Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

FINAL - Appendix E

Monitoring and Adaptive Management

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1.0 Introduction

The Lower Yellowstone Intake Diversion Dam Fish Passage Project (Project) is a proposal to improve pallid sturgeon fish passage at Intake Diversion Dam, a feature of the Lower Yellowstone Project which provides irrigation water to approximately 58,000 acres of cropland in eastern Montana and western North Dakota. The Lower Yellowstone Intake Diversion Dam Fish Passage Project Environmental Impact Statement (EIS) was developed based on the best available scientific information for pallid sturgeon and identifies the Bypass Channel Alternative as the preferred alternative.

This Monitoring and Adaptive Management Plan (AMP) has been prepared by U.S. Bureau of Reclamation (Reclamation) in cooperation with the Corps of Engineers (Corps) consistent with the Memorandum of Agreement between the two agencies (See Section 1.7 – Agency Roles, Responsibilities and Funding) to provide a structured framework for decision making that can adjust Project features and operations if monitoring results indicate the Project is not meeting performance objectives as contemplated in the Final Environmental Impact Statement (FEIS). This AMP has been prepared in a manner consistent with the processes described in the report, *Adaptive Management, The U.S. Department of Interior Technical Guide* (Department Guide) (Williams et al. 2012). The Department Guide frames adaptive management within the context of structured decision making, with an emphasis on uncertainty about resource responses to management actions and the value of reducing that uncertainty to improve management.

The Department Guide describes implementing projects in two phases. The first phase sets up the AMP's key components. This phase was essentially completed through project planning and the development of the EIS. The second phase is an iterative phase in which the components are linked in a sequential iterative decision process of monitoring, assessment, and decision-making, that is repeated at least annually to advance and improve the process and Project over time. This is being developed as part of this AMP.

1.1 Scope and Timeline

The scope of this AMP is limited to the area surrounding the Lower Yellowstone Project. This area includes three miles upstream of the existing weir structure and 70 miles downstream to the Yellowstone and Missouri River confluence. All adaptive management measures are specific to each alternative. All potential changes to these structures are considered modifications of features or operations.

This AMP is a living document that will evolve over time as research and knowledge of pallid sturgeon expands. However, this plan is only intended to last for the first 8 years of the Project. After 8 years, Reclamation will initiate discussions with the U.S. Fish and Wildlife Service (Service) to determine if the existing AMP should continue or if significant modifications to the AMP are necessary. Final monitoring requirements and timelines are subject to change following completion of appropriate NEPA and ESA compliance.

1.2 Project Overview

1.2.1 Description of the Lower Yellowstone Project

Reclamation's Lower Yellowstone Project (LYP) is an irrigation project located in eastern Montana and western North Dakota operated by the Lower Yellowstone Irrigation Project Board of Control (LYIP), Reclamation's authorized agent. The LYP includes the Intake Diversion Dam, which is a rock-filled timber crib weir crossing the Yellowstone River about 70 miles upstream of its confluence with Missouri River and 18 miles downstream of Glendive, Montana. The Intake Diversion Dam raises the river water elevation to divert water from the Yellowstone River through the recently constructed headworks to the LYP's Main Canal on the north side of the river.

River ice and high flows can cause rocks on the Intake Diversion Dam to be displaced. Such displaced rocks have been transported downstream over the years, creating a boulder field on the downstream side of the weir. A side channel on the south side of the Yellowstone River diverges from the main channel upstream of the Intake Diversion Dam and reconnects with the main channel downstream of the weir. The side channel holds water through its entire length when the Lower Yellowstone flow exceeds 20,000 cfs, but does not effectively provide passage until flows exceed 40,000 cfs.

1.2.2 Project Purpose

The purpose of the Project is to improve fish passage for pallid sturgeon and other native fish at the Intake Diversion Dam, continue the viable and effective operation of the LYP, and contribute to ecosystem restoration.

1.3 Project Goals and Objectives

1.3.1 Project Goals

The project goal is to improve pallid sturgeon fish passage at the Intake Diversion Dam. This would make approximately 165 miles of additional habitat available for pallid sturgeon migration and spawning in the Yellowstone River, upstream of Intake Diversion Dam. Under current conditions, the majority of the spawning activity takes place within the lowest 10 to 20 miles of the Yellowstone River (Delonay et al 2016; Bramblett 1996), which does not allow for adequate drift distance for free embryos and larval pallid sturgeon to mature and settle out before they reach the headwaters of Lake Sakakawea, where they are believed to succumb to hypoxia (Bramblett & Scholl 2016; Guy et al. 2015).

By improving passage at Intake Diversion Dam, the majority of adult pallid sturgeon that migrate up to the weir would be able to migrate and spawn further upstream, increasing the

available drift distance and improving survival, which could ultimately contribute to increased recruitment of pallid sturgeon within the Great Plains Management Unit (Upper Missouri River and Yellowstone River area as defined by the U.S. Fish and Wildlife Service [Service] in the Pallid Sturgeon Recovery Plan [2014]).

The following specific objectives are based on the physical and biological criteria developed by the Service's Biological Review Team (BRT) and assumptions made in the FEIS. Physical criteria developed earlier for a rock ramp are displayed in parentheses as they have some slight differences (BRT 2009). Physical criteria do not apply to weir removal alternatives as removing the weir would return the river channel to essentially natural conditions. The biological criteria apply to all alternatives.

