Boardman River to meet the following objectives:

- Restore the natural balance between coldwater and coolwater species throughout the study area. This objective addresses Induced Species Disruptions.
- Allow movement of woody debris and sediment materials through the river system. This objective addresses Habitat Fragmentation and Habitat Degradation.
- Reduce water temperature impacts associated with the impoundments. This objective addresses Thermal Disruptions.
- Facilitate the passage of various fish species upstream and downstream, especially the passage of lake sturgeon between Lake Michigan and the Boardman River. This objective addresses Habitat Fragmentation.

It is anticipated that these objectives could be realized immediately upon implementation of an alternative.

3.4 Planning Constraints

The Feasibility Study recognized both technical and process constraints. The objectives must be accomplished without transporting pollutants into West Grand Traverse Bay of Lake Michigan, including additional sedimentation. The alternatives must not allow the passage of invasive aquatic species further upstream. The alternatives must not adversely impact the floodplain nor increase flooding risks. Given that prospective actions include the removal and modification of one or more of the dams on the Boardman River system, compliance with Federal floodplain management requirements is necessary. Specifically, the recommended alternative must comply to the extent possible with Executive Order 11988 (Floodplain Management), requiring that projects: 1) reduce the hazards and risk associated with floods; 2) minimize the impact of floods on human safety, health, and welfare; and 3) restore and preserve natural floodplain values. With regard to the latter, the Executive Order further stipulates that projects must comply with all other Federal, State, and local regulations (including environmental regulations); support USACE's Environmental Operating Principles; recognize the special status of tribal nations and fully incorporate them into the planning process; and include features compatible with existing agricultural and open space uses in rural areas to the maximum extent practicable. Toward this end, the project also considers sea lamprey control. In accordance with the USFWS desire to retain the Union Street Dam as a lamprey barrier, removal of the dam is not proposed.

4 Alternatives Development

The development of alternative plans first entailed the identification of measures to address problems and opportunities. These measures were then evaluated (using conceptual-level costs) with respect to their ability to meet project objectives. Some measures or variants of measures were subsequently eliminated from further consideration based on their inability to meet objectives as cost-effectively as other variants. The remaining measures were combined into alternatives, which were evaluated to identify a selected alternative.

4.1 Measures Identified to Address Problems and Opportunities

Measures were developed to address the identified problems and opportunities. These measures focus on modifying the dams to facilitate fish passage over or around the dams and the removal of the dams and restoration of the waterway. Measures were developed for each dam to accommodate the particular constraints and conditions at individual locations. The measures were further refined through a Value Engineering process (see

Section 4.1.4). For the purposes of the measures identified for this study, the following definitions apply:

- **Dam modification** measures involve maintaining the existing dam structures and impoundments and constructing or modifying fish passage structures and providing cooling mechanisms to mitigate thermal disruption. Modification also encompasses non-structural measures such as trap-and-transfer activities.
- **Dam removal** means that the dam would be partially or completely removed and the impoundment would be completely removed.

The measures developed for each dam location are summarized below. Detailed descriptions of the measures may be found in **Appendix A: Engineering**.

4.1.1 Measures for Union Street Dam

Enabling the movement of lake sturgeon between West Grand Traverse Bay of Lake Michigan and the Boardman River is a project objective. Currently, sturgeon below the Union Street Dam are unable to move upstream for foraging or spawning purposes. Although the Boardman River provides suitable habitat for sturgeon, the removal of the Union Street Dam was considered as a measure, but rejected based on its role as a sea lamprey barrier and because local infrastructure around the lake (i.e., outfalls, boat launches, public and private docks, breakwalls, environmental remediation systems) are configured for current lake levels. Measures were developed for the Union Street Dam modification to assist sturgeon passage while blocking the movement of aquatic nuisance species (ANS) from the Great Lakes into the Boardman River. The following measures were considered:

- Trap-and-transfer operation for sturgeon at the MDNR Boardman River fish weir with modifications to the Union Street Dam to allow downstream passage while maintaining the existing fish ladder.
- Construction of a rock ramp structure at the Union Street Dam location.
- New sturgeon lift-and-sort facility at the Union Street Dam.

All these measures would at least partly meet project objectives. A conceptual-level cost and feasibility analysis of these potential measures was conducted, and concluded that the construction of a new lift-and-sort facility at the site of the Union Street Dam would entail excessive costs and could encounter potential difficulties relative to real estate acquisition. Similarly, a rock ramp structure in place of the existing dam would also be expensive while not maintaining control of ANS (e.g. sea lamprey). Because of these excessive costs and potential issues, these two measures were not considered to be logistically feasible and were eliminated from further consideration. The analysis indicated that a trap-and-transfer operation at the MDNR Boardman River fish weir measure would be cost effective and would face minimal difficulties. As such, the measure was carried forward in this form for further analysis. The measure is summarized below.

For a trap-and-transfer operation at the MDNR Boardman River fish weir, upstream passage would be accomplished by trapping sturgeon at the existing weir facility and manually transferring them to upstream locations. The existing fish ladder at the Union Street Dam would be maintained, and downstream passage would be accomplished by modifying the existing Union Street Dam to be more conducive to passing adult sturgeon through the auxiliary spillway. The trap-and-transfer operation at the MDNR facility would require the use of two fishery technicians to collect the sturgeon and lift the fish and water into a truck to be transported upstream. This operation would require the installation of a lift system at the weir to get the fish to the truck level. A truck capable of transporting the fish and water and safely discharging them back into the river would also be needed. Modification of the existing auxiliary spillway at Union Street Dam would include removing the grates, constructing a plunge pool, and replacing the existing culverts with new culverts that would intersect with the plunge pool.

4.1.2 Measures for Sabin Dam

Dam removal. This measure would include removal of the concrete spillway and creation of a floodplain through the earthen dam. The exposed bottomlands would be restored to a free-flowing channel through the former impoundment, with the river choosing its own path. In doing so, it would move sediment and self-armor with existing gravel, cobble, and boulders. Based on the data available, it is anticipated that this could be accomplished with limited active engineering. If needed, channel alignment could be encouraged through the sediment removal and management operation. In addition, active excavation and bank stabilization approaches could be used if any critical infrastructure is threatened during the dam removal process. Sediment management would occur via sediment traps located immediately upstream of the existing dam, slow drawdown, and active sediment removal along the exposed banks by land-based excavators to provide an appropriately dimensioned floodplain.

The VE study resulted in several improvements to this measure. These included:

- The powerhouse would remain since removal of the existing structure is not critical to ecosystem restoration.
- The channel alignment would be through the area of the existing auxiliary spillway. This would eliminate the need to restore a channel through the existing wetland to the east of the auxiliary spillway (and where the historic channel may have been aligned).
- The floodplain through Sabin impoundment was optimized and its width was reduced.

Dam modification. Dam modification would maintain the existing water level of the impoundment while providing structures to pass fish to the downstream reaches. Upstream fish passage structures would include a fish lift capable of lifting 6 tons vertically and a discharge passage into Sabin Pond. Downstream fish passage would consist of a concrete channel with a natural bottom that slopes from the impoundment to the river below. Devices to cool water temperatures would include passive systems, such as a bottom draw, and active systems, such as a bubbler or chiller system.

An evaluation of modifications to improve cooling was undertaken, and these modifications were determined to be partially effective. The coldwater reservoir within the Sabin Dam impoundment is likely insufficient to provide cooling during the entire summer and, thus would provide improved temperatures only during limited periods. Using chillers would alleviate this concern but would require operation and maintenance. Additionally, there are significant construction concerns associated with the installation of a bottom draw outlet, particularly regarding safety and stability of the dam during construction and long term because the outlet is tunneled through the earthen embankment and core wall. For these reasons, water cooling was eliminated from further consideration as part of the dam modification measure.

4.1.3 Measures for Boardman Dam

Dam removal. With this measure a channel and floodplain would be created through the earthen dam. The exposed bottomlands would be restored to a free-flowing channel through the former impoundment. The river would choose its own path. In doing so, it would move sediment and self-armor with existing gravel, cobble, and boulders. Based on the data available, it is anticipated that this can be accomplished with limited active engineering. If needed, channel alignment could be encouraged through the sediment removal and management operation. In addition, active excavation and bank stabilization approaches could be used if any critical infrastructure is threatened during the dam removal process. Sediment management would occur via sediment traps located immediately upstream of the existing dam, as well as slow drawdown and active sediment removal along the exposed banks by land-based excavators to provide an appropriately dimensioned floodplain.

The VE study resulted in several improvements to this measure. These included:

- The powerhouse would remain since removal of the existing structure is not critical to ecosystem restoration.
- The floodplain through Boardman impoundment was optimized and its width was reduced.

Dam modification. Dam modification would maintain the existing water level of the impoundment while providing structures to pass fish. Upstream fish passage structures would include a fish lift capable of lifting 6 tons vertically and a discharge passage into Boardman Pond. Downstream fish passage would consist of a concrete channel with a natural bottom that slopes from the impoundment to the river below.

Modifications to improve cooling would also be partially effective. The coldwater reservoir within the Boardman Dam impoundment is likely insufficient to provide cooling during the entire summer and, thus, would provide improved temperatures only during limited periods. Using chillers alleviates this concern, but increases operations and maintenance costs. For these reasons, water cooling, and mechanical fish elevators were eliminated from further consideration as part of the dam modification measure.

4.1.4 Refinements

Value Engineering. A Value Engineering (VE) study was conducted for this project because it is expected to exceed $10 million in total cost, per USACE policy (ER11-1-321). The VE Team undertook the task using the VE work plan and approach. Complete documentation of the VE study is located in **Appendix A: Engineering**.

During the speculation phase of this VE study, 12 of the 37 proposed ideas were developed into VE recommendations. Given that cost is an important issue for comparison of VE proposals, the costs presented in this report are based on original design quantities with unit rates obtained from the estimate as prepared by the Design Team and included in their submission, published cost databases, and VE Team member experience.

After further review and discussion with the Design Team and non-Federal sponsor, the following VE Team recommendations were accepted and implemented into the Feasibility Study design:

- Retain the Boardman and Sabin Dam powerhouses in lieu of removal.
- Route the restored Boardman River alignment through the existing Sabin Dam auxiliary spillway in lieu of the historic channel to the east of the spillway and powerhouse.[2]
- Optimize the designed floodplain width in the restored segment of the Boardman River to narrow it where possible to reduce excavation costs. The width of the

[2] Depth of refusal investigations and tree stump surveys indicated that there were historically two different alignments for the river in the vicinity of Sabin Dam. One alignment passed through the current spillway while the other passed through the embankment to the west. These investigations indicate that either channel alignment would likely result in a stable channel geometry and profile.

floodplain would remain sufficient to allow flood flows to disperse their energy on the floodplain.

- Improve sediment management efficiency by using fewer and larger placement areas.
- Increase the use of targeted restoration using live stakes on steep banks and slopes in lieu of passive and/or seeding restoration options.

City of Traverse City. Following the identification of a selected alternative, the City of Traverse City requested the evaluation of design refinements to the measures proposed for modifying the Union Street Dam. The refinements would involve converting the dam from a gate-controlled, flow-through dam to a free-flowing, flow-over dam. To accomplish this, a new concrete core wall would be installed upstream of the current dam. This wall would be supported upstream and downstream with fill and would feature a rock ramp, engineered riffle, or step pool features downstream. The flow-over structure would be constructed at a shallow enough gradient to accommodate the passage of all desired fish species common to the area.

Given that the modified dam would no longer prevent the upstream passage of ANS, a new sea lamprey barrier would be installed at the location of the current MDNR trap-and-transfer facility between Front Street and the northern Union Street crossing. This location would provide a barrier for Hospital Creek as well as the Boardman River mainstem and would allow for use of the MDNR's existing trap-and-transfer facility. The trap-and-transfer facility would be modified to accommodate the manual passage of the sturgeon past the barrier. The barrier is proposed as a permanent structure with stop logs that allow for seasonal variations of barrier heights.

The proposed refinements were evaluated for their costs, benefits, and impacts. A flow over structure would allow for uninhibited fish passage, and result in lower maintenance costs. The proposed design refinements would have considerable habitat benefits in that a lamprey barrier downstream of Hospital Creek would have the effect of protecting the tributary from access by ANS. However, these refinements would result in significant flooding of property and public works due to the constrained river channel through Traverse City. Therefore, these refinements were eliminated from consideration. Costs to mitigate this increased risk of flooding are likely to be considerable, and real estate impacts and easements necessary for construction could be difficult to obtain, disruptive, and costly. These findings were presented to the City of Traverse City, and a decision was made to cease any further pursuit of design refinements. **Appendix A: Engineering** includes detailed information regarding the development and evaluation of the city's proposed design refinements.

4.2 Cost Estimates for Boardman Restoration Measures

Conceptual-level cost estimates for each of the measures were developed from unit costs obtained from local contractors, approximated on the basis of previously bid projects, or obtained from published unit costs (MDOT 2012). The overall project costs were then compared to similar projects in the region to verify the validity of the estimates. For each measure, the "anticipated" cost was calculated. It is the most likely cost based on the information currently available. The preliminary (conceptual-level) cost estimates for the dam removal and modification measures are summarized in **Table 8**. A detailed description of cost-estimating assumptions and methodologies is provided in **Appendix C: Cost Engineering**. Note that these costs were developed to allow a conceptual-level evaluation of the measures for the purpose of developing alternatives. They do not include operations, maintenance, repair, replacement, and rehabilitation costs (OMRR&R); operating costs are quantified in the Cost-Effectiveness evaluation described in **Section 4.6**.

Table 8: Conceptual-Level Cost Estimates for the Boardman River Restoration Measures

Measure	Anticipated Cost*
Sabin Dam Removal	$2,669,426
Boardman Dam Removal	$7,981,601
Union Street Dam Modification	$694,908
Sabin Dam Modification	$4,692,900
Boardman Dam Modification	$9,320,375

*Anticipated costs represent the screening level costs from the initial screening of the individual measures.

4.3 Evaluation of Measures

The measures were evaluated using conceptual-level costs and benefits. The ability of dam removal and modification measures to meet project objectives is summarized in **Table 9**.

Table 9: Ability of Measures to Meet Project Objectives

Project Objectives and Constraints	Dam Modification			Dam Removal	
	Union Street	Sabin	Boardman	Sabin	Boardman
Restore natural balance between coldwater and coolwater species	Partial	Partial	Partial	Yes	Yes
Allow movement of woody debris and sediment materials	No	No	No	Yes	Yes
Negate thermal disruption	NA	Partial	Partial	Yes	Yes
Reduce water temperature in impoundments	No	No	No	Yes	Yes
Facilitate fish passage	Partial	Yes	Yes	Yes	Yes
Prevent passage of invasive species	Yes	Partial	Partial	No	No
Anticipated Cost ($ millions)	0.69	4.69	9.32	2.67	7.98

As noted above, the Union Street Dam is not being proposed for removal because it acts as a barrier to upstream migration of sea lamprey and because the local infrastructure around the lake is configured for existing water levels. Because of these factors only the modification measures were evaluated.

Based on the conceptual evaluation of the measures' ability to meet project objectives within project constraints (**Table 9**), two measures were removed from further consideration: modifications to the Sabin and Boardman Dams. Modifications to enable fish passage at the Sabin and Boardman Dams are costly and do not perform well in meeting all project objectives. The cost to modify the Sabin and Boardman Dams is more expensive than their removal. Removal measures are much more effective at meeting project objectives, and when taken in combination with modification of the Union Street Dam, their removal would be irrelevant to preventing the passage of invasive species as these species would not be able to move into the Boardman River upstream of Union Street. The modification measures at the Sabin and Boardman Dams would be less effective in mitigating thermal disruptions and reconnecting fragmented habitat than would dam removal.

As such, the following measures were carried forward into the formulation of alternative plans:

- Modification of the Union Street Dam
- Removal of the Sabin Dam
- Removal of the Boardman Dam

4.4 Formulation of Alternatives

Alternatives are combinations of potential measures to address project objectives within project constraints. The three measures carried forward were combined to form eight alternatives (including a No Action Alternative) for evaluation. These alternatives are listed in **Table 10** and described in this section.