Water reliability is critical to the success of this project. Under current conditions, diversions range from 600 cfs to the full water right of 1,374 cfs. Alternatives that include a weir structure (Rock Ramp, Bypass Channel, Modified Side Channel) are all expected to continue reliable diversions. However, the pumping alternatives (Multiple Pumps and Multiple Pumps with Conservation Measures) have uncertainties associated with water diversion which are discussed in Chapter 2 of the FEIS. To address these uncertainties an additional objective has been added to address this concern (Objective 4).

1.3.2 Project Objectives

Objective 1: Construct and maintain appropriate physical criteria parameters that allow pallid sturgeon passage. The physical criteria are:

- **Objective 1a - Depth**
  1) Minimum depths in fish passageway measured at the lower discharge range of 7,000 cfs to 14,999 cfs at any sampled cross-section must be greater than or equal to 4.0 feet across 30 contiguous feet of the measured channel cross section profile.

  2) Minimum depths in the fish passageway measured at the discharge range of 15,000 cfs to 63,000 cfs at any sampled cross-section must be greater than or equal to 6.0 feet across 30 contiguous feet of the measured channel cross sectional profile.

- **Objective 1b - Velocities**
  1) Mean cross-sectional velocities must be equal or greater than 2.0 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 7,000 cfs to 14,999 cfs (equal to or less than 4.0 feet/second for a rock ramp).

  2) Mean cross-sectional velocities must be equal or greater than 2.4 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 15,000 cfs to 63,000 cfs (equal to or less than 4.0 feet/second for a rock ramp).

Objective 2: Upstream and downstream passage of pallid sturgeon:

- **Objective 2a - Upstream Adult Passage**
    1) Greater than or equal to 85% of motivated adult pallid sturgeon (fish that move up to the weir) annually pass upstream of the weir location during the spawning migration period (April 1 to June 15) within a reasonable amount of time without substantial delay (≥0.19 miles/hour).

- **Objective 2b - Upstream Juvenile Passage**
    1) No Criteria Set - Develop decision criteria to trigger adaptive management options to improve passage for juveniles if the lack of juvenile passage is demonstrated to result in negative population level effects.
- **Objective 2c - Downstream Adult Passage**
    1) Mortality of adult pallid sturgeon that migrate downstream of the weir location cannot exceed 1% annually during first 10 years. Document any injury or evidence of adverse stress.
- **Objective 2d – Pallid Sturgeon Free Embryo and Larval Downstream Passage**
    1) Assess impingement and entrainment of free-embryo, larval, and young-of-year sturgeon at headworks/screens, irrigation canal and downstream of the weir location.

Objective 3: Upstream and Downstream Passage of Native Fish:

- **Objective 3a – Native Species Upstream Passage**
    1) Determine if native fish are migrating upstream of the weir location at a level greater than or equal to existing conditions.
- **Objective 3b – Native Species Downstream Passage**
    1) Determine if native fish are migrating downstream of the weir location at a level greater than or equal to existing conditions.

Objective 4: Reliable Delivery of Water for Irrigation (Pumping Alternatives Only)*:

1) Determine if 1,374 cfs of water can be reliably diverted (Multiple Pump Alternative).
2) Determine if 608 cfs of water can be reliably diverted (Multiple Pumps with Conservation Measures).

*Objective 4 could be assessed under all alternatives however, past experience has shown that a diversion weir at elevation 1991.0 feet, as proposed under the rock ramp, bypass channel and modified side channel alternatives, generally meets current crop demands and enables 1,374 cfs to be diverted from the Yellowstone River. As discussed below and Chapter 2 of the FEIS there are questions whether the current design of the pumping alternatives would meet current crop demand or have the ability to divert the water needed by the Lower Yellowstone Project.

1.4 Monitoring Plan

Monitoring is used in adaptive management to track resource system behavior and, in particular, the responses to the management actions over time. Monitoring is an ongoing activity, producing new data after each monitoring period to evaluate management actions and ensure that goals and objectives are being met. Monitoring also includes a means to validate assumptions and prioritize management actions during follow-up monitoring periods. In general, monitoring provides data in adaptive management for three key purposes:

- Evaluate progress toward achieving Project goals and objectives.
- Track resource behavior in response to management actions.
- Increase understanding of resource dynamics via the comparison of predictions against monitoring results.

Project monitoring included in this AMP is designed to be coordinated with existing and proposed monitoring programs conducted by the Corps' Missouri River Recovery Program, State of Montana Fish, Wildlife and Parks (MFWP), and the U.S. Geological Survey (USGS). The monitoring program commitments in this AMP are designed to be inclusive of the monitoring commitments between the Corps and Reclamation as described in the Memorandum of Agreement signed April 7, 2015 (see section 1.7 - Agency Roles, Responsibilities and Funding).

Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the Project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete. Once the field season is complete, Reclamation will work with field crews to compile monitoring results for the Technical Team's assessment (Section 1.5).

Specific monitoring plans for each alternative can be found below.

1.5 Assessment

This step includes the process of determining whether unanticipated changes to any of the alternatives are necessary or responses by pallid sturgeon and native fish have occurred. Data collected from physical and biological monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with a Technical Team in the winter/spring of each year. The Technical Team will consist of qualified

engineers and fisheries biologists. The Technical Team (see Section 1.5.1) will use their findings from the assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team (see Section 1.6.1).

1.5.1 Technical Team

Below are the agencies and disciplines to be represented on the Technical Team. Additional support and disciplines would be added as necessary to address specific team needs.

- **Bureau of Reclamation (Lead)**
  - Project Manager
  - Fisheries Biologist
  - Engineer
- **Army Corps of Engineers**
  - Project Manager
  - Fisheries Biologist
  - Engineer
- **U.S. Fish and Wildlife Service**
  - Fisheries Biologist
- **U.S. Geological Survey**
  - Fisheries Biologist
- **Montana Fish, Wildlife, and Parks**
  - Fisheries Biologist
- **Montana Department of Natural Resources and Conservation**
  - Engineer/Irrigation Specialist
- **Lower Yellowstone Irrigation Project**
  - District Manager

1.5.2 Adaptive Management Measures

To address any potential problems with any of the alternatives, Reclamation has identified some potential modifications that could be implemented. Tables are included under each alternative containing potential measures that could be implemented in response to various findings related to the physical performance and pallid sturgeon biological performance related to passage success. The decision to implement any of the potential adaptive management actions will be a joint effort between the Technical Team (1.5.1) and the Executive Team (1.6.1) as described below.

1.5.3 Technical Team Recommendations

The Technical Team will make recommendations on implementation of adaptive management measures or changes to the monitoring plan on a case by case basis to the Executive Team. Consensus recommendations are desirable but not required. Recommendations from Technical Team members that differ from the majority recommendation shall be noted in the Technical Team recommendations.

In order for the Technical Team to make recommendations to the Executive Team, the following questions (which may be revised based upon Technical Team input) need to be considered and addressed during this assessment stage:

1) Is the Project meeting Physical Criteria?

- If Yes, move onto #2
- If no, identify potential reasons why
    - If enough information is available, identify a potential adaptive management measure
    - If not enough information is available, identify modifications to the monitoring plan that will help gather additional information needed to identify the problem

2) Is the Project Meeting Biological Criteria?

- If yes, move onto #3
- If no, identify potential reasons why
    - If enough information is available, identify a potential adaptive management measure
    - If not enough information is available, identify modifications to the monitoring plan that will help gather additional information needed to identify the problem

3) Does the current monitoring effort need to be intensified or modified?

- If yes, what are the suggested changes?
- If no, continue with current monitoring plan

4) Does an adaptive management measure(s) need to be implemented?

- If yes, what are they?
- If no, no measure is identified

5) What is the Technical Team's recommendation to the Executive Team?

- Development of a recommendations report to Executive Team

1.6 Decision-Making

This step in the process represents adaptive management decision-making based on the current level of understanding and anticipation of the consequences of decision-making. Once the Technical Team has had a chance to review the results and make recommendations (continue monitoring or implement an adaptive management measure) they will provide a report and brief the Executive Team. The Executive Team will be responsible for making decisions about the proposed path forward and funding strategy. Reclamation's Regional Director or his delegate will be the final decision-maker on implementation of continued or new monitoring and adaptive management measures stemming from this AMP.

1.6.1 Executive Team Members

- Bureau of Reclamation – Regional Director or Delegated Official
- Army Corps of Engineers – Northwest Division Commander or Delegated Official
- U. S. Fish and Wildlife Service – Regional Director or Delegated Official

The Executive Team, while making a decision will consider the following:

- Funding
- Authorities
- Contribution to Science
- Time-frame
- Effects to Pallid Sturgeon
- Effects to the Operation and Maintenance of Lower Yellowstone Project

1.7 Agency Roles, Responsibilities and Funding

Reclamation and the Corps signed a Memorandum of Agreement (MOA) (April 7, 2015) outlining each agencies' roles and responsibilities as it pertains to this AMP. The MOA states the following:

Bureau of Reclamation

Using its own funds, or funding identified through partnerships or contractual agreements, Reclamation shall perform the following activities:

- Develop an action specific Adaptive Management and Monitoring Plan in consultation with the Corps, the Service, and Montana Fish, Wildlife and Parks.
- Provide funding and coordinate post-construction adaptive management and monitoring consistent with applicable success criteria specified by the BRT, conferred by the Service, and agreed upon by Reclamation for any Adaptive Management and Monitoring plan modifications.

- Provide Reclamation staff to lead and execute implementation of any Adaptive Management and Monitoring Plan. Implementation will consist of establishing a Technical Team, and Executive Managers who will coordinate and recommend appropriate strategies for any actions as a result of implementing the Adaptive Management and Monitoring Plan. Such recommended action may be carried out with the approval of the parties.
- Coordinate the execution of operation and maintenance activities consistent with Reclamation's obligations through ESA consultation with the Service for continued operation of the Lower Yellowstone Project. Operation and maintenance of the new headworks and screens; as well as the fish passage, will commence on each feature as the physical construction of each feature is completed or at the date that feature is deemed substantially complete and put in service and the one year construction warranty on the feature starts. Warranty covers issues related to construction defects. If the defect is caused by O&M activities, then it would not be covered under warranty. Operation and maintenance activities will be conducted concurrent with the Adaptive Management and Monitoring Plan.
- Additional responsibilities as designated and described further in any Adaptive Management and Monitoring Plan, to the extent not inconsistent with the MOA dated April 7, 2015.

Additionally Reclamation recognizes there may be adaptive management measures or additional monitoring that the Technical and Executive teams believe are beneficial to implement in response to monitoring or other data, which are not planned in Reclamation's budget (i.e., actions that should be implemented with some immediacy). To address this, Reclamation plans to provide additional funding for these measures through transfers or other means within existing authorities.