Table 10: Alternatives Selected for Further Analysis

Alternative	Union Street Dam	Sabin Dam	Boardman Dam
Alternative 1	No Action	No Action	No Action
Alternative 2	Modify	No Action	No Action
Alternative 3	Modify	Remove	No Action
Alternative 4	Modify	No Action	Remove
Alternative 5	Modify	Remove	Remove
Alternative 6	No Action	Remove	No Action
Alternative 7	No Action	No Action	Remove
Alternative 8	No Action	Remove	Remove

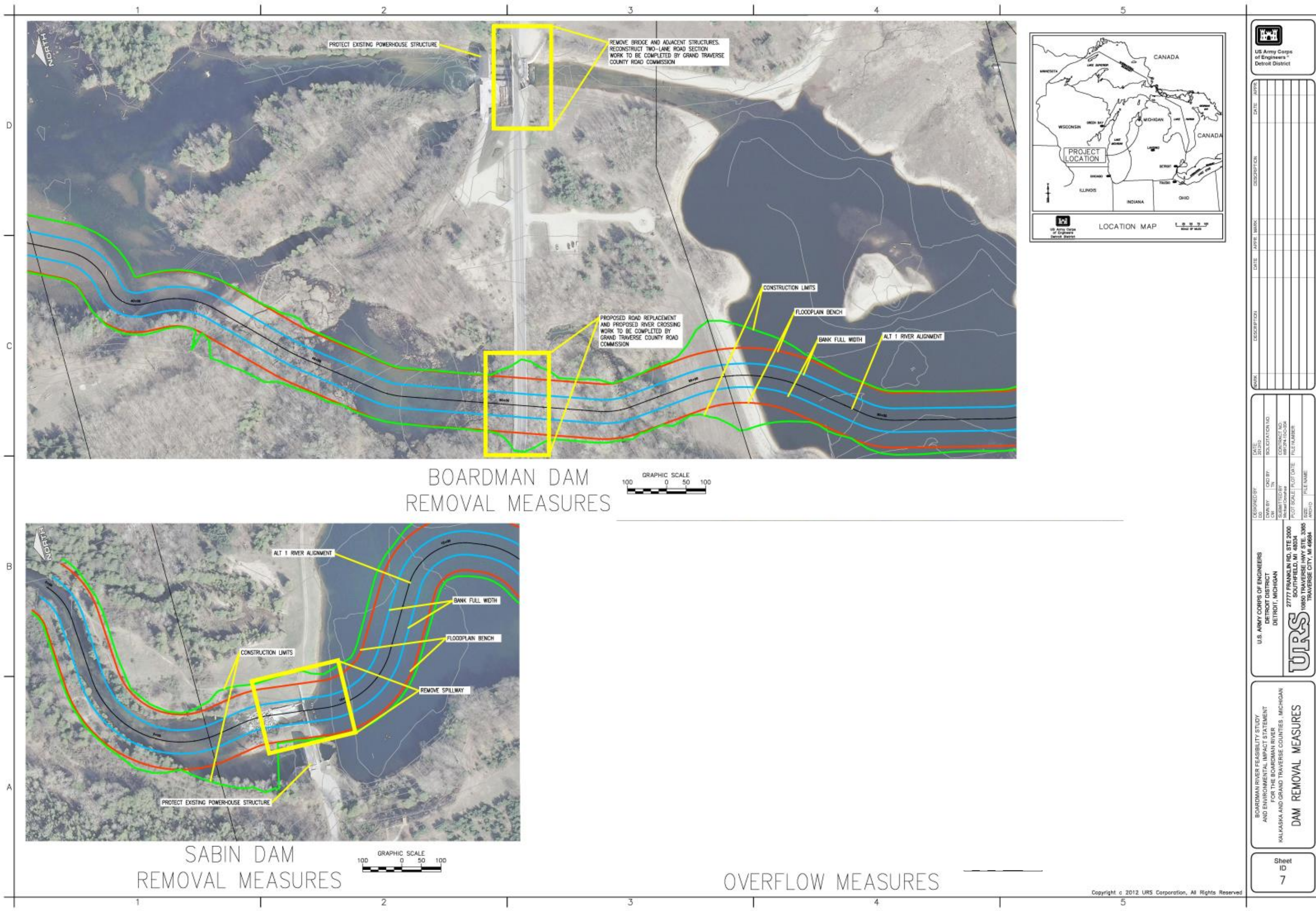

Figure 17. Dam removal measures.

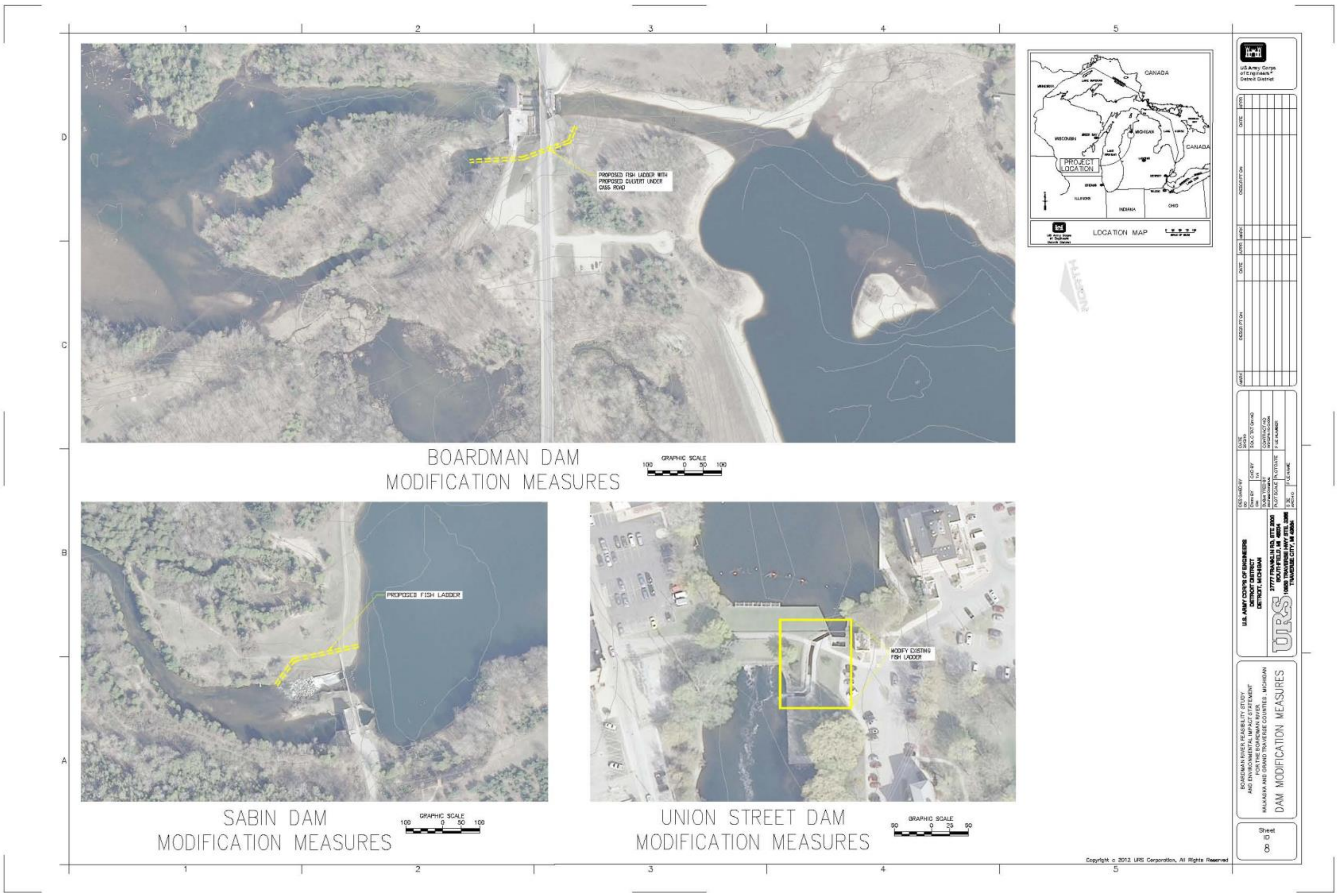

Figure 18. Dam modification measures.

Alternative 1. Alternative 1 (No Action Alternative) consists of retaining and maintaining all of the dams, powerhouses, and spillways. No measures would be implemented to restore or improve coldwater habitat. Water levels and impoundment sizes would not change. The dams would not be modified to allow increased fish passage. The fish ladder at the Union Street Dam would be maintained, along with the MDNR Boardman River fish weir. The No Action Alternative is included in the analysis to provide a baseline against which the beneficial and adverse impacts of the with-project alternatives may be compared.

Alternative 2. Alternative 2 consists of modifying the Union Street Dam to improve fish passage with the establishment of a trap-and-transfer operation at the MDNR Boardman River fish weir. It would provide spawning and foraging habitat in Boardman Lake and the Boardman River up to Sabin Dam for lake sturgeon that were manually transferred past the weir/dam. The dam and existing fish ladder would remain in place to maintain the current Boardman Lake level, but downstream passage would be improved through the dam's auxiliary spillway. The Sabin Dam would be maintained as it currently exists. The Boardman Dam would be retained and the pool elevation would remain lowered to meet the Dam Safety Act requirements of the MDEQ.

Alternative 3. Alternative 3 consists of modifying the Union Street Dam to improve fish passage with the establishment of a trap-and-transfer operation at the MDNR Boardman River fish weir. The dam and existing fish ladder would remain in place to maintain the current Boardman Lake level, but downstream passage would be improved through the dam's auxiliary spillway. The Sabin Dam would be removed to allow a free-flowing river to be restored from the Boardman Dam to Boardman Lake. The Sabin Dam would be breached in the area of the auxiliary spillway. In this area the river and floodplain would be designed. All other parts of the dam (i.e. the powerhouses and other portions of the earthen embankment) would remain in place. The proposed river alignment would include engineered riffles/grade control structures at the former Sabin Dam auxiliary spillway location that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at this location to redirect the channel and protect stream banks. The Boardman Dam would be retained and the pool elevation would remain lowered to meet the Dam Safety Act requirements of the MDEQ.

Alternative 4. Alternative 4 consists of modifying the Union Street Dam to improve fish passage with the establishment of a trap-and-transfer operation at the MDNR Boardman River fish weir. The dam and existing fish ladder would remain in place to maintain the current Boardman Lake level, but downstream passage would be improved through the dam's auxiliary spillway. The Sabin Dam would be maintained as it currently exists. The Boardman Dam would be removed and Boardman Pond would return to a more natural riverine state. The proposed river alignment would include engineered riffles/grade control structures at the former location of the Boardman Dam that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at this location to redirect the channel and protect stream banks. Breaching the Boardman Dam at the river's pre-dam location would require removing the current Cass Road where it intersects the new river path. A bridge to span the relocated river is currently being designed for the County by a professional engineering firm. The County Road Commission is on record as supporting a continued Cass Road crossing of the Boardman River and has State funds available to fund bridge work. All road and bridge work (design, demolition and construction) would be the responsibility of the Grand Traverse County Road Commission and would not be part of the USACE Ecosystem Restoration Project.

Alternative 5. Alternative 5 consists of modifying the Union Street Dam to improve fish passage with the establishment of a trap-and-transfer operation at the MDNR Boardman River fish weir. The dam and existing fish ladder would remain in place to maintain the current Boardman Lake level, but downstream passage would be improved through the dam's auxiliary spillway. The Sabin Dam and the Boardman Dam would be removed to allow a free-flowing river to be restored from upstream of Boardman Pond to Boardman Lake. The dams would be breached in the location of the historic channel. In this area the river and floodplain would be designed. All other parts of the dam (i.e. the powerhouses and other portions of the earthen embankment) would remain in place. The proposed river alignment would include engineered riffle/grade control structures at both dams that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at the dams to redirect the channel and protect stream banks.

Breaching the Boardman Dam at the river's pre-dam location would require removing the current Cass Road where it intersects the new river path. A bridge to span the relocated river is currently being designed for the County by a professional engineering firm. The County Road Commission is on record as supporting a continued Cass Road crossing of the Boardman River and has State funds available to fund bridge work. All road and bridge work (design, demolition and construction) would be the responsibility of the Grand Traverse County Road Commission and would not be part of the USACE Ecosystem Restoration Project.

Alternative 6. Alternative 6 consists of retaining the Union Street Dam, along with the existing fish ladder and fish weir operation. The current fish ladder operation would continue. The Sabin Dam would be removed to allow a free-flowing river to be restored from the Boardman Pond Dam to Boardman Lake. The Sabin Dam would be breached in the area of the auxiliary spillway. In this area the river and floodplain would be designed. All other parts of the dam (i.e. the powerhouses and other portions of the earthen embankment) would remain in place. The proposed river alignment would include engineered riffles/grade control structures at the Sabin Dam that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at the former Sabin Dam location to redirect the channel and protect stream banks. The Boardman Dam would be retained and the pool elevation would remain lowered to meet the Dam Safety Act requirements of the MDEQ.

Alternative 7. Alternative 7 consists of retaining the Union Street Dam, along with the existing fish ladder and fish weir operation. The Sabin Dam would be maintained as it currently exists. The Boardman Dam would be removed and Boardman Pond would return to a more natural riverine state. The Boardman Dam would be breached through the earthen embankment in the location of the historic channel. In this area the river and floodplain would be designed. All other parts of the dam (i.e. the powerhouses and other portions of the earthen embankment) would remain in place. The proposed river alignment would include engineered riffles/grade control structures at the former Boardman Dam location that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at this location to redirect the channel and protect stream banks. The bridge and road construction project required as a result of moving the river channel at Cass Road would be undertaken by the Grand Traverse County Road Commission and is not part of the USACE Ecosystem Restoration Project.

Alternative 8. Alternative 8 consists of retaining the Union Street Dam, along with the existing fish ladder and fish weir operation. The Sabin Dam and Boardman Dam would be removed to allow a free-flowing river to be restored from the Boardman Pond to Boardman Lake. The dams would be breached in the location of the historic channel. In this area the river and floodplain would be designed. All other parts of the dam (i.e. the powerhouses and other portions of the earthen embankment) would remain in place. The proposed river alignment would include engineered riffle/grade control structures at both dams that would add stability to the restored channel in areas of relatively steep slopes. In addition to engineered rock riffles, other bank stabilization measures might be used at the dams to redirect the channel and protect stream banks. The bridge and road construction project (design, demolition and construction) required as a result of moving the river channel at Cass Road would be undertaken by the Grand Traverse County Road Commission and is not part of the USACE Ecosystem Restoration Project.

4.5 Framework for Evaluation of Alternatives

The U.S. Water Resources Council publication, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983), directs Federal agencies to formulate plans that are economically and environmentally sound. Cost Effectiveness and Incremental Cost Analyses (CE/ICA) are recommended for evaluating ecosystem restoration projects. Using CE/ICA, the costs and non-monetary environmental outputs of each alternative are weighed against each other to identify the National Ecosystem Restoration (NER) plan.

The environmental outputs are not expressed in monetary terms because no acceptable method for measuring many environmental outputs in monetary terms currently exists. Consequently, the environmental outputs are expressed as average annual habitat units (AAHUs), accounting for both quality and quantity of improvements to coldwater and wetland habitat resulting from implementation of the alternatives. The following section describes the development of AAHUs for each alternative and is followed by a section describing cost estimating for each alternative.

4.5.1 Habitat Output Development

The use and suitability of impacted habitat was assessed for the Boardman River fisheries and wetlands. The benefits relating to controlling the passage of sea lamprey were also quantified. The benefits related to controlling sea lamprey were quantified as AAHUs using miles of river protected by a physical barrier to prevent infestation. Several project alternatives included the measure of modifying the Union Street Dam and construction of a sea lamprey barrier downstream of the confluence of the Boardman River and Hospital Creek. This would prohibit sea lamprey from migrating into Kids Creek (also known as Hospital Creek) and a large portion the Boardman River between the Union Street Dam and Grand Traverse Bay. It would also provide increased exclusion of lamprey compared to the No Action Alternative. Detailed descriptions of model development and application are included in **Appendix E: Habitat Analysis**. Given that the project goal focuses on the restoration of coldwater habitat to benefit Great Lakes ecosystems, modeling efforts addressed coldwater species. Warmwater habitat, relatively abundant in the northern Lower Peninsula of Michigan, was not modeled. Impacts to warmwater habitat are addressed qualitatively in the Trade-off Analysis in **Section 4.6.3**.

Fish Habitat. Correspondence with the USFWS and the MDNR identified the species for habitat analysis in the Boardman River system. The species selected were native coldwater species that should benefit from the proposed ecosystem restoration alternatives. Thus, their habitat would serve as an indicator when evaluating, selecting, and designing the Boardman Dam ecosystem restoration alternatives. Brook trout and longnose dace were selected as resident coldwater species and lake sturgeon were selected as migratory species for habitat modeling. Fish habitat for coldwater species is expected to improve in both quality and quantity with the implementation of an alternative.