Historically, Reclamation's annual appropriations bill has included authority to perform fund transfers. Based on current authority, a fund transfer may be performed to provide "up to $300,000 for any program, project, or activity for which less than $2,000,000 is available at the beginning of the fiscal year". The Lower Yellowstone Project (Project) falls into this category and could benefit from this authority in the year of execution.

Reclamation has used its authority to fund these types of unanticipated monitoring and investigations associated with pallid sturgeon entrainment monitoring and passage planning activities over the last several years. As an example, Reclamation used the fund transfer authority in FY 2016 to provide an additional $229,000 to the Project's enacted level of $380,000, resulting in total funding of $609,000 for Project use. Because the benefits of this monitoring, data gathering, and analysis are not limited to the Project, expenditure of these funds is considered non-reimbursable.

U.S. Army Corps of Engineers

Consistent with its authority under Section 3109 of WRDA 2007, P.L. 110-114, and using its own funds, the Corps shall:

- Demonstrate and ensure that project design and hydraulic performance criteria have been met. In coordination with the Service and Reclamation, develop the monitoring and measurement plan that will be used to verify that the completed construction project meets the design and hydraulic performance criteria. The plan shall include measurement of flow split to the bypass channel, bypass channel depth, and bypass channel velocity within the range specified in the design criteria. Additionally, the plan shall account for uncertainty and inherent variability of flow conditions in the bypass channel.
- The Corps, in coordination with Reclamation, will complete any construction modifications required to meet the design and hydraulic performance criteria (i.e. correction of any design and/or construction related deficiencies) identified within the one year warranty period after substantial completion.
- Additional responsibilities as designated and described further in any Adaptive Management and Monitoring Plan, to the extent not inconsistent with the MOA dated April 7, 2015.

1.8 Reporting

Reclamation will provide annual reports to the Service documenting monitoring results and previous management actions. Recommendations for changes to monitoring or management actions will be proposed as necessary and this document may be updated and reissued.

For each monitoring element, the report will document the methods and results. Results will be evaluated with respect to the goals and objectives of the adaptive management program, and may indicate that changes in monitoring priorities and management activities are warranted.

1.9 Data Management

All monitoring data will be stored electronically on a secured server maintained by Reclamation and will comply with Reclamation's proposed data stewardship guidelines. All data collected by contractors will be provided to Reclamation in an agreed upon electronic format. Additionally, contractors will provide hard copies of any field notes or data sheets. Upon completion of the Monitoring and Adaptive Management Program, all data, results of analyses, and reports will be archived.

2.0 Rock Ramp Alternative

This alternative is intended to provide fish passage past Intake Diversion Dam by constructing a low gradient rock ramp on the downstream side of the replacement weir to reduce the drop at the weir and also to reduce velocities and turbulence and thus encourage fish passage. The existing side channel would remain as a possible migration corridor when flows exceed 40,000 cfs in the river. The key features of the Rock Ramp Alternative include:

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens designed to reduce entrainment of fish larger than 40 mm into the Main Canal.

Rock Ramp. The rock ramp would extend for 1,200 feet downstream of the replacement weir, burying the existing boulder field, with variable slopes from 0.2 to 0.7%. The ramp would be constructed with large rock (1 to 4 feet in diameter) with cobbles filling in the voids. A low flow channel would be constructed into the shape of the ramp to concentrate flows during low flow periods and also to mimic a deeper main channel route for main channel oriented fish such as pallid sturgeon.

Replacement Concrete Weir. To maintain irrigation diversion capabilities with the screened headworks, a concrete weir would be constructed to an elevation of 1991.0 feet. The concrete weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities.

Weir Notch. A low-flow notch would be constructed in the new weir with a bottom elevation of 1988 feet, with an 80 ft bottom width and approximately 350 ft top width. This notch would connect to the low flow channel in the ramp.

2.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the rock ramp that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Modeling conducted by the Corps indicates that the rock ramp would not meet the Service's BRT physical criteria for pallid sturgeon passage under all flow conditions (i.e. velocities exceed criteria at the toe of the ramp at flows above 30,000 cfs and the depths are lower than criteria at flows less than 7,000 cfs). There are also concerns about whether the rock would remain in place without frequent maintenance due to ice and flood damage which occur annually on the Yellowstone River.

The use of rock will also introduce roughness that will likely create turbulent flows, which pallid sturgeon appear to avoid or have difficulty passing through (White and Medford 2002; Kynard et al. 2002, 2008). Further, sturgeon can be injured by large rock or bedrock as they swim close to the substrate (Kynard et al. 2012).

2.2 Monitoring

The following monitoring plan is proposed to evaluate if the Rock Ramp Alternative is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 1: Monitoring Plan - Rock Ramp Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Physical Criteria Monitoring (Objective 1a and 1b)	
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the rock ramp to analyze depths and velocities. These locations include: 1. Downstream toe (bottom) of the rock ramp 2. Cross-sections at 300, 600, and 900 feet up from the toe of the rock ramp 3. Low-flow notch The ADCP unit will be deployed by boat or line across the rock ramp during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked up the rock ramp during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the rock ramp performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Seven telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the Lower Yellowstone River 2. At the toe (bottom) of the rock ramp 3. At the replacement weir (top of the ramp) 4. One mile upstream of the project 5. At the downstream end of the existing side channel 6. At the midpoint of the existing side channel 7. At the upstream end of the existing side channel Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the toe of the ramp, replacement weir, and one mile upstream of the project will be used to determine if pallid sturgeon try and succeed in using the rock ramp. The stations located in the existing side channel will document if pallid sturgeon use the side channel. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the existing side channel or over the rock ramp. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream over the replacement weir and rock ramp or through the existing side channel. If pallid sturgeon attempt to move back downstream over the weir and rock ramp they will be monitored using that station located near the replacement weir. The stations within the existing side channel will detect pallid sturgeon using the side channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream through either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
	Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)	
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the replacement weir and rock ramp to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the rock ramp.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
	Native Species Upstream and Downstream Passage (Objective 3a & 3b)	
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate seven land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the existing side channel will be used to determine whether these native species are using the natural side channel. If native species are migrating over the weir and rock ramp, they will be monitored using the stations located on or near the rock ramp.	Reclamation

2.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 2 and 3 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 2: Physical Criteria – Potential Rock Ramp AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in rock ramp do not meet criteria.	Modify low flow channel to be deeper or narrower.	Modify low-flow notch in weir. Create pools in the ramp	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in rock ramp do not meet criteria.	Modify low flow channel to be wider.	Create low velocity pools in the ramp	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Rock is moved frequently by ice	Incorporate larger rock into the ramp	Anchor boulders into place with concrete	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 3: Biological Criteria – Potential Rock Ramp AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)		
No use of rock ramp	1-3	1) Conduct additional ADCP monitoring on rock ramp 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Use of a portion of the rock ramp; no passage	1-3	1) Conduct additional ADCP monitoring along rock ramp 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		• Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs; <85% of motivated adult pallid sturgeon	1-3	1) Conduct additional ADCP monitoring 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		4) Conduct additional ADCP monitoring along rock ramp
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Conduct additional ADCP monitoring 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria in all years likely; • Depths - change low flow channel invert • Velocities - change low flow channel width and depth
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Conduct additional ADCP monitoring 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir notch, could be increased in size or depth
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream passage occurs but >1% mortality	1-3	1) Conduct additional ADCP monitoring 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir, or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir notch; could be increased in size or depth 2) Rock ramp a potential hazard • Rock – Reconfigure to have a smoother surface
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage - no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct larval drift study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Inadequate depth over weir or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir notch - modification of weir not, could be increased in size or depth

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		2) Rock ramp a potential hazard • Rock – Reconfigure to have a smoother surface
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
		Upstream Passage of Native Fish (Objective 3a)
Less than baseline upstream passage	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
Same as baseline or improvement	1-8	No adaptive management measures required

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir, or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing Wall - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir Notch - modification of weir notch, could be increased in size or depth 2) Rock ramp a potential hazard • Rock – Reconfigure to be smoother
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

3.0 Bypass Channel Alternative

The Bypass Channel Alternative is intended to improve fish passage by creating a 2.1 mile long, low-gradient channel around the replacement weir, existing weir and rock field. The primary features of this alternative are described below. The effectiveness of these features to provide passage will be monitored, and if needed, modifications will be made in an effort to achieve Project objectives.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Bypass Channel. The bypass channel would be excavated from the inlet of the existing side channel to just downstream of the existing weir and rock field. The bypass channel alignment is approximately 11,150 feet long at a slope of 0.07 percent. The channel cross section has a 40-foot bottom width with side slopes varying from 1V:8H to 1V:4H. The bypass channel would divert on average 13-15% of the total flow of the Yellowstone River.

Upstream Control Structure. A buried riprap control structure designed to control flow split and stabilize the water entrance (fish exit) to the bypass channel would be situated on the upstream end of the channel.

Existing Side Channel Plug. Fill will be placed in the existing side channel to keep all split flows within the bypass channel.

Vertical Control Structures. Two buried vertical control structures (riprap sills) are proposed within the bypass channel for maintaining channel slope and allowing for early identification of channel migration.

Downstream Vertical Control Structure. A buried riprap sill is proposed at the downstream end of the bypass channel to maintain channel elevations.

Armor Layer. The bed of the bypass channel would be armored with sorted sands, gravels and cobbles to reduce the risk of bed degradation. The proposed armor layer would be similar to naturally-formed bed material in the Yellowstone River.

Replacement Concrete Weir. To maintain irrigation and bypass channel diversion capabilities a replacement concrete weir would be constructed to an elevation of 1991.0 feet. The new weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities.

Weir Notch. A low-flow notch would be constructed in the new weir with a bottom elevation of 1989 feet, with an 85 foot bottom width and approximately 125 foot top width.

Downstream Fill. Fill is proposed near the downstream entrance of the bypass channel to reduce eddy formation and to increase attraction flows.

3.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the bypass channel that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Existing modeling indicates that the bypass channel would meet BRT criteria under all flow conditions, but it remains to be seen if the channel maintains these characteristics over the long term and if these physical criteria result in biological performance.