Fish habitat was assessed using existing Habitat Suitability Index (HSI) models developed by the USFWS; the models were run with regional field data. These segment-specific HSI scores estimate how critical fish species and their associated habitat would be impacted by the different project alternatives. The current status of the Boardman River (reflecting the removal of the Brown Bridge Dam and, therefore, representing the future without-project conditions), along with the potential project alternatives, was analyzed in terms of habitat suitability for the selected fish species within 10 river segments. The HSI scores for each segment were multiplied by the river segment lengths (in miles) to account for quantity of habitat. The species-specific HSI scores for each river segment were then used to calculate AAHUs for each of the alternatives. To produce AAHUs, HSI scores were subjected to several correction factors and mathematical equations.

Wetlands. Although wetland restoration is not identified in the project objectives, assessing the impacts to wetlands is an important component of evaluating the alternatives for the Boardman River Project. Wetlands play an integral role in the health of a river system through flood and stormwater control, protection of subsurface water resources, pollution treatment, erosion control, wildlife and fish spawning and forging habitat, and other means.

Changes to wetland habitat were evaluated to provide a complete assessment of the impacts of alternatives. Dam removal measures are expected to increase the quantity of wetlands in the project area as impoundments are drained and the Boardman River resumes its natural course, providing valuable habitat to numerous aquatic and terrestrial plant and animal species. Changes to wetland habitat were quantified by scoring each affected wetland type using the Michigan Rapid Assessment Method (MiRAM) to assess the functions and values of individual wetlands affected by the alternatives. The MiRAM scores for individual wetlands were then multiplied by the wetland size (in acres) to account for size and available habitat to produce an AAHU score. This allowed the wetland-specific AAHU scores to take into account not only the quality of habitat, but also the amount of habitat.

4.5.2 Habitat Model Output Results

The tables in this section portray the AAHUs scores for fish and wetland habitat within the project area. The net AAHU is the difference between the with-project and the without-project (No Action Alternative) values.

Fish Habitat Output. HSI scores were evaluated by river segment and include only the river segments that would be affected. The scores also account for habitat connectivity (i.e., whether migratory fish, such as lake sturgeon, can pass through the Union Street Dam).The species-specific HSI scores for each river segment were used to calculate the AAHUs for each alternative. The AAHUs associated with the brook trout, longnose dace, and lake sturgeon were combined when applicable. **Table 11** shows the total and the net AAHUs estimated for each alternative for improvements to fisheries.

Table 11: Fisheries Average Annual Habitat Units

Alternative Description	Fisheries AAHUs	Fisheries Net AAHUs
1. No Action	2,908	0
2. Modify Union	2,973	65
3. Modify Union, Remove Sabin	3,176	268
4. Modify Union, Remove Boardman	3,233	325
5. Modify Union, Remove Sabin and Boardman	3,928	1,020
6. Remove Sabin	3,089	181
7. Remove Boardman	3,168	260
8. Remove Sabin and Boardman	3,349	441

AAHUs = average annual habitat units

Wetlands Output. Wetland habitat quality was quantified by scoring wetlands using MiRAM to assess their functions and values. MiRAM Quantitative Ratings are a series of metrics designed to provide a numerical score that reflects the total functional value of a wetland, which includes a wetland's ecological condition (integrity) and its potential to provide ecological and societal services (functions and values). Among others, factors assessed include wetland size, scarcity, buffer width, and internal connectivity.

The AAHU scores estimate how individual wetlands would be impacted by the different alternatives (**Table 12**).

Table 12: Wetland Average Annual Habitat Units

Alternative Description	Wetland AAHUs	Wetland Net AAHUs
1. No Action	1,726	0
2. Modify Union	1,726	0
3. Modify Union, Remove Sabin	3,371	1,645
4. Modify Union, Remove Boardman	3,142	1,416
5. Modify Union, Remove Sabin and Boardman	4,787	3,061
6. Remove Sabin	3,371	1,645
7. Remove Boardman	3,142	1,416
8. Remove Sabin and Boardman	4,787	3,061

AAHUs = average annual habitat units

4.5.3 Habitat Output Conclusions

Fish Habitat. Given that there is an abundance of warmwater habitat in the surrounding areas, the opportunity to increase the rare, coldwater habitat takes precedence. Only the dam removal alternatives would significantly increase the HSI and AAHU scores for brook trout and longnose dace, which both rely on coldwater habitat, as the removal would result in an increase of available coldwater habitat. The conversion of impoundment to riverine habitat would provide more usable habitat for coldwater species by lowering water temperatures and increasing the current.

HSI scores for lake sturgeon predictably increase for each alternative that provides access to additional reaches of the Boardman River. The alternative that incorporates both dam removals and the Union Street Dam modification would provide the greatest increase in available habitat within the Boardman River for lake sturgeon.

The primary limitation to HSI and AAHU modeling efforts was imposed by the project goal to explore the potential to restore fish habitat by restoring the internal connectivity and coldwater characteristics of the Boardman River, and increase the diversity of species moving between the Great Lakes and the river. The goal of coldwater stream restoration determined the fish species selected for HSI analysis, which ultimately led to increased HSI and AAHU scores for those alternatives that maximized this habitat type. Consequently, the impacts to warmwater habitat and associated fish species were not quantified during HSI and AAHU modeling because they were not included in the project goal. The loss of warmwater habitat must be accepted as a consequence of improving coldwater riverine habitat.

Wetlands. Using MiRAM, AAHUs scores favored alternatives that created or preserved wetland habitat with the following qualities: a large size, high plant diversity, forested habitat, complex hydrology, lack of invasive species, multiple habitat features, and scarcity. The alternatives that involve dam removal scored high due to the additional acres of wetland habitat anticipated to form from draining the impoundments.

Sea Lamprey Control. For each alternative, control of sea lamprey using the existing Union Street Dam is preferred. Given that the Union Street Dam is considered to be a barrier impermeable to sea lamprey, Alternative 1 (No Action Alternative), receives the same score for controlling sea lamprey as the other alternatives. Therefore, the net AAHU for sea lamprey control for each alternative is zero. Sea lamprey control was included in the habitat analysis so alternate locations for a barrier could be considered. The City of Traverse City proposed an alternative (Appendix A, Attachment 6) that included moving the sea lamprey barrier to the fish weir location. Ultimately this alternative was found to induce flooding through parts of the City and implementing it would have required substantial flood risk mitigation activities. Because of the flooding it was not considered further. Therefore, all of the 8 alternatives evaluated had the same net AAHU for sea lamprey.

4.5.4 Significance of Habitat Outputs

The effects on the quantity and quality of coldwater habitat generated by the alternatives represent a significant contribution to the Great Lakes Basin ecosystem. The significance of the restored habitat is reported in terms of institutional, public, and technical recognition as outlined in the USACE Planning Guidance Notebook (ER 1105-2-100).

The institutional significance of the habitat outputs is recognized in its inclusion in numerous State and Federal studies, including the Great Lakes Fishery and Ecosystem Restoration Program under whose auspices this Feasibility Study is undertaken. Various efforts to plan for restoration of the Boardman River habitat have been conducted by USFWS, MDNR, Grand Traverse County, and the City of Traverse City over a period spanning a decade or more.

The public recognition of the significance of the ecosystem of the Boardman River is reflected in the high level of public interest and cooperation in planning for its future. The cooperating organizations and agencies participating in the Boardman River IT include Federal, State, and local agencies; Native American tribes; citizens’ groups (such as the Conservation Resource Alliance and the Watershed Center of Grand Traverse Bay); and business interests.

The technical significance of coldwater habitat in the lower peninsula of Michigan and the Great Lakes region is represented by its relative scarcity compared to warmwater habitat. Furthermore, implementation of the alternatives would reconnect fragmented habitat for coldwater species, allowing free passage of species for the length of the river and improving passage to and from the Boardman River for select Lake Michigan species. Finally, the ecosystem outputs of the alternatives are technically significant in that they would increase the biodiversity of aquatic organisms by increasing genetic diversity of coldwater species throughout the river system.

4.5.5 Habitat Output Summary

When the AAHUs scores from fisheries, wetlands, and sea lamprey control assessments are compiled, project alternatives can be ranked based on overall benefit to the habitat of the Boardman River system. The net AAHU is the difference between the with-project and the without-project (No Action Alternative) values. **Table 13** summarizes the results of the net AAHU modeling for coldwater habitat and wetland habitat.

Table 13: Summary of Net Average Annual Habitat Units

Alternative Description	Fisheries Net AAHUs	Wetlands Net AAHUs	Total Net AAHUs
1. No Action	0	0	**0**
2. Modify Union	65	0	**65**
3. Modify Union, Remove Sabin	268	1,645	**1,913**
4. Modify Union, Remove Boardman	325	1,416	**1,741**
5. Modify Union, Remove Sabin and Boardman	1,020	3,061	**4,081**
6. Remove Sabin	181	1,645	**1,826**
7. Remove Boardman	260	1,416	**1,676**
8. Remove Sabin and Boardman	441	3,061	**3,502**

AAHUs = average annual habitat units
Note: Net AAHUs for sea lamprey are not included in this table, as their net value is zero.

The highest scoring project alternative is Alternative 5, modifying the Union Street Dam and removing both the Sabin and Boardman Dams. This alternative would conserve and create the most wetland habitat and restore the most usable aquatic habitat for native coldwater fish species.

4.5.6 Cost Development of Alternatives

All costs were calculated in terms of present value and then annualized. The average annual cost (AAC) is based on 2012 price levels, the current fiscal year (FY14) Federal discount rate of 3.50 percent, and a 50-year period of analysis. The discount rate, specified by the Water Resources Council, is to be used by Federal agencies in the formulation and evaluation of water and land resource plans. Costs include all expenditures required to implement the alternatives. More detailed cost information is available in **Appendix C: Cost Engineering**.

Construction costs for the Sabin and Boardman Dams include earthworks and site preparation, stream restoration, dam removal, incidental construction, and re-vegetation. The Union Street Dam construction costs include fish lift costs, demolition of the existing spillway, earthworks and site clearing, structural concrete, and fencing. Administration costs for the Sabin and Boardman Dams include soil sampling/analysis during the planning, engineering and design phase. The interest during construction for each alternative is calculated based on a period of 6 months for construction. The environmental monitoring cost for each alternative is $10,000 per year for 3 years after construction is complete and the present value is $28,000. Monitoring costs include temperature and dissolved oxygen monitoring; fish sampling to assess fish species diversity and abundance; and monitoring the channel and habitat structure stability.

Alternative 1, the No Action Alternative, assumes the three dams would be maintained for another 50 years; the present value of the necessary improvements and maintenance is approximately $1,929,100, an AAC of $82,200. This cost assumes an annual operation and maintenance cost of $20,000 for each dam, a $500,000 repair of stop log structures at the Union Street Dam, and $20,000 each for the Sabin and Boardman Dams to repair degradation of structures. Cass Road spans the intake works of Boardman dam and is integrated with this structure. The operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) cost for the No Action Alternative does not include costs to repair Cass Road Bridge, only the costs to maintain the existing dams.

The OMRR&R cost for the Union Street Dam modification is approximately $24,000 (present value of $562,900), which includes trap-and-transfer costs. After their removal, the Sabin and Boardman Dams would not have annual OMRR&R costs. For each alternative, OMRR&R is calculated for the entire system, including all three dams. For alternatives that include the removal of a dam or dams, the OMRR&R is associated with the remaining dam(s). **Table 14** summarizes the estimated cost for each alternative. All anticipated study costs are counted against the Federal share, but are not included in the total project costs. These costs are considered sunk costs and are not included in the CE/ICA. The net present value is the difference between the with-project and without-project costs. The net AACs are used in the CE/ICA.

Table 14. Summary of Alternative Costs

Description	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**	**Alternative 7**	**Alternative 8**
Real Estate	-	$5,200	$38,200	$67,000	$100,000	$33,000	$61,800	$94,800
Construction	-	$459,800	$2,147,400	$4,345,800	$6,033,400	$1,687,600	$3,886,000	$5,573,600
Engineering	-	$92,000	$429,500	$869,200	$1,206,700	$337,500	$777,200	$1,114,700
Administration	-	$23,000	$142,400	$252,300	$361,700	$119,400	$229,300	$338,700
Contingency	-	$115,000	$536,900	$1,086,400	$1,508,300	$421,900	$971,500	$1,393,400
Interest During Construction	-	$5,000	$23,700	$47,700	$66,400	$18,700	$42,700	$61,300
Present Value of Monitoring Cost	-	$28,000	$28,000	$28,000	$28,000	$28,000	$28,000	$28,000
Present Value of OMRR&R	$1,929,100	$1,539,800	$1,051,400	$1,051,400	$562,900	$1,440,600	$1,440,600	$952,200
Present Value of Total Cost	$1,929,100	$2,267,800	$4,397,500	$7,747,800	$9,867,400	$4,086,700	$7,437,100	$9,556,700
Net Present Value	$0	**$338,700**	**$2,468,400**	**$5,818,700**	**$7,938,300**	**$2,157,600**	**$5,508,000**	**$7,627,600**
Average Annual Cost	**$0**	**$14,400**	**$105,200**	**$248,100**	**$338,400**	**$92,000**	**$234,800**	**$325,200**

OMRR&R = operation, maintenance, repair, replacement, and rehabilitation

Note: Average annual costs were calculated using the FY14 Federal discount rate of 3.50 percent and a 50-year period of analysis. All costs are in 2012 dollars and were rounded to the nearest hundred. The OMRR&R costs include all three dams. The net present value is the difference between the with-project and the without-project costs.

4.6 Evaluation of Alternatives

The alternatives underwent cost effectiveness and incremental cost analyses. This section summarizes the results of those analyses.

4.6.1 Cost-Effectiveness Analysis

A CE analysis is conducted to ensure the least-cost alternatives are identified for various levels of environmental output. The CE analysis begins with a comparison of the AAC and the AAHUs of each alternative to identify the least-cost alternative for every level of environmental output considered. **Table 15** summarizes the results of the CE analysis.

Table 15: Cost Effectiveness Analysis Results

Alternative Description	AAC	Net AAHUs	AAC/AAHU	Cost Effective (Y/N)
1. No Action	$0	0	$0	Y
2. Modify Union	$14,400	65	$222	Y
3. Modify Union, Remove Sabin	$105,200	1,913	$55	Y
4. Modify Union, Remove Boardman	$248,100	1,741	$143	N
5. Modify Union, Remove Sabin and Boardman	$338,400	4,081	$83	Y
6. Remove Sabin	$92,000	1,826	$50	Y
7. Remove Boardman	$234,800	1,676	$140	N
8. Remove Sabin and Boardman	$325,200	3,502	$93	Y

Alternatives 1, 2, 3, 5, 6 and 8 were carried forward to ICA, as these were shown to be cost effective.

4.6.2 Incremental Cost Analysis

An ICA of the cost-effective solutions was conducted to reveal and evaluate changes in costs for increasing levels of environmental outputs. The ICA compares the environmental outputs with economic costs of alternatives to identify the alternative that has the lowest incremental cost per AAHU. Of the cost-effective alternatives, the alternative with the lowest incremental cost per unit of output of all alternatives is the first “best buy” alternative. Then, all cost-effective alternatives are compared to the first best buy alternative in terms of increments of cost and increases in increments of output. The alternative with the next lowest incremental cost per unit of output is the second best buy alternative, and so on. The screening analysis eliminated some alternatives that have lower total costs but are relatively inefficient in production. From the ICA, Alternatives 5 and 6 were identified as the best buy alternatives.

Table 16 presents a summary of the ICA. The ICA results show the additional cost that would be incurred to gain additional AAHUs for each successive level of attainable AAHUs. Given that Alternative 1 entails making no changes, the concept of incremental values does not apply.

Table 16: Results of the Incremental Cost Analysis

Alternative	AAC	AAHUs	Incremental Cost	Incremental AAHUs	Incremental Cost per AAHU	Best Buy
1. No Action	$0	-	-	-	-	Y
2. Modify Union	$14,400	65	$14,400	65	$222	
6. Remove Sabin	$92,000	1,826	$77,600	1761	$44	Y
3. Modify Union, Remove Sabin	$105,200	1,913	$13,200	87	$152	
8. Remove Sabin and Boardman	$325,200	3,502	$220,000	1589	$138	
5. Modify Union, Remove Sabin and Boardman	$338,400	4,081	$13,200	579	$23	Y

AAC= average annual cost
AAHUs= average annual habitat units
Note: Average annual costs were calculated using the FY14 Federal discount rate of 3.50 percent and a 50-year period of analysis. All costs are in 2012 dollars.

Alternatives 5 and 6 were identified as best buy alternatives, with Alternative 5 producing the most AAHUs of all the alternatives.

4.6.3 Trade-off Analysis

The alternatives are composed of various combinations of discrete measures developed to meet project objectives. Varied costs and impacts on the surrounding environment are projected for each alternative. This is because of the many variables involving the multiple dams, river segments, and impoundments.

Coldwater vs. Warmwater Habitat. The goal of this study is to determine a preferred alternative for the restoration of Great Lakes tributary habitat in the Boardman River. Any action alternative designed to increase the amount, quality, and connectivity of coldwater stream habitat would have the effect of decreasing the amount of existing warmwater habitat found in the impoundments upstream of the Boardman River dams. The existing habitat in these impoundments is primarily warmwater habitat of a type that is relatively common throughout northwestern Michigan. A preferred alternative would facilitate the transition of the abundant warmwater habitat back to the original coldwater habitat, which has become increasingly scarce in this region, along with wetlands contributing to the quality of the resultant coldwater habitat. The reestablishment of riverine coldwater habitat would result in a loss of approximately 120 acres of low- to moderate-quality warmwater habitat in Sabin and Boardman Ponds. The warmwater habitat would be replaced by approximately:

- 16 acres of coldwater riverine habitat
- 57 acres of wetlands
- 47 acres of riparian upland habitat

Alternative 1: No Federal Action

Advantages: No capital expenditures required by the Federal government. Sediment in the impoundments would not be mobilized. This alternative provides a baseline of 7,848 AAHUs for selected coldwater species. It would have no effect on the floodplain.

Disadvantages: The no action alternative would not meet the project objectives. It would not restore, create or improve coldwater habitat; it would not increase species diversity and restore the natural balance of aquatic species in the Boardman River; it would not allow the movement of woody debris and sediment; it would not negate thermal disruption or facilitate fish passage.

Alternative 2: Modify Union Street Dam

Advantages: This alternative would have the lowest AAC of the action alternatives. It would create an additional 65 AAHUs over no action by facilitating the movement of lake sturgeon downstream of the Sabin Dam.

Disadvantages: Alternative 2 was not identified as a "best buy". It would increase species diversity in the lower reaches of the Boardman River only minimally; it would not allow the movement of woody debris and sediment; it would not negate thermal disruption.

Alternative 3: Modify Union Street Dam, Remove Sabin Dam

Advantages: Alternative 3 requires low annual financial expenditures compared to other action alternatives. It would produce the advantages of Alternative 2, and would additionally open the Boardman River to sturgeon passage and the movement of aquatic species and organic material downstream of the Boardman Dam. It would mitigate the thermal disruptions caused by the presence of the Sabin Dam.

Disadvantages: The benefits to restoration of coldwater habitat are limited with this alternative due to the proximity of the Sabin and Boardman Dams; their impoundments essentially function together in raising water temperatures and preventing the natural movement of aquatic species, woody debris and sediment.

Alternative 4: Modify Union Street Dam, Remove Boardman Dam

Advantages: This alternative would produce a moderate net benefit in terms of AAHUs. It would mitigate thermal disruptions in the immediate area surrounding the Boardman Dam.

Disadvantages: Alternative 4 is not cost effective. It would not improve the free passage of aquatic species, woody debris and sediment in the lower Boardman River to any considerable degree due to the close downstream proximity of the Sabin Dam.

Alternative 5: Modify Union Street Dam, Remove Sabin Dam, Remove Boardman Dam

Advantages: Alternative 5 would produce the greatest benefit in terms of net gain in habitat units and improvements to coldwater habitat for aquatic organisms. It would best meet the project objectives, mitigating thermal disruptions for the lower Boardman River, allowing the passage of woody debris and sediment, and facilitating the movement of coldwater fish species. Actions at the Union Street Dam would facilitate the passage of migratory species between West Grand Traverse Bay of Lake Michigan and the Boardman River. This alternative was identified as a "best buy". Given that it produces the greatest amount of habitat at a reasonable incremental cost, Alternative 5 is identified as the NER alternative consistent with the Federal objectives for the project. This alternative is preferred by the non-Federal sponsor.

Disadvantages: Alternative 5 requires the greatest capital investment of the alternatives.

Alternative 6: Remove Sabin Dam

Advantages: Alternative 6 would provide a moderate net increase in AAHUs compared to the other alternatives. Its incremental cost per AAHU was shown to be reasonable in the ICA, and the alternative was identified as a "best buy". This alternative would mitigate thermal disruptions in the area immediately contiguous with the Sabin Dam.

Disadvantages: This alternative would produce limited progress toward meeting the project objectives. As with Alternatives 3, 4, and 7, the proximity of the Boardman and Sabin Dams to one another limits the beneficial effects to coldwater habitat in the lower Boardman River if measures are undertaken at only one of the dams. Therefore, although Alternative 6 requires a relatively low capital investment, it would not have significant beneficial impacts in restoring the unimpeded passage of aquatic organisms or the transport of sediment and woody debris.

Alternative 7: Remove Boardman Dam

Advantages: Removing the Boardman Dam alone would produce benefits similar to those produced by removing the Sabin Dam alone (Alternative 6). It would moderately increase net AAHUs while mitigating thermal disruptions in the immediate vicinity of the dam.

Disadvantages: Alternative 7 is not cost effective. As with the other alternatives that address only one of the two upstream dams in the study area, this alternative would produce limited progress toward meeting the project objectives. Alternative 7 would not have significant impacts in restoring the unimpeded passage of aquatic organisms or the transport of sediment and woody debris in the lower reaches of the river.

Alternative 8: Remove Sabin and Boardman Dams

Advantages: Removing the Sabin and Boardman Dams would produce the second highest habitat restoration benefits among the alternatives, opening up coldwater habitat to the entire Boardman River upstream of the Union Street Dam. This alternative would alleviate thermal disruptions caused by the dam and facilitate the natural movement of aquatic species, along with woody debris and sediment.

Disadvantages: Alternative 8 would require a high level of capital investment. It would not facilitate the movement of lake species into the Boardman River system as it includes no action at the Union Street Dam.

4.7 Alternative Evaluation Criteria

The alternatives introduced in **Section 4.4** were compared using four formulation criteria suggested by the U.S. Water Resources Council and ER 1105-2-100. These criteria are completeness, effectiveness, efficiency, and acceptability. Through the results of the Cost-Effectiveness Analysis, ICA, Trade-off Analysis, and local opinion, it appeared that Alternative 5 would best meet the project objectives; Alternative 5 was weighed in greater detail against these four evaluation criteria than were the other seven alternatives.

Completeness. Completeness is a determination of whether or not the plan includes all elements necessary to achieve its objectives. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others. Alternative 5 would result in restoration of coldwater habitat, facilitate fish passage upstream and downstream, allow movement of woody debris and sediment materials, negate thermal disruption, prevent passage of invasive species upstream, and reduce water temperatures in the impoundments. Alternative 5 does not require any additional actions to achieve the anticipated benefits.

Effectiveness. All of the final eight alternatives provide some contribution to the planning objectives. Effectiveness is defined as a measure of the extent to which a plan achieves its objectives. Alternative 5 would be more successful in achieving the project objectives than the other alternatives. The objectives would also be accomplished without transporting pollutants into West Grand Traverse Bay of Lake Michigan or increasing flood risks.

Efficiency. All of the final eight alternatives provide net benefits. Efficiency is a measure of the cost effectiveness of the plan expressed in net benefits. Alternative 5 is more efficient than the other alternatives, as it provides the greatest net benefits to the surrounding habitat for an incremental cost determined to be a “best buy.”

Acceptability. All of the final eight alternatives must be in accordance with Federal law and policy. Each of the alternatives meets this requirement. In addition, acceptance of the plan for the non-Federal sponsor and the concerned public is important for implementation. Alternative 5 is the preferred alternative of the non-Federal sponsor, as it completely, effectively, and efficiently achieves the project objectives to a higher degree than the other alternatives.

Based on the formulation criteria, the alternative selected for further development is Alternative 5. This alternative includes modifying the Union Street Dam to enable passage of lake sturgeon and the removal of the Sabin Dam and the Boardman Dam.

5 Selected Alternative

Alternative 5 is the NER plan, reasonably maximizing net ecosystem benefits in a cost effective manner. Alternative 5 would meet the project objectives by restoring internal connectivity and tributary habitat, allowing movement of woody debris and sediment materials through the river system, negating thermal disruption, and restoring the natural species balance in the Boardman River. These objectives would be accomplished without transporting pollutants into West Grand Traverse Bay of Lake Michigan or allowing upstream migration of invasive aquatic species.

Each of the alternatives was shown to be cost effective in meeting project objectives. The IWR Planning Suite criteria identify Alternative 5 as a “best buy,” providing the greatest increase in AAHUs for the lowest increase in investment. Given that most of the alternatives are cost effective, habitat restoration benefits and progress toward the project objectives would be realized from the implementation of any of the components of Alternative 5, or by the sequential implementation of its components. However, due to the proximity of the Sabin and Boardman Dams (they are essentially adjacent in the river system), action at only one dam would have considerably limited benefits compared to action at both. Full implementation of Alternative 5 would maximize the habitat benefits in the lower reaches of the Boardman River.

The selected alternative would realize the greatest progress toward meeting project objectives. It allows for a high percentage of sturgeon passage from West Grand Traverse Bay of Lake Michigan to the Boardman River via a trap-and-transfer operation requiring small changes to the existing fish weir located along the lower Boardman River, and does not increase flood risks downstream. The Sabin and Boardman Dam removals maximize available habitat for all species considered. The components of the selected alternative at each dam are described below.

5.1 Union Street Dam Modifications

In accordance with the USFWS’s desire to retain the Union Street Dam as a lamprey barrier, removal of the dam is not under consideration. Upstream passage of lake sturgeon would be accomplished by trapping and transferring sturgeon at the existing James P. Price Trap-and-Transfer facility to upstream locations, such as Medalie Park, Hull Park, or the Grand Traverse Nature Education Center (site of the Sabin Dam). Operational constraints in the form of a sturgeon-specific “standard operating procedure” would be developed to limit mortality to adult sturgeon and other fish species present during the collection activities. Minimizing mortality must be a primary concern of the trap-and-transfer operation because the numbers of spawning sturgeon are low.

The existing fish ladder at the Union Street Dam would be maintained, and downstream passage would be accomplished by modifying the existing Union Street Dam to be more conducive to passing adult sturgeon through the auxiliary spillway. This would also maintain the existing level of ANS (e.g., sea lamprey) protection. This measure is expected to require the following:

- Two fishery technicians to perform the upstream trap-and-transfer operation for 20 hours per week while sturgeon are moving upstream (approximately mid-April to early May).
- A truck suitable for transporting sufficient water to support sturgeon to the discharge location. The truck would be modified to hold and discharge fish and water as the discharge location might not have a launch.
- Traps and nets for sturgeon collection.
- Elevator system at weir facility to bring sturgeon and water to truck level.
- Stairs to safely allow fishery technicians to move from the water level to the weir level.
- Modification to the Union Street Dam fish ladder to facilitate downstream passage of adult sturgeon. The modification would include the alteration or replacement of the existing auxiliary spillway (200 cubic yards of concrete, two 48- inch diameter culverts 150 lineal feet long) and developing inlet characteristics that would attract sturgeon and accommodate downstream passage (Amaral, et al 2002). The existing fish ladder would be maintained to continue facilitating the upstream passage of salmonids and other species. The existing hydraulic conditions at the modified auxiliary spillway would not be changed to maintain the existing level of ANS protection.

5.2 Sabin Dam Removal

Dam removal would include removal of the concrete auxiliary spillway and a floodplain bench through the earthen dam adjacent to the auxiliary spillway, but would retain the existing powerhouse. An engineered riffle is proposed at the site of the existing auxiliary spillway to provide grade control and proper substrate, and to tie the pre-dam river elevation through the impoundment into the existing channel alignment below the dam.

The exposed bottomlands would be restored using permanent seeding, live staking and plantings, and by allowing the area to passively re-vegetate using the native seed bank. Erosion from the exposed bottomlands would be controlled by restoration activities in areas of steep slopes. These activities include seeding, planting and the placement of erosion control blankets. A free-flowing channel would form through the former impoundment, allowing the river to choose its own path, with limited active engineering. In doing so, it would move sediment and self-armor with existing gravel, cobble, and boulders. Based on bathymetry and depth of refusal data, the restored river would be expected to follow the pre-dam river channel. Stream bank protection is expected in the form of toe revetments, root wad revetments, or brush mattresses in areas of tight meanders. The proposed drawdown and construction methods are designed to limit the quantity of sediment that would be transported downstream. Implementation is discussed in further detail in **Section 5.4**.

5.3 Boardman Dam Removal

Dam removal would create a channel and floodplain through the earthen embankment to restore the Boardman River to its pre-dam alignment. The existing powerhouse would remain in place. The exposed bottomlands would be restored using permanent seeding, live staking and plantings on steep slopes, and by allowing the area to passively re-vegetate using the native seed bank. Erosion from the exposed bottomlands would be controlled by restoration activities in areas of steep slopes. These activities include seeding, planting, and the placement of erosion control blankets. A free-flowing channel would form through the former impoundment, allowing the river to choose its own path with limited active engineering. In doing so, it would move sediment and self-armor with existing gravel, cobble, and boulders. Based on bathymetry data, the restored river would be expected to follow the pre-dam river channel. Stream bank protection is expected in the form of toe revetments, root wad revetments, or brush mattresses in areas of tight meanders. The proposed drawdown and construction methods are designed to limit the quantity of sediment that would be transported downstream.

Implementation is discussed in further detail in **Section 5.4**.

5.4 Design and Construction

Design and construction for the selected alternative involves sediment management within each of the impoundments, along with the modification of the Union Street Dam and removal of the Sabin and Boardman Dams. The following sections describe the methods by which the design and construction of the selected alternative would occur. See **Appendix A: Engineering** for a more detailed description of these procedures.

5.4.1 Sediment Management Framework

This section discusses a preliminary sediment management framework for Sabin and Boardman Ponds. This framework assumes that all sediment exists at a contamination level below thresholds requiring special handling and placement techniques and are not a threat to human health. This is supported by sediment samples showing all contaminant levels below nonresidential DCC. Areas for sediment placement have been identified within the existing impoundment boundaries that account for all of the expected sediment removed during restoration. Contaminants are not expected to have an impact on placement locations. Coordination with regulatory agencies shall occur during PED to insure that sediment management approaches are consistent with state and federal regulations. This shall require the final designs to include development of a sediment management plan that provides the appropriate level of control for the quantity and quality of sediment that is expected to be mobilized from the impoundments. This may include institutional controls to be placed on the land precluding residential uses.

For Sabin and Boardman Ponds, a total sediment volume to be mobilized for the establishment of the proposed cross-section and profile has been determined. These feasibility-level designs only provide estimates of where the new river channel would naturally occur. The proposed channel cross-section is based on observations of natural channel and floodplain width outside of the currently impounded areas; natural processes would be allowed to establish the channel (bankfull) alignment, and sediment traps would be constructed near the Sabin and Boardman Dams to aid in the capture of naturally mobilized sediment from channel formation. These trapped sediments would then be removed by mechanical means to storage locations outside the existing channel and floodplain. Sediment volumes are detailed in **Appendix A: Engineering.**

Mechanical excavation would likely be required within the existing impoundments to establish a floodplain bench to provide a naturally functioning restored river channel. Excavating the floodplain bench would decrease stresses within the channel during larger flood events and prevent head-cutting and bank erosion. Excavation of the floodplain bench can follow impoundment drawdown, in the dry. **Figure 19** illustrates the proposed channel section and floodplain bench. **Figure 20** illustrates areas where excavated material can be placed for permanent storage.