3.2 Monitoring

The following monitoring plan is proposed to evaluate if the bypass channel is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 4: Monitoring Plan – Bypass Channel Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Physical Criteria Monitoring (Objective 1a and 1b)	
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the bypass channel to analyze depths and velocities. These locations include: 1. Downstream entrance to the bypass channel. 2. Cross-sections at 1,000, 5,000 and 10,000 feet up from the downstream entrance or representative cross-sections at rock sills and at intermediate sections. 3. Upstream outlet to the river. The ADCP unit will be deployed by boat or line across the bypass channel during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked in the bypass channel during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use of the channel. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the bypass channel performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Eight telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the lower Yellowstone River 2. The downstream entrance to the bypass channel 3. Two locations within the bypass channel 4. The upstream outlet of the bypass channel 5. One mile upstream of the project on the lower Yellowstone River 6. The downstream entrance to the existing side channel 7. The old headworks structure Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the bypass channel entrance, within the bypass channel (two locations), and at the upstream outlet of the bypass channel will determine if pallid sturgeon try and succeed in using the bypass channel. The station located at the existing side channel will document if pallid sturgeon try to use the side channel after it no longer has flows. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the bypass channel and continued migrating upstream. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Objective 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. If pallid sturgeon attempt to move back downstream over the weir they will be monitored using that station located on the old headworks structure. The stations within the bypass channel will detect pallid sturgeon using the bypass channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream for either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the new weir to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the boulder field.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate eight land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the bypass channel will be used to determine whether these native species are using the bypass channel. If native species are migrating over the weir, they will be monitored using the stations located on the old headworks structure.	Reclamation

3.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 5 and 6 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 5: Physical Criteria – Potential Bypass Channel AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in bypass channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the bypass channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the bypass channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in bypass channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the bypass channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the bypass channel).	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Flows splits do not meet criteria	Modify upstream control structure – this structure controls the amount of flow that is allowed into the bypass channel; modification would consist of excavating the channel invert to a lower elevation.	Modify upstream control structure	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 6: Biological Criteria – Potential Bypass Channel AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)
No use of bypass channel	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance • Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River 3) Sediment build up or rock displacement into bypass channel entrance • Boulders - during low flows, use equipment to remove • Sediment - dredge material 4) Entrance location and design determined to be cause • Entrance angle - adjust the entrance angle to the bypass channel to provide better transition into Yellowstone River. • Entrance width - adjust the entrance to be larger or smaller to increase passage success. • Entrance location - move entrance upstream or downstream 5) Conduct additional ADCP monitoring at fish entrance
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Use of a portion of the bypass channel; no passage	1-3	1) Conduct additional ADCP monitoring within bypass channel 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria likely; • Depths - change channel invert, removal of sediment or excavate bypass channel deeper • Velocities - change channel invert, change control structures, increase depths in bypass channel • Flow Split - change channel invert or change control structures 2) Passage barrier at control structure or low water crossing, implement modification based on ADCP Data • Control Structure - add fill to bypass channel to provide better transition over control structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance • Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream passage occurs, but does not occur annually;	1 - 3	1) Conduct additional ADCP monitoring within bypass channel 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria in all years likely; • Depths - change channel invert, removal of sediment or excavate bypass channel deeper • Velocities - change channel invert, change control structures, increase depths in bypass channel • Flow Split - change channel invert or change control structures
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rubble field • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir notch, could be increased in size or depth
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir, or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir not, could be increased in size or depth 2) Rock field a potential hazard • Rock - removal of a portion of the downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage - no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Inadequate depth over weir or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field • Wing wall or jetty - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir notch - modification of weir notch, could be increased in size or depth 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance • Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	3-5	1) Inadequate depth over weir, or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field • Wing Wall - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir Notch - modification of weir not, could be increased in size or depth 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

4.0 Modified Side Channel

The Modified Side Channel Alternative is intended to improve fish passage by meeting the Service's BRT criteria for flows, depths, and velocities by modifying the existing side channel that has already been demonstrated to be used by upstream migrating pallid sturgeon to bypass around Intake Diversion Dam (Rugg 2014, 2015). The primary features of this alternative are described below. The effectiveness of the deeper channel to provide passage will be monitored, and if needed, modifications will be made in an effort to achieve project objectives.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Existing Weir. The existing weir would remain as is for this alternative.

Existing Side Channel. The existing side channel would be excavated along the majority of its length to be deep enough to achieve the 13-15 percent flow volumes in the Service's BRT criteria. The modified side channel would be slightly shorter than the existing side channel by cutting off three meander bends to ensure the desired volume of flow can be achieved across the range of flows in the river. The modified side channel would be approximately 20,350 ft long at a slope of 0.06 percent. The channel cross section has a 40-ft bottom width with side slopes varying from 1V:4H to 1V:8H.

Upstream Control Structure. A buried riprap control structure designed to control discharge and stabilize the entrance to the modified side channel would be situated on the upstream end of the channel.

Vertical Control Structures. Two buried vertical control structures (buried riprap sills) are proposed within the modified side channel for maintaining channel slope and allowing for early identification of channel movement.

Downstream Vertical Control Structure. A buried riprap sill is proposed at the downstream end of the modified side channel to maintain channel elevations.

Armor Layer. The bed of the modified side channel would be armored with sorted sands, gravels and cobbles to reduce the risk of bed degradation. The proposed armor layer would be similar to naturally-formed bed material in the Yellowstone River.

4.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the modified side channel that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Modeling conducted by Tetra Tech (Appendix A of the EIS) indicates that the modified side channel would meet the Service's BRT criteria under all flow conditions, except at the upstream connection to the river, which might be slightly higher than the BRT criteria of 6 feet/second, at 6.7 feet/second. However, these velocities are consistent with those calculated for the Yellowstone River channel at this location and may not represent the high-flow channel due to the velocity averaging within the 1D model. If this design moves forward, a 2D model would be recommended to provide detailed design parameters.

It also remains to be seen if the channel would maintain these characteristics over the long term and if the physical criteria result in the desired biological performance.