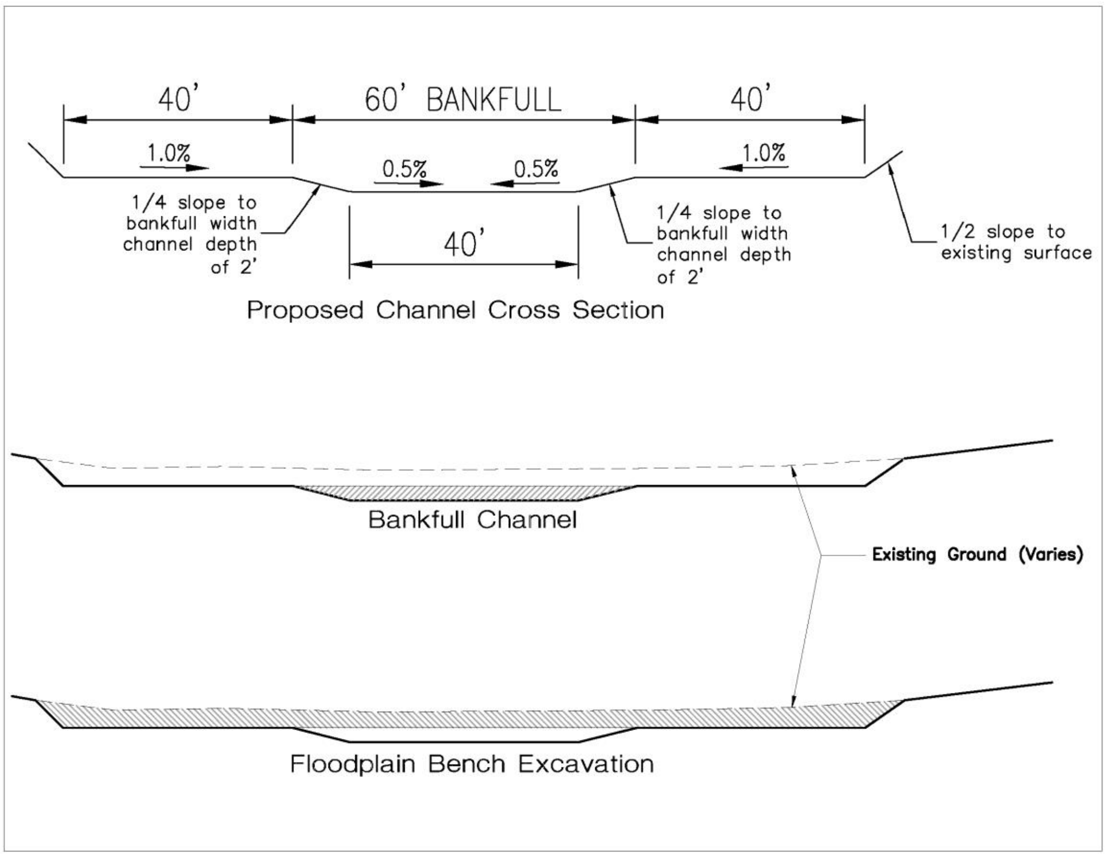

Figure 19: Proposed Channel Cross-section

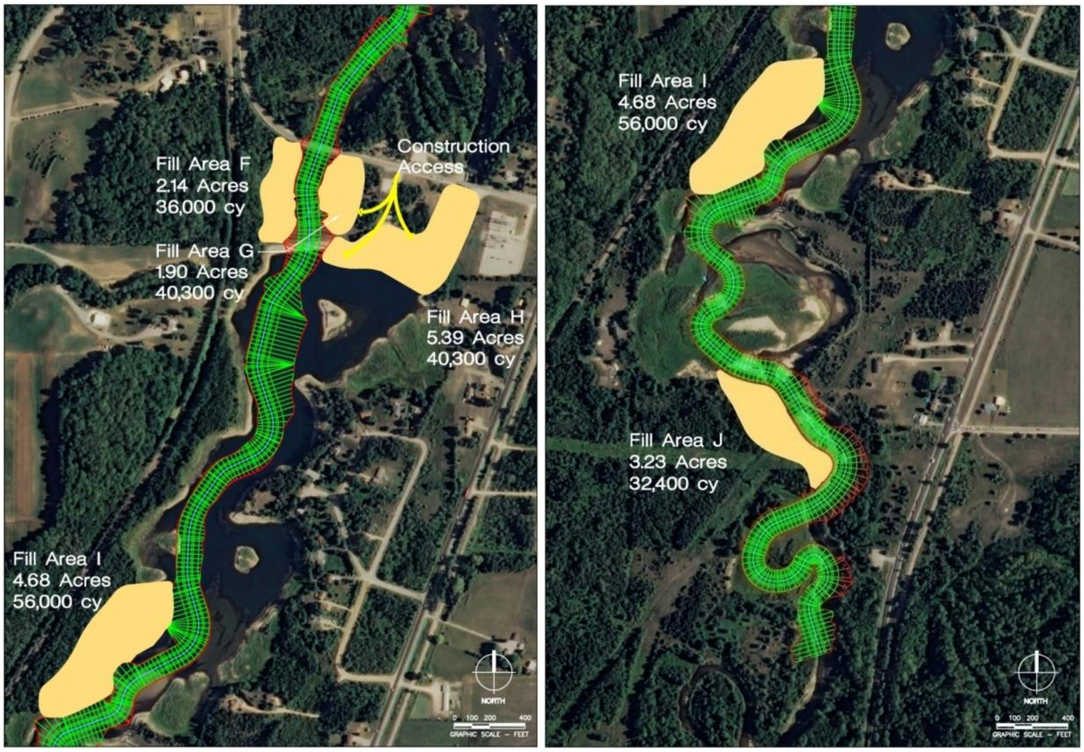

Figure 20. Proposed alignment through the existing Boardman Pond. The left side of the figure is the area near the dam; the right side is the area further upstream. Red areas indicate locations where high amounts of sediment removal may be required based on proposed conceptual alignments requirements for floodplain width.

A sediment volume required to excavate the floodplain bench has been determined for Sabin and Boardman Ponds. Potential fill areas (following drawdown) have been identified within both Sabin and Boardman Ponds to accommodate this sediment **(Figure 20 and Figure 21)**. These estimates are preliminary and for feasibility purposes only. Bathymetric data in the reservoirs were collected before recent drawdowns, and therefore, do not reflect any sediment movement that may have happened since the drawdowns.

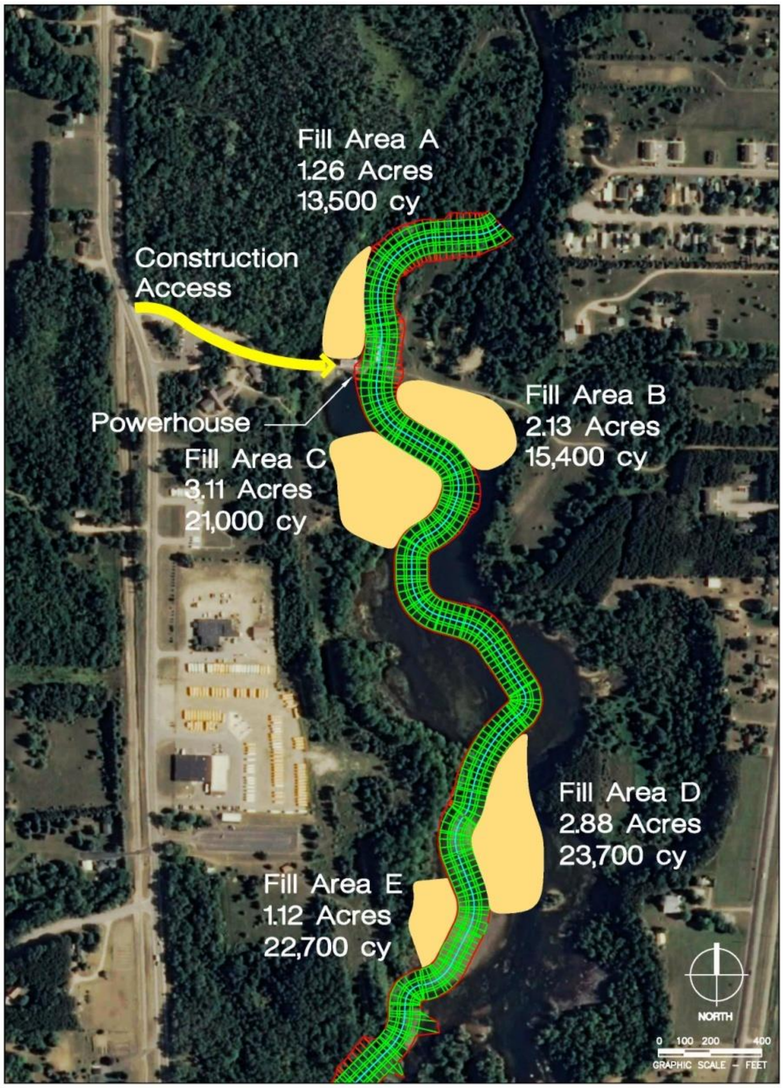

Figure 21. Proposed alignment through existing Sabin Dam impoundment

Although natural processes would mobilize sediment within the two ponds, mechanical excavation would be required to breach the existing dams and establish proposed channel alignments in these areas. As the earthen dam material is likely well drained, it would be placed in existing channel areas near powerhouse structures that would no longer be used after proposed channel restoration.

The construction activities associated with the channel restoration and dam breaching would result in fine silts and clays to be transported downstream to Boardman Lake. This material would be managed via a slow drawdown of the impoundment which would limit, but not eliminate movement of fine grained material. The magnitude and duration of fine sediment that is released downstream during construction should be monitored. During PED, water quality based expectations related to turbidity and fine material levels shall be developed with the regulatory agencies and in accordance with USACE policy. This approach to managing the short and long term impacts of mobilized material would reflect a level of control commensurate with the environmental risk they pose during transport and settlement in Boardman Lake. Sediment quality sampling reported that all contaminants sampled were below the PEC and only arsenic and cadmium were above the TEC which indicates there should be limited to no toxicity from the mobilized sediments. This conclusion is further supported by the lack of sediment quality related water quality or aquatic toxicity issues in either Boardman or Sabin ponds. Sediment sampling shall be conducted as required by the regulatory agencies, and in accordance with USACE policy, to analyze and approve the sediment management approach developed during PED.

During construction a large area would be devoid of vegetation and the potential for soil erosion would be present. During PED a detailed soil erosion and sedimentation control plan that meets local, state and federal regulatory requirements would be developed in coordination with regulatory agencies and in accordance with USACE policy. This plan shall limit erosion and sedimentation within the limits of construction using adequate and efficient control measures during the construction phase.

Several areas along the proposed alignment would benefit from engineered riffles and grade control structures. These riffles would add stability to the restored channel in areas of relatively steep slopes. In addition, engineered rock riffles would provide habitat and fish passage in the restored channel.

Figure 22 shows an example of engineered rock riffles during low flow that exhibit natural materials resisting erosion and dissipating energy. In addition to engineered rock riffles, other bank stabilization measures may be used to redirect the channel and protect stream banks. These measures may include J-Hook weirs, soil wraps, brush matting, rock and log toe protection, and root wad bank protection. These features provide varied habitat with structure, shade, and controlled scour holes.

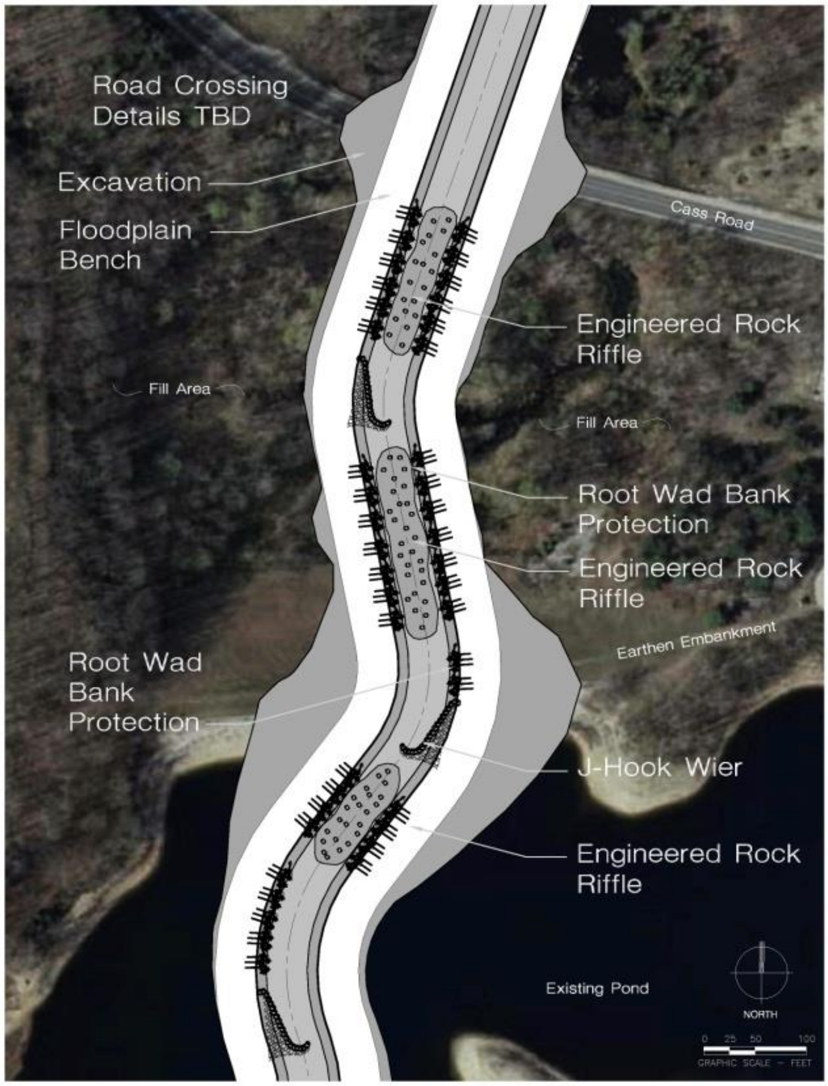

Figure 22: Application of Engineered Riffles and Bank Stabilization Measures

5.4.2 Construction at Union Street Dam

Dam modifications would include a trap-and-transfer operation at the MDNR facility with modifications to the Union Street Dam to allow downstream passage for fish species (**Figure 23**). The trap-and-transfer operation at the MDNR facility would require two fishery technicians to collect the sturgeon and lift the fish and water into a truck to be transported upstream. This operation would require the installation of a lift system at the weir to get the fish to the truck level. Stairs from the MDNR facility down to the water level are recommended for safety. A truck capable of transporting the fish and water and safely discharging them back into the river would also be needed.

Downstream passage of sturgeon at the Union Street Dam would be facilitated by modifying the existing auxiliary spillway. The modifications would include constructing a permanent concrete sill in place of the current gate. The top of the sill would be even with the elevation of the fish ladder entrance. The approach to the sill, from upstream, would gradually slope up to direct the bottom-swimming sturgeon up and over the sill. The spillway intake would need to be reconstructed to provide a plunge pool for the sturgeon, with a minimum depth of 6 feet. In addition, the two 48-inch diameter culverts would be replaced at a shallower slope. These modifications would ensure that the channel maintains the current level of protection against upstream sea lamprey passage while better facilitating the downstream passage of sturgeon.

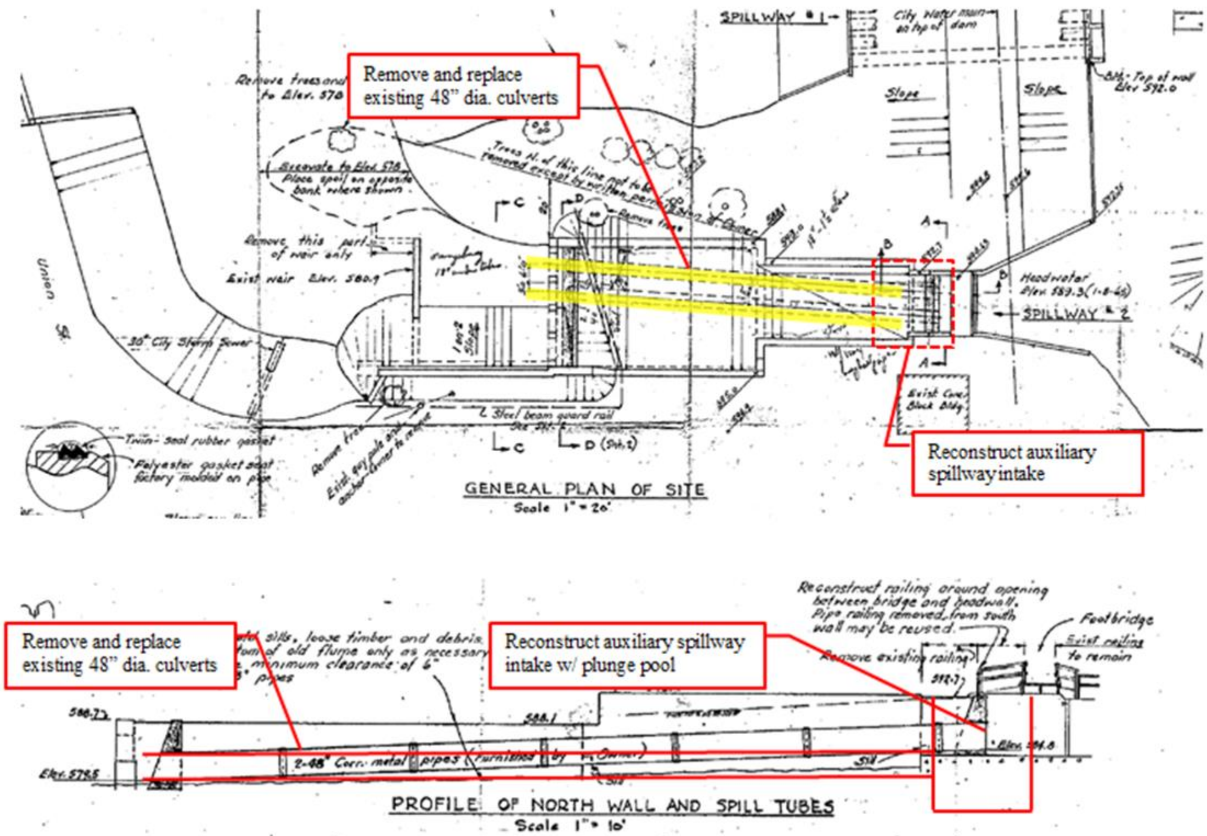

Figure 23: Union Street Dam Modification

5.4.3 Construction at Sabin Dam

Dam removal would remove the concrete spillway and create a floodplain through the earthen dam. Other components of the dam (powerhouse and earthen embankment) would be left in place. The exposed bottomlands would be restored to a free-flowing channel through the former impoundment. The river would be allowed to form its own path during the drawdown process with help from limited active engineering. In doing so, it would move sediment and self-armor with existing gravel, cobble, and boulders, and is expected to follow the pre-dam river channel.

Recently, the Sabin Dam impoundment has been drawn down approximately 4 feet from its normal pool elevation. This drawdown was accomplished by removing all of the stop logs at the powerhouse and spillway structures. Under low-flow conditions, all of the flow passes through the chutes under the auxiliary spillway (elevation 600.3 feet). Under higher flow conditions some of the flow passes through the powerhouse (elevation 608.9 feet).

The breach point for the Sabin Dam is proposed to be at the current auxiliary spillway location (**Figure 24**). The breaching would be performed in 1 foot intervals and complete drawdown is anticipated to take 20 to 30 days. The spillway is constructed of reinforced concrete with extensive energy dissipating structures in the form of large concrete chunks. These structures would be re-purposed during construction to build a downstream sediment trap during the drawdown process.

The drawdown would be accomplished by notching down the concrete spillway using an excavator-mounted hydraulic jack hammer. The contractor would notch down the spillway incrementally to draw down the impoundment at a maximum rate of 1 foot per day. This draw-down increment was estimated based on the difference between the capacity of the breaching channel and the average daily flows. The actual draw down rate would be determined in the field, based on observed sediment movement and hydrologic conditions. The incremental drawdown would continue until the breach elevation is 2 feet below the proposed engineered riffle. The engineered riffle would then be keyed into the remaining substructure.

Sediment management during the drawdown operation would be accomplished through a series of sediment traps and active excavation of the channel and floodplain. When the drawdown begins, the impoundment would operate as a large sediment trap that captures the majority of the sediment; a secondary sand trap would be constructed immediately below the auxiliary spillway where the breach is occurring (**Figure 24**). As the water level continues to drop, sediment traps would be placed within the impoundment area to trap sediment migrating from upstream. The sediment traps would be re-excavated, as needed, to maintain a minimum depth of 5 feet or as deemed necessary by downstream sediment migration. In addition to the sediment traps, the channel and floodplain would be actively shaped to ensure that design criteria are met. This would result in sediment being removed to placement sites within the impoundment that would not be subject to erosion and transport. Turbidity monitoring would be necessary downstream of the breaching operations through the duration of the project.

Figure 24: Sabin Dam Breaching Plan

5.4.4 Construction at Boardman Dam

Dam removal would involve excavation of the earthen embankment to provide a properly sized floodplain through the earthen portion of the dam. The powerhouse and spillway would remain. The river would be allowed to choose its own path through Boardman Pond with limited active engineering, and is expected to follow the path of the historic river channel. In doing so, it would move sediment; self-armor with existing gravel, cobble, and boulders; and expose the former channel bed. Excavation of the river channel would provide for removal of sediment from the channel, as needed, as well as provide for an appropriately sized floodplain. This would occur during and after the drawdown process.

The Boardman Dam breaching operation (**Figure 25** and **Figure 26**) is planned for the earthen embankment in the location of the pre-dam river alignment. The breaching would be accomplished by pumping the water over the earthen embankment and removing the earthen dam in the dry. The earthen embankment is composed of fill material and a reinforced concrete core wall. A sheet pile curtain wall extends a minimum of 10 feet below the concrete core wall. The native soils below the embankment are a mixture of sands and clays.

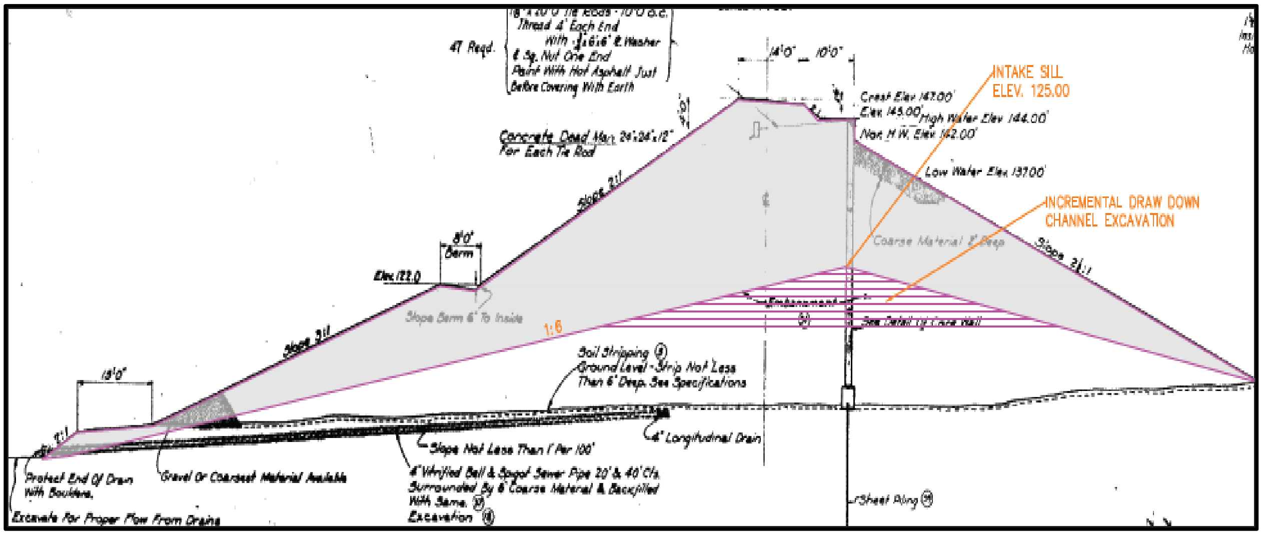

Figure 25: Profile of Boardman Dam Breaching Operation

The breaching operation would begin with the removal of the top of the embankment and core wall to within 5 feet of the existing water surface elevation in the impoundment. Portable pumps would be installed on this newly created "work pad" on the west side of the embankment. Fused high density polyethylene (HDPE) pipes would be connected to the pumps for suction and discharge lines. The total capacity of the pumping system would be 400 cubic feet per second (cfs). This rate would provide ample capacity to meet the desired drawdown rate of 1 foot per day under mean flow conditions (approximately 270 cfs) (Prein & Newhof, 2009). This flow rate also exceeds the 10 percent exceedance flow of 390 cfs (for the months of June, July, August and September).

As a redundant safety measure, the contractor would have onsite flexible hard armor mats (ArmorFlex) to place in a constructed channel across the embankment, in the event that the pumps fail or capacity is exceeded. Additionally, the contractor would always maintain a minimum of 5 feet of freeboard on the earthen berm until the impoundment level is within 3 feet of the proposed river profile. At such time, the contractor would complete removal of the earthen dam. A float activated alarm system would be installed on the upstream side of the impoundment to notify the contractor if the water level begins to rise.

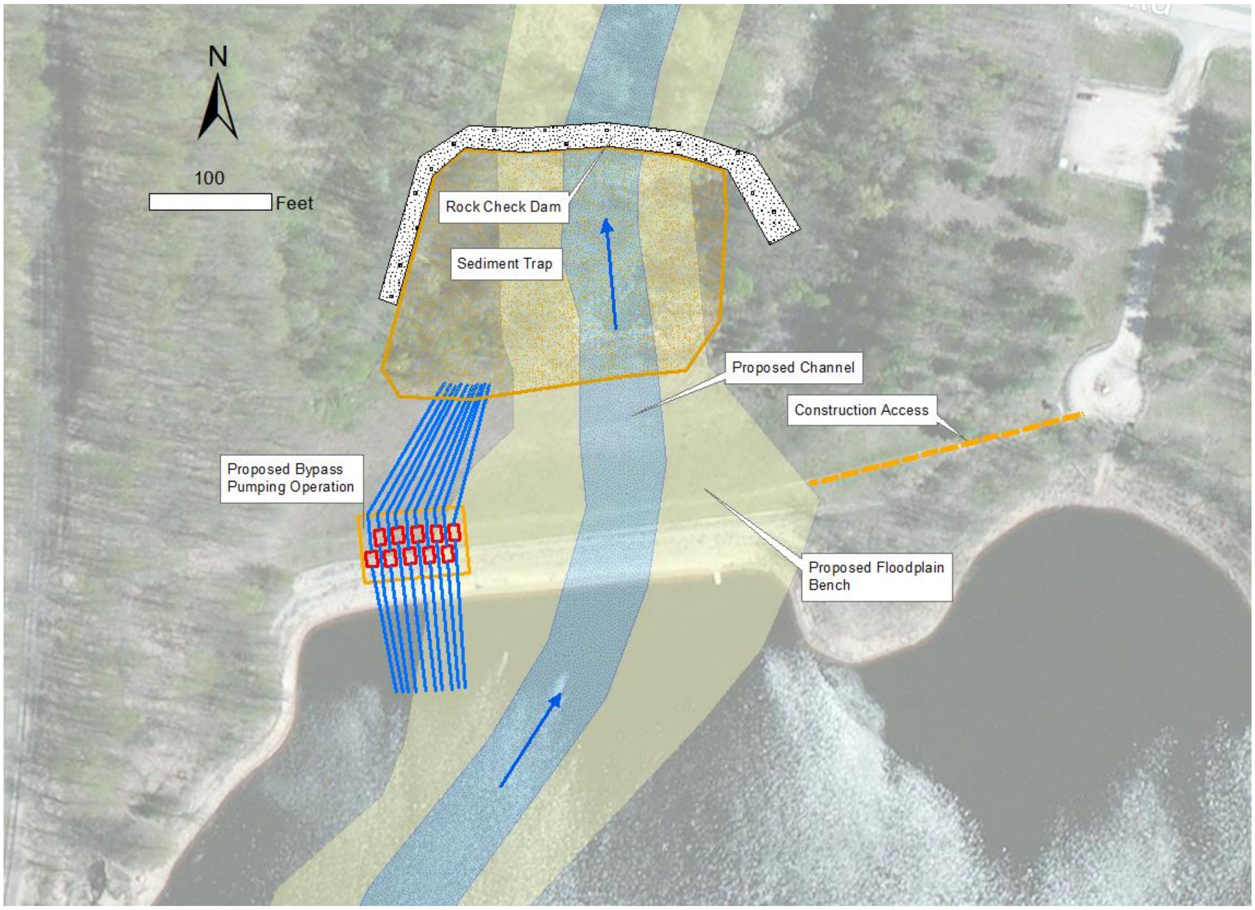

Figure 26: Plan View of Boardman Dam Breaching Operation

Sediment management during the drawdown operation would be accomplished through a series of sediment traps and active excavation of the channel and floodplain. When the drawdown begins, the impoundment would operate as a large sediment trap that captures the majority of the sediment; a secondary sand trap would be constructed immediately below the earthen embankment, where the breach is occurring. As the water level continues to lower, sediment traps would be placed within the impoundment area to trap sediment migrating from upstream. The sediment traps would be re-excavated as needed to maintain a minimum depth of 5 feet or as deemed necessary by downstream sediment migration. In addition to the sediment traps, the channel and floodplain would be actively shaped to ensure that design criteria are met. This would result in sediment being removed to placement sites within the impoundment that would not be subject to erosion and transport. Turbidity monitoring would be necessary downstream of the breaching operations throughout the duration of the project.

5.5 Real Estate

A Real Estate Plan was completed by the USACE, Detroit District (see **Appendix D: Real Estate Plan**). The non-Federal sponsor would provide all land, easements and rights of way necessary for the construction, operation and maintenance of the project. The total land required is approximately 184.2 acres, consisting of 181.6 acres of fee ownership that includes the modified course of the Boardman River, 0.6 acres of temporary easement for work and storage at the Trap and Transfer and Fish Ladder sites, 0.1 acres of permanent easement for access at the Fish Ladder, and 2.0 acres of temporary easement for work and storage at the Cass Road site. All land associated with the project is owned by the NFS, or they have an agreement in place with the City of Traverse City, the entity that owns the property around Union Street Dam. They have the full power, authority and capability to provide their share of the total project costs. **Figure 27** and **Figure 28** depict the land area and limits of work for all aspects of the project.

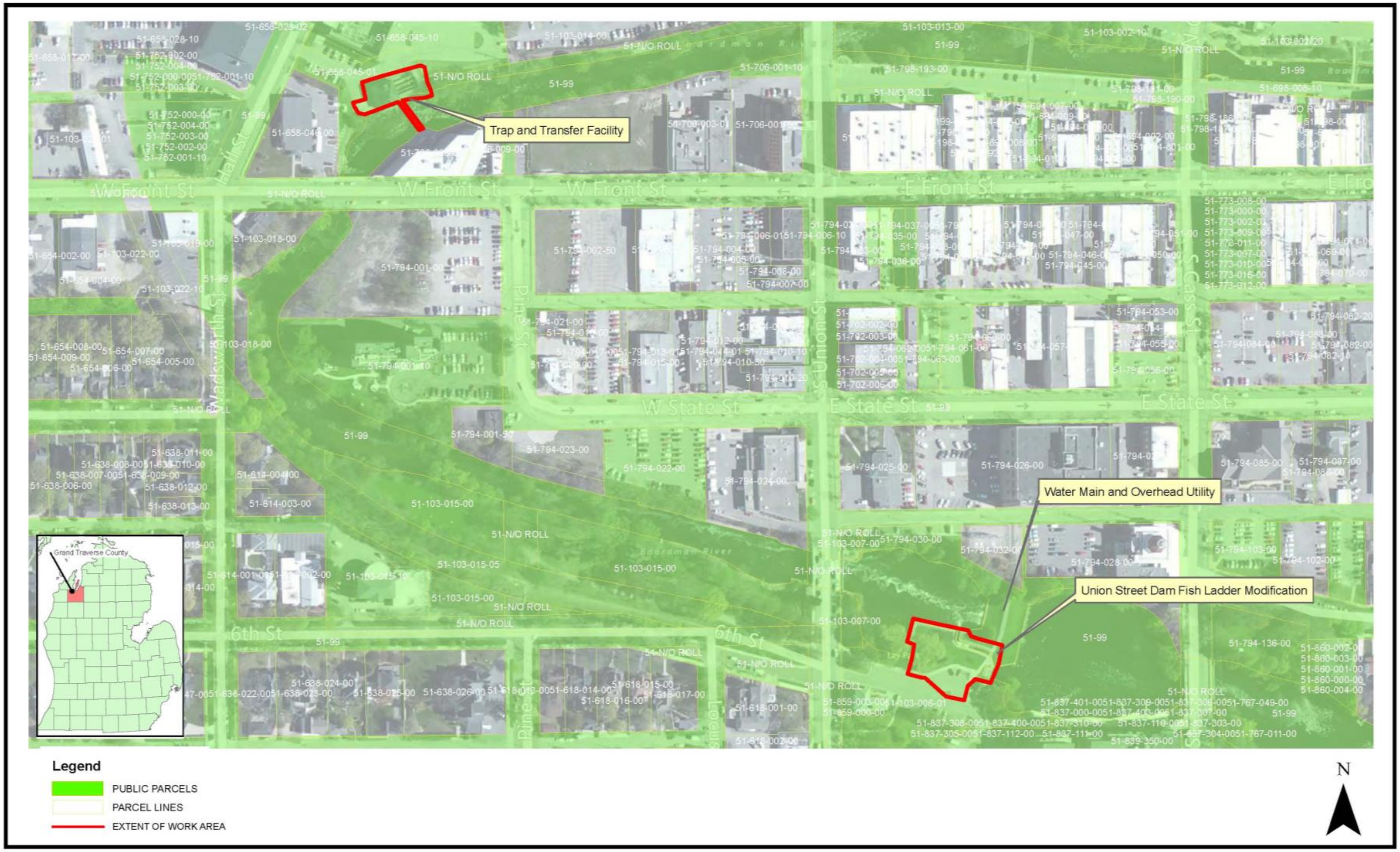

Figure 27. Extent of work areas near Union Street Dam.