4.2 Monitoring

The following monitoring plan is proposed to evaluate if the Modified Side Channel Alternative is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 7: Monitoring Plan - Modified Side Channel Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Physical Criteria Monitoring (Objective 1a and 1b)	
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the modified side channel to analyze depths and velocities. These locations include: 1. Downstream entrance to the modified side channel 2. Cross-sections at 5,000, 12,000 and 20,000 feet up from the downstream entrance 3. Upstream outlet to the river The ADCP unit will be deployed by boat or line across the modified side channel during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked in the modified side channel during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use of the channel. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the modified side channel performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Eight telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the lower Yellowstone River 2. The downstream entrance to the modified side channel 3. Two locations within the modified side channel 4. The upstream outlet of the modified side channel 5. One mile upstream of the project on the lower Yellowstone River 6. Immediately downstream of the existing weir structure 7. The old headworks structure Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the modified side channel entrance, within the modified side channel (two locations), and at the upstream outlet of the modified side channel will determine if pallid sturgeon try and succeed in using the channel. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the modified side channel or over the weir structure and continued migrating upstream. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the project. If pallid sturgeon attempt to move back downstream over the weir they will be monitored using that station located on the old headworks structure. The stations within the modified side channel will detect pallid sturgeon using the channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream for either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)	
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the weir to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the boulder field.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
	Native Species Upstream and Downstream Passage (Objective 3a and 3b)	
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate eight land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the modified side channel will be used to determine whether these native species are using the channel. If native species are migrating over the weir, they will be monitored using the stations located in the area of the existing weir.	Reclamation

4.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 8 and 9 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 8: Physical Criteria – Potential Modified Side Channel AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in modified side channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the modified side channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in modified side channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the modified side channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Flow splits do not meet criteria	Modify upstream control structure – this structure controls the amount of flow that is allowed into the modified side channel; modification would consist of excavating the channel invert to a lower elevation.	Modify upstream control structure	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 9: Biological Criteria – Potential Modified Side Channel AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)
No use of the modified side channel	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of modified side channel fish entrance • Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River 3) Sediment build up or rock displacement into the channel entrance • Boulders - during low flows, use equipment to remove • Sediment - dredge material 4) Entrance location and design determined to be cause • Entrance angle - adjust the entrance angle to the modified side channel to provide better transition into Yellowstone River. • Entrance width - adjust the entrance to be larger or smaller to increase passage success. • Entrance location - move entrance upstream or downstream 5) Conduct additional ADCP monitoring at fish entrance
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Use of a portion of the modified side channel; no passage	1-3	1) Conduct additional ADCP monitoring within the channel 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria likely; • Depths - change channel invert, removal of sediment or excavate channel deeper • Velocities - change channel invert, change control structures, increase depths in the modified side channel • Flow Split - change channel invert or change control structures 2) Passage barrier at control structure or low water crossing, implement modification based on ADCP Data • Control Structure - add fill to modified side channel to provide better transition over control structure(s)
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of the modified side channel fish entrance • Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
	6 - 8	1)Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream passage occurs, but does not occur annually;	1 - 3	1) Conduct additional ADCP monitoring within the modified side channel 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria in all years likely; • Depths - change channel invert, removal of sediment or excavate channel deeper • Velocities - change channel invert, change control structures, increase depths in modified side channel • Flow Split - change channel invert or change control structures
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir • Fill - Removal or placement of additional fill material to provide better transition over existing weir structure and rubble field • Weir notch – add weir notch to existing structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir • Fill - removal or placement of additional fill material to provide better transition over existing weir structure and rock field • Weir notch – add weir notch to existing structure 2) Rock field a potential hazard • Rock - removal of a portion of the downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage - no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Inadequate depth over weir • Fill - removal or placement of additional fill material to provide better transition over existing weir structure and rock field • Weir notch – add a weir notch to the existing structure 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of modified side channel fish entrance • Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir • Fill - Removal or placement of additional fill material to provide better transition over existing weir structure and rock field • Weir Notch – adding weir notch to existing structure 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

5.0 Multiple Pump Alternative

The Multiple Pump Alternative is intended to improve fish passage by removing the existing weir and rock rubble field down to river grade and returning the river to a more natural channel. The depths and velocities in the natural channel are not required to meet the Service's BRT criteria, because it is presumed that this is essentially a natural condition and the channel is passable for most species during most flows. The one exception would be that the weir would only be removed down to grade. It is possible that buried portions of the existing weir could become exposed over time and create a fish passage barrier. The primary features of this alternative are described below.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the main irrigation canal.

Existing Weir and Rock Rubble Field. The existing weir and the rock rubble field will be removed from the river channel to grade. The accumulated wedge of coarse sediment upstream from the existing weir will be allowed to naturally transport downstream over time.

Pump Stations. Five pump stations would be installed over a distance of about 20 miles from the existing weir and downstream that would withdraw surface water from the Yellowstone River to supplement gravity flow into the main irrigation canal. Each of the pump stations would be equipped with V-screens that would reduce entrainment of fish larger than 40 mm into the pumps. Additionally, a fish return pump would be installed to return fish to the river that are swept or swim past the screens.

5.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the pumping alternative that could affect whether the project meets the goal and objectives. As mentioned above, only a portion of the existing weir would be removed down to river grade, if the channel begins to migrate or head cutting occurs the remaining portion of the structure may need to be removed.