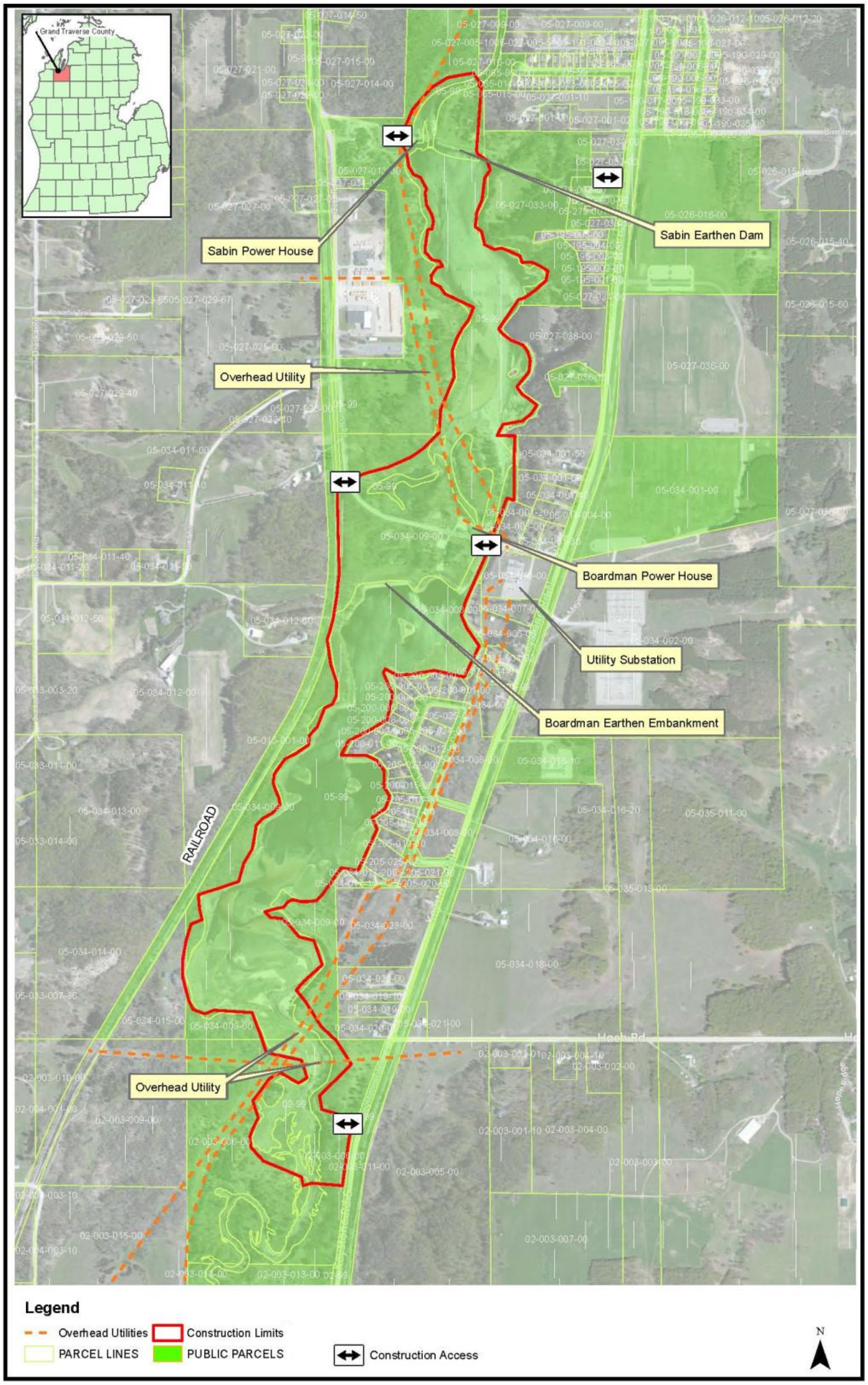

Figure 28. Extent of work area for removal of Sabin and Boardman and associated restoration activities.

The entire impounded area, as well as the riparian upland areas containing the dams, has been allocated to the project. The actual work would utilize much of the riparian upland area for work and storage activities, and the impoundments would be used for sediment disposal as defined in the Environmental Assessment and, briefly, in **Appendix D: Real Estate Plan**.

The environmental testing results may require that institutional controls would need to be placed on the lands prohibiting residential uses. Final determination of any appropriate institutional controls would be determined following final environmental testing and review.
The baseline cost estimate for the value of lands, easements, rights-of-way (LERs) is $100,000. The Federal administrative costs are estimated to be $20,000.

No cemeteries, historic properties or special aquatic sites are impacted by the project, with the exception of upstream wetlands which may be affected by flowage easements.

5.6 Monitoring

A monitoring plan is required following guidance from ER 1105-2-100, and is an important tool to help establish post-construction success of an ecosystem restoration project. Monitoring provides data to compare pre- and post-project conditions, gauge the success of the project, and achieve the project objectives. The monitoring plan for the Boardman River Ecosystem Restoration project would be cost shared between the USACE and NFS for up to 10 years as expressed in the Project Partnership Agreement (PPA) or until ecological success has been achieved for the project. A decision point for success of the project objective would be made during monitoring year 3 and, if necessary, years 6, 8, and 10. A detailed description of the monitoring plan can be found in **Appendix F: Monitoring Plan**.

Project-specific parameters for monitoring include: temperature and dissolved oxygen (DO), monitoring of channel and habitat structure stability and gradation, sediment deposition and accumulation, and fish sampling for species identification and colonization by invasive species. The information gathered as part of the monitoring program would be collected in coordination with the MDNR to ensure consistency and comparability with previously collected data. Temperature, DO, and fish sampling results would be recorded and reported annually to the USACE and project stakeholders. After 3 years of monitoring river channel habitat, sediment deposition data, temperature and DO, and 1 year of fisheries monitoring, results would be reviewed and compared to baseline data to determine whether evidence exists to determine project success. Although monitoring for up to 10 years (or until the Commander deems the project is successful) is permitted, 3 years is considered the minimum time required to determine success for this type of project.

The cost for monitoring would be approximately $10,000 per year for up to a ten year period. Monitoring would be undertaken for a minimum of three years, and the need for any additional monitoring would be determined at the end of that time period. The non-Federal sponsor is responsible for performing the monitoring, or having it performed via a contractor. Monitoring expenses would be cost shared as specified in the PPA.

Detailed adaptive management actions would need to be devised based on the monitoring data. Adaptive management actions must be tailored to the specific issues encountered and may vary depending on the magnitude of the discrepancy between post-construction conditions and desired conditions. Therefore, the specifics of the adaptive management actions would involve a multi-disciplinary group that includes, at a minimum, the MDNR, the non-Federal sponsor and the USACE. Adaptive management costs are a non-Federal expense under Section 506 guidelines.

5.7 Plan Accomplishments

Removal of the Boardman and Sabin Dams and modification of Union Street Dam provides connection of the upper Boardman River with West Grand Traverse Bay of Lake Michigan for a variety of fish species. The removal of Boardman and Sabin Dams would eliminate fish passage barriers within the Boardman system, while modifications to the existing Union Street Dam fish ladder would provide downstream passage of all fish species and trap-and-transfer operations would move lake sturgeon upstream.

Primary changes to fish and wildlife habitat from removal of a dam would be the loss of impounded water and its lake-like, slower-moving water and warmer water habitats. Historically, the Boardman River was a coldwater riparian habitat. The removal of the dams would allow the river to transition back to its natural coldwater habitat. Such habitat is relatively rare in the lower peninsula of Michigan compared to the many warmwater habitats found in the surrounding areas. Wildlife species preferring riverine, flowing-water habitat would benefit. Those that prefer (or are dependent upon) lake-like conditions would lose habitat and population along the lower reaches of the Boardman River. However, because this lentic habitat is relatively common in the area, much of this population is likely to find new locations on nearby lakes.

Alternative 5 would reduce water elevation within the impoundments, and is predicted to result in a gain in wetland acreage with the conversion of open water areas to wetlands. This would produce an increase in species and structural diversity with the conversion of deep aquatic habitats to emergent and ultimately emergent/scrub-shrub systems. Such a shift in wetland type and extent would improve the quality, and increase the quantity of rare species and overall wildlife habitat available along the Boardman River. These changes would also open up a more diverse fishing environment for recreational anglers and tribal members in the surrounding areas. The changed conditions for the impoundments, wetland, river, and riparian upland land types are summarized in **Table 17** and

Table 18. A detailed analysis of changed conditions can be found in **Appendix E: Habitat Analysis**.

Table 17: Project Area Impacts for Sabin Dam Removal

Sabin Dam Project Area Land Types		
Category	**No Action (acres)**	**Dam Removal (acres)**
Impoundment	40.0	0.0
Wetland	16.7	47.2
River	1.6	6.4
Riparian Upland	1.4	6.1
Total	59.7	59.7

Table 18: Project Area Impacts for Boardman Dam Removal

Boardman Dam Project Area Land Types		
Category	**No Action (acres)**	**Dam Removal (acres)**
Impoundment	78.0	0.0
Wetland	13.1	39.6
River	0.0	11.0
Riparian Upland	0.0	40.5
Total	91.1	91.1

The selected alternative meets all of the project objectives within the project constraints. It would:

- Restore natural habitat balance through the restoration of the historical coldwater habitat along the Boardman River.
- Allow unimpeded movement along the river upstream of the Union Street Dam, which must remain in place to block the upstream passage of ANS. Additionally, woody debris and sediment would be able to move freely along the length of the Boardman River.
- Negate thermal disruption and reduce water temperatures along the length of the river by removing the impoundments.
- Facilitate fish passage by removing the barriers at the existing Sabin and Boardman Dams, and facilitate improved downstream passage at the Union Street Dam. Desirable Great Lakes fish species would be assisted in moving upstream from West Grand Traverse Bay of Lake Michigan at the trap-and-transfer facility at the Union Street Dam, while invasive species would be prevented from moving upstream.

5.8 Summary of Environmental and Social Effects

The following sections provide a summary of the environmental and social effects involved with the integration of Alternative 5. A full detailed description can be found in the **Environmental Assessment**.

5.8.1 Environmental Effects

The Boardman River Restoration project offers a sustainable solution to the restoration of rare coldwater fish habitat in the lower peninsula of Michigan. Environmental and economic data was analyzed to formulate the recommended alternative. The recommended alternative was subject to a risk analysis which included substantial input from project stakeholders.

Based on the findings of the Environmental Assessment, implementation of Alternative 5 would not have significant adverse, direct, indirect, or cumulative effects on the quality of the environment. The selected alternative would restore the aquatic ecosystem along the Boardman River. It would improve habitat by restoring the coldwater temperature regime; allow sediment, organic material, and woody debris to move downstream; remove barriers to fish passage within the Boardman River; and allow sturgeon to be manually passed over the Union Street Dam, opening up additional habitat for this threatened species. Based on the analysis of potential impacts, implementing this alternative does not constitute a major Federal action that significantly affects the quality of the environment. Given that no significant impact would result from Alternative 5, a Draft Finding of No Significant Impact (FONSI) is recommended.

It should be noted that there are potential unintended consequences to fish populations with the implementation of the alternative. Whereas Alternative 5 would increase suitable coldwater stream habitat for native fish species like brook trout and longnose dace, it could also benefit non-native coldwater species like brown trout and rainbow trout. These non-native trout species have the potential to depress native brook trout populations, but overall benefits of river restoration outweigh a potential increase in these non-target fish populations. Additionally, dam removal would not introduce brown trout or rainbow trout to additional river segments since they are already found throughout the Boardman River and in every non-impounded river segment where brook trout currently exist.

5.8.2 Social Effects

Alternative 5 would have little to no significant impacts on the social factors within the project area. These factors include aesthetics, recreation, transportation, utilities and infrastructure, public services, socioeconomics, and environmental justice. Any negative impacts identified would be temporary in nature and take place only during the construction phases of the project.

As part of the National Environmental Policy Act (NEPA) process, consideration of the effects of the project on any historic properties is required under Section 106 of the National Historic Preservation Act of 1966 (Title 16 of the U.S. Code 470 et seq., as amended). The Section 106 process, as well as guidance from the Michigan State Historic Preservation Officer (SHPO) and

Office of the State Archaeologist (OSA), typically involves archival research, tribal consultation and field reconnaissance.

In correspondence dated July 13, 2005, October 13, 2005, August 22, 2007, and July 8, 2008, the Michigan SHPO and OSA indicated that no historic aboveground properties would be affected by the proposed undertaking. Therefore, the modification or removal of the dam structures would not represent an adverse effect to historic properties. However, this correspondence included a request from the Michigan SHPO that an archaeological survey be conducted of the former impoundments, following drawdown, and targeted on the former shorelines of the Boardman River.

In June 2012, following a cultural literature review, archaeologists undertook a Phase I archaeological survey for the Boardman River Feasibility Study Project. This archaeological investigation focused on three survey areas located along the Boardman River in Grand Traverse County, MI. The three survey areas were targeted in an effort to identify remnant shorelines after drawdown of the impoundments along the Boardman River; this collectively totaled 9.88 acres. The archaeological survey involved pedestrian visual inspection and hand-excavated shovel tests at each location, per Michigan SHPO and OSA guidelines. No archaeological resources were identified within or adjacent to the three survey areas and no evidence of intact remnant shorelines was encountered.

The standard Phase I report was sent to the USACE for review, prior to submittal to the Michigan SHPO and OSA. Additional detail on the results of this Phase I archaeological survey is available from the USACE.

Concurrent with the 2012 archaeological survey, a historic architecture examination was conducted, focusing on aboveground resources fronting and adjacent to Boardman Pond and Sabin Pond, as requested by the Michigan SHPO in correspondence dated 8 July 2008. This examination documented extant buildings via photographs from the public right-of-way. These investigations concluded that none of the developed properties adjacent to the Boardman Pond are 50 years or older. For Sabin Pond, two structures, 50 years or older, were identified. Based on analysis of the public right-of-way, neither of the two properties appear to be eligible for the NRHP.

Section 106 of the NHPA requires that Federal agencies identify whether any historic or cultural resources that are listed, or potentially eligible for listing, on the NRHP could potentially be affected by the Recommended Alternative. The consultation with the SHPO resulted in a determination that the Union, Sabin, and Boardman Dams are not eligible for the NRHP.

Project coordination with Native American Tribal Organizations in Michigan occurred in June 2012. This tribal correspondence, along with other details on cultural resources, is included in the **Environmental Assessment**.

6 Plan Implementation

The following sections provide information regarding implementation of the selected alternative, including the design and construction schedule, cost apportionment, and a risk and uncertainty analysis.

6.1 Schedule and Cost Apportionment

To ensure the success of the dam modification and removal project, the USACE would continue to coordinate with the non-Federal sponsor, as well as stakeholders that have expressed an interest in the proposed project. The following schedule of remaining tasks (**Table 19**) assumes construction can begin in 2016.

Table 19: Approximate Construction Schedule for Selected Alternative

Task Name	Duration	Start Date *	Finish Date *
Define Channel DS of Boardman and into Sabin	40 days	06/01/2016	07/11/2016
Boardman Breach	60 days	07/02/2016	08/31/2016
Sabin Breach	30 days	08/15/2016	09/14/2016
Boardman Restoration	120 days	07/02/2016	10/30/2016
Sabin Restoration	120 days	07/02/2016	10/30/2016
Union Street Dam and MDNR Trap-and-Transfer Facility Modifications	30 days	07/02/2016	08/01/2016

*The dates provided are representative and would need to be finalized during the design phase.

A detailed cost estimate was prepared for the recommended alternative in accordance with the guidance contained in ER 1110-2-1302, Civil Works Cost Engineering, and ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works. The refined cost estimate was prepared using Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII) software for cost estimating. These costs are reported in **Table 20.** The real estate, construction, engineering, administration, and contingency costs; the annualized investment costs; and the annual OMRR&R and monitoring costs, compose the overall cost of the selected alternative.

Table 20: Cost Apportionment of the Selected Alternative

Category	Total Cost	Cost Share/Remarks
A. Feasibility Phase Costs	**$2,000,000**	First $100,000 fully Federal, remainder split 65% Federal / 35% non-Federal
B. Total Project Cost	**$13,223,000**	Excluding Feasibility Phase Costs [1]
a. LERRDs	$127,000	Lands, Easements, Rights of Way and Disposal. 100% non-Federal responsibility, credited against non-Federal cash share.
b. Planning, Engineering & Design	$1,882,000	Costs include contingencies
c. Construction	$10,209,000	Costs include contingencies
d. Construction Management and Monitoring	$1,005,000	Costs include contingencies
C. Net Federal Share	**$9,930,000**	Federal investment in GLFER projects is limited to $10 million; all costs in excess of that amount would be a non-Federal responsibility.
D. Net non-Federal Share	**$5,293,000**	

[1] Per USACE Guidance, GLFER feasibility study costs are not included in the total project cost, but are counted against the Federal share.

Note: Annual operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs are estimated to be $24,000 per year as detailed in **Appendix B: Economic Analysis.**

The non-Federal sponsor for this project is Grand Traverse County, Michigan. The non-Federal sponsor has agreed to fulfill the cooperation requirements, including provision of a 35 percent non-Federal cost share of all project related costs during both the Feasibility and Implementation phases. Feasibility phase costs include all the project planning, coordination and study-related efforts since USACE involvement commenced on the Boardman River dams. For the implementation phase, the cost sharing is 65 percent Federal and 35 percent non-Federal. The implementation phase includes the development of final plans and specifications, construction of the selected alternative, and monitoring as outlined in the monitoring plan. In addition, the non-Federal sponsor must provide all lands, easements, rights-of-way, relocations and sediment placement areas (LERRDs) required to construct the project, but these costs are credited towards the non-Federal cost share. If contaminated material is encountered onsite during the construction process, the non-Federal sponsor is responsible for cleanup and disposal of the material and mitigating the release of any hazardous material.

6.2 Risk and Uncertainty Analysis

Areas of risk and uncertainty are analyzed and described so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans. The potential for successful ecosystem restoration on the Boardman River is high due to the availability of data on the target species and the simplicity of the proposed alternative (i.e., removing structures). However, uncertainties are tied to the existence of various unknowns (some at the design stage and others at future points in the project). Sources of uncertainty for this project include:

- **Design**. Uncertainties are associated with how closely various design assumptions mirror actual conditions. This includes parameters such as impounded soil conditions, soil/ geotechnical conditions of the earthen embankments, and volume and spatial distribution of impounded sediments. Consequences include longer construction durations and higher associated construction costs.
- **Project Performance.** A certain degree of uncertainty is associated with how well the project performs as compared to its projected performance level at the time of design. Performance can be influenced by presence/absence of expected fish species, such as sturgeon; impacts of climate change; and other unforeseen habitat stressors on suitable spawning and rearing habitat. These effects could significantly alter anticipated project outputs.
- **Project Implementation.** Some uncertainties would have an impact on project implementation. These are principally related to the involvement of the non-Federal sponsor and uncontrollable environmental factors. This Feasibility Study assumed that the non-Federal sponsor would participate in the project and would be supportive of the recommended alternative. In addition, the sequencing and scheduling of the project is not dependent on other activities, such as the Cass Road Bridge project, that the NFS has planned. Because the project team has ongoing discussions with the non-Federal sponsor, the risks associated with this assumption are low. Typical environmental factors that could affect implementation include high-flow conditions in the river, frequent large volume precipitation events during construction, and early snow cover. Typical environmental conditions were considered when developing the design and planning construction schedule and sequencing for dam removal and restoration. Given that environmental conditions fluctuate normally, there is a moderate risk that these factors could impact the project. Assumptions have been made regarding the structural integrity of the dams based upon detailed inspections performed by others, as well as best available data. However, unforeseeable risks may arise during construction. The

proposed measures have been revised to provide for redundancy to mitigate the risk of dam failure.

A certain degree of risk is associated with each of these uncertainties. Risk is a function of the probability of an occurrence and the magnitude of its impacts. In cases where a quantitative risk and uncertainty analysis is not undertaken, areas of risk and uncertainty are analyzed and described in a qualitative manner so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans. The following table (**Table 21**) documents various project uncertainties, characterizes risks, describes risk management techniques, and tracks various means to limit risk.

Table 21: Risk Register

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
Actual costs far exceed estimated costs.	Project would have to be re-scoped or halted until additional funds are available.	Low	Much of the construction costs are related to the removal and movement of sediment. Increases in fuel costs would have an impact on total costs. However, all components of the project are known science and, thus, should have well defined cost estimates.
Coldwater habitat may not be restored as a result of continued solar influence.	Habitat would be less than desirable and coldwater fish might not move through the area.	Low	Groundwater is a major contributor to inflows in the Boardman River system; it keeps stream temperature low even without good cover.
The non-Federal sponsor cannot resolve real estate issues in regards to riparian rights.	Necessary real estate would not be acquired or would be delayed as a result of legal hold.	Low	Some deeds show riparian rights, while original parcel deeds do not. The discrepancy would need to be resolved.
The non-Federal sponsor cannot supply the necessary cost share funds required by the Project Partnership Agreement (PPA).	Project would be delayed or shelved until the sponsor has adequate funding to continue.	Low	Sponsor has indicated a willingness to pursue grant funding to support their cost share requirements and has demonstrated ability to acquire funds.
Failure of dams during construction due to high flows.	Substantial amounts of sediment would be moved downstream damaging existing and restored habitat	Low	Dams are structurally sound and not at risk of near term failure. However, construction activities could weaken critical components

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
	for aquatic species; flooding would occur		of the dam leading to failure.
Failure of dams during construction due to soil erosion during breaching.	Substantial amounts of sediment would be moved downstream, damaging existing and restored habitat for aquatic species.	Low	Design considers several redundant measures to control erosion at the earthen embankment during dewatering of the impoundment.
Poor fish passage due to high velocities in engineered riffles.	Although habitat would be improved, connectivity between reaches would not. This would limit genetic diversity within the stream and limit access to habitat for some species.	Low	Modeling was used to assess velocities as they relate to fish passage. In addition, large woody debris and rocks could be placed instream to provide micro habitat after construction is complete, also lowering effective velocities.
Sediment transport and settling downstream due to insufficient sediment management.	Substantial amounts of sediment would be moved downstream damaging existing and restored habitat for aquatic species.	Moderate	The sediment management approach includes several redundant measures. However, weather and flow conditions can impact sediment movement. Thus, some sediment may escape capture and be transported.
Post-construction erosion of steep banks due to insufficient plantings.	Poor aesthetics, lack of riparian habitat, and high sediment loads would all lead to less than optimal habitat.	Low	This could cause aesthetic issues and result in higher than expected sediment load. However, impacts to improved aquatic habitat would be minor.
Poor channel geometry after construction as a result of insufficient depth of refusal data.	Habitat would be less than optimal for aquatic species.	Low	Depth of refusal data would be collected during the design phase and would provide a high level of detail related to channel geometry.

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
Insufficient sturgeon numbers migrate up the Boardman River to initiate trap and transfer activities.	Sturgeon would not be transferred past the Union Street Dam and the project would not improve the population of lake sturgeon in the Great Lakes.	High	Limited data on the Boardman River sturgeon population exist. If sturgeon are not transferred upstream of the Union Street Dam, the status of sturgeon in the Boardman River would be similar to the No Action Alternative and remain at its current state.
Invasive plant species dominate the new wetlands and riparian uplands created by removing the dams.	Wetland habitat would become monoclonal and would not function as efficiently to provide wildlife habitat and water quality improvements. Additionally, it would become a seed source for invasive species to invade other nearby wetlands.	Moderate	Although the newly created wetlands would be of low quality, wetland restoration techniques are available to remove invasive plant species and promote the growth of native wetland plants. Past wetland fieldwork around the Boardman River impoundments identified several invasive species and provided evidence of the potential risk. Past project experience and invasive species removal techniques provide a basis for assessing the effort and cost for wetland restoration and managing invasive species.
The U.S. Army Corps of Engineers (USACE) Selected Plan is not supported by local sponsor.	USACE might choose not to participate in project because of design issues or cost of local share.	Low	The non-Federal sponsor has provided input into the recommended alternative and is expected to support it. If, for some reason, the non-Federal sponsor does not support the preferred alternative, the project would not likely move forward without changes. This would delay the restoration.
Funding for program not appropriated.	Implementation would be delayed because of lack of funding for Federal share.	Moderate	Funding levels are unknown. If no funding is available, the project won't move forward with Federal involvement, potentially lengthening the time until

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
			restoration is achieved.
Exposed sediments pose human health hazards as a result of high levels of arsenic.	Costly remediation of soil would be required, as would cover for soil or access limitations to areas with high concentrations.	Low	Impoundment sediments are known to contain arsenic. If sediment concentrations exceed health and safety criteria, excavation and removal to an appropriate site would be required. This would have limited impact on habitat restoration, but could potentially limit the ability of people to access the site or require mitigation of the health risk which can be costly.
Structural problems at Cass Road Bridge over the Boardman River due to instability and movement of the restored channel.	Additional post-restoration and bridge construction fixes would be required to maintain bridge stability.	Low	Some level of channel migration would be included in the design of the bridge, and channel restoration measures would be engineered in this area to maintain desired channel alignment.
Hazardous materials found in earthen dam and/ or excavated material.	Excavation/ disposal costs would be increased.	Low	Would not impact final restoration, but would increase project costs.
Soil properties at engineered riffles and areas where excavation equipment is required are not appropriate for proposed construction activities.	Construction costs would be increased.	Low	Would not impact final restoration, but would increase project costs.
Soil conditions increase costs of structures because no geotechnical information has been gathered.	Construction costs would be increased.	Low	Would not impact final restoration, but would increase project costs

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
Insufficient onsite sediment placement areas exist within the former impoundment as a result of formation of more wetlands/ seeps than expected.	Construction costs would be increased because off-site sediment placement would be required.	Moderate	A wetland investigation was conducted to map existing wetlands and assess where future wetlands may form. Disposal areas were developed around these areas.
Stream temperatures do not decrease because of a lack of mature shade trees.	In-stream habitat would be degraded until sufficient cover grows.	Low	The river is primarily groundwater fed, which contributes to coldwater temperatures.
Bank erosion becomes a consistent problem during and after construction activities because of a lack of vegetation cover and poor soil characteristics in the former impoundments.	Sedimentation / sediment loads would be greater than expected and might bury existing or restored habitat.	Low	A planting and seeding plan is proposed for exposed areas to mitigate this issue.
Vegetation does not grow because of a lack of organic material in the former impoundments.	Sedimentation / sediment loads would be greater than expected and might bury existing or restored habitat.	Low	Level of organic materials in impounded sediments is low, which may result in vegetation taking longer to become established. Organic material can be added in critical locations if required.
More bank erosion in reaches downstream of dams due to an increase in small storm peaks passing through the impoundment area unmitigated.	Sedimentation / sediment loads would be greater than expected and might bury existing or restored habitat. Unanticipated streambank maintenance would be required.	Low	Changes would be within the existing range of stream flow and stage. Thus, banks have demonstrated sufficient stability to not erode under these conditions.
Climate change impacts flow regime in such a manner that the designed channel has poor habitat characteristics related to depth and velocity.	Channel would adapt over time to new flow equilibrium.	Low	The river characteristics would adapt to changing flow patterns.

Risk and Cause	Consequence	Consequence Rating	Evidence for Consequence Rating
Sedimentation occurs in areas impacting habitat as a result of increases in sediment transport.	Existing areas of habitat would be displaced	Low	Sediment transport model was used to assess recommended alternative. Results do not indicate changes to depositional/ scour zones in the river system.
Lower groundwater levels due to the dam removals.	Wells would go dry.	Low	Analysis showed that all wells in the area were screened below the predicted groundwater level, but not all well data may have been recorded and/or available during time of analysis.

7 Summary of Coordination Efforts, Public Views and Other Comments

Throughout the development of this Feasibility Study, the USACE team worked closely with the non-Federal sponsor, local interest groups, and individuals in Grand Traverse County. In particular, the project team worked in collaboration with the BRDC IT in the development of the selected alternative, and developed future without-project scenarios that include the work proposed by the IT. The project team had representation at the IT's bimonthly meetings throughout the course of project development, and a representative attended the monthly meetings of the IT project management. Additionally, project planners coordinated directly with the IT's consultant team to develop data.

An Environmental Assessment was undertaken in accordance with NEPA provisions in conjunction with this Feasibility Study. The NEPA process is designed to inform the public of the potential environmental consequences of the Action Alternatives and involve them in the Federal decision making process. Formal notification and opportunities for public participation, as well as informal coordination with government agencies and city planners have been incorporated into the reporting process. Agencies, organizations, and members of the public having a potential interest in the Proposed Action were invited to participate in the decision making process. Coordination was conducted with the MDNR, USFWS, MDEQ, USEPA, Michigan Land Use Institute, Northern Michigan Environmental Action Council, Watershed Center, Grand Traverse County Parks & Recreation, Michigan SHPO, and tribal organizations to request information regarding the resources on and near the project area.

Letters requesting information about traditional cultural properties or sites of particular interest near the study area were sent to various Native American organizations. Consultation letters were also sent to other local stakeholders.

A list of stakeholders contacted and responses received to date is included in the **Environmental Assessment**.

8 Summary and Conclusion

One of the State of Michigan's greatest assets is its abundant supply of fresh water and associated resources. Michigan's inland lakes and streams as well as the Great Lakes have felt the effects of development over the past two centuries. This project would help to restore the natural ecosystem and miles of coldwater trout stream on the Boardman River, while continuing to block ANS from migrating further upstream. The USACE has coordinated work on this project with the non-Federal sponsor (Grand Traverse County), USFWS, MDEQ, and MDNR. The non-Federal sponsor and the above-mentioned agencies strongly support the selected alternative and are motivated to see the project through to completion. The non-Federal sponsor is responsible to operate and maintain the project.

9 Recommendation

The Detroit District of the U.S. Army Corps of Engineers has given consideration to all significant aspects in the overall public interest for this project. Those aspects considered include environmental, social, and economic effects; engineering feasibility; and any other elements bearing on this recommendation.

We understand that the non-Federal sponsor for this project, Grand Traverse County, MI , prior to implementation, agree to provide the required items of cooperation. This includes providing all lands, easements, rights-of-way, relocations of utilities or interfering infrastructure and placement areas for excavated material. We also understand that the non-Federal sponsor agrees to hold the United States and its contractors free of damages and liability as outlined in the Project Partnership Agreement between the USACE and Grand Traverse County, MI to be signed prior to construction.

Based on the information and analyses presented in this report, the Detroit District, USACE recommends that the Boardman River Section 506 ecosystem restoration project proceed with construction of Alternative 5 – Modify Union Street Dam, remove Sabin Dam, and remove Boardman Dam. The estimated Total Project Cost for this alternative is $13,233,000. The cost share formula for Section 506 projects is 65% Federal/35% Non-Federal. An additional $2,000,000 in feasibility study costs are also cost shared 65% Federal/35% Non-Federal, after the first $100,000 which is Federally funded. The cost share has a per project cap of $10,000,000 on Federal contributions. All costs above that limit must come from non-Federal sources. Post-construction effectiveness monitoring costs are also the responsibility of the Non-Federal sources.

The recommendations contained herein reflect 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 Army Corps of Engineers. Consequently, the recommendations may be modified before they are submitted for implementation funding. The sponsor, the State, interested Federal agencies, and other parties would be advised of any modifications and would be afforded an opportunity to comment further if significant changes are proposed.

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