Also, pump and water delivery reliability is uncertain with this alternative. Channel migration, ice and sediment accumulations are concerns that could have a large impact on the success of this alternative. Because water delivery would occur from 6 locations (existing gravity headworks and 5 pump stations) instead of one primary location, entrainment levels is also an uncertainty associated with this alternative.

5.2 Monitoring

The following monitoring plan is proposed to evaluate if the Multiple Pumps Alternative as designed and constructed, meets the water delivery criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the biological responses to these criteria would begin the first migration season after construction is complete. Because this alternative would provide an open river no physical criteria will be monitored (Objective 1a and 1b).

As mentioned under Section 1.3.2 and 5.1 pump and water reliability (Objective 4) are uncertain under this alternative. Pump and water reliability would be monitored from April 15 – October 15 (typical irrigation season). This monitoring would also begin the first year of operation.

Table 10: Monitoring Plan – Multiple Pump Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Five telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of Pump Station #5 on the lower Yellowstone River 2. Between pump station #5 and #3 3. Between pump station #3 and #2 4. Between pump station #2 and #1 5. One mile upstream of the headworks structure/pump station #1 Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project (pump station #5) will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) between the pumping stations will determine if pallid sturgeon successfully migrate upstream through the area. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the project and over the former weir location. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project near the headworks and pump station #1. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. The station located one mile downstream of the Project, near pump station #5 will detect the total number of pallid sturgeon successfully migrating downstream. Entrainment monitoring in the feeder canals to each pumping station would also be monitored to ensure screens are working as designed, and any fish that gets entrained would be safely returned to the Yellowstone River via the fish return pump. Additional details on entrainment monitoring are found below. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Entrainment monitoring would also occur at the 5 pumping stations for the same 3 weeks identified above. Entrainment nets would be hung behind the screens to ensure the screens are working properly. Fish that do get entrained and returned to the Yellowstone River via the fish return pump would also be capture to determine effects to fish.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate five land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Reliable Delivery of Water for Irrigation (Objective 4)	
1-8	Under this alternative water would be delivered through six primary locations: 1. Headworks 2. Pump station #1 3. Pump station #2 4. Pump station #3 5. Pump station #4 6. Pump Station #5 When water is being diverted through the existing headworks structure the flows would be measured at the Main Canal Bridge located approximately .5 miles down the Main Canal. When water is diverted through the pumping stations flows would be measured in the discharge pipes that lead from each pumping station into the main canal. Once in the main canal, water diversions will be measured and monitored using a SCADA system and several flow measuring devices (weirs or flumes). Channel migration will also be monitored near each feeder canal to determine the level of movement. Banks will be monitored 1,000 feet both upstream and downstream of the feeder canal entrance location. Sediment accumulation within each feeder canal will be monitored to ensure the entrance does not become blocked and that the screens are functioning as designed.	LY Irrigation Project Board of Control

5.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 11 and 12 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 11: Biological Criteria – Potential Multiple Pump AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objectives 2a and 2b)		
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing
	6 - 8	1)Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 3) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 4) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 5) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 6) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Successful downstream passage – no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations/headworks • Install trash racks with smaller spacing (pumps stations) • Modify Screen structure (headworks and pump stations) • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations) 3) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 3) Problems with fish return pumps • Modify or redesign fish return pump
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations/headworks • Install trash racks with smaller spacing (pumps stations) • Modify Screen structure (headworks and pump stations) • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations) 3) Problems with fish return pumps • Modify or redesign fish return pump
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

Table 12: Water Delivery Criteria – Potential Multiple Pump AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		Reliable Delivery of Water for Irrigation (Objective 4)
Reduced diversions to LYP/Less than 1,374 cfs delivered	1-3	1) Debris and sediment accumulation • Widen or deepen feeder canals • Increased sediment removal by LYIP • Install trash racks with smaller spacing • Install automated trash rack • Redesign fish screen structure • Install wing wall to deflect debris 2) Yellowstone River channel migration • Increase bank protection on either side of the river • Construct headworks structure 3) Physically unable to divert full water right • Install additional pumping stations • Increase bank protection to keep Yellowstone River thalweg next to pumping stations 4) Unable to maintain Main Canal water elevations • Modify canal operations • Install additional check structures • Reduce size of main canal • Pump water from main canal into laterals 5) Impacts from Ice • Install bank stabilization • Install headworks structure
	3-8	1) Conduct modeling and value engineering study to identify further adaptive management measures
Diversion Requirement Met	1-8	No adaptive management measures required

6.0 Multiple Pumps with Conservation Measures Alternative

The Multiple Pumps with Conservation Measures Alternative is intended to improve fish passage by removing the existing weir and rock field and returning the river to a more natural channel. The one exception would be that the weir would only be removed down to riverbed grade. It is possible that buried portions of the existing weir could become exposed over time and create a fish passage barrier. The depths and velocities are not required to meet the Service's BRT criteria, because it is presumed that this is a natural condition and the channel is passable for most species during most flows. The key features of this alternative are described below.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Existing Weir and Rock Rubble Field. The existing weir and rock field will be removed to grade to return it to a natural channel. The accumulated wedge of coarse sediment upstream of the weir will be allowed to naturally transport downstream over time.

Ranney Wells. Seven alluvial groundwater pump stations (i.e. Ranney Wells) would be installed along the river from the site of the existing weir down to below Sidney. These pump stations would not pump surface water, but would pump shallow groundwater in the alluvial aquifer associated with the river to supplement gravity flows into the Main Canal.

Water Conservation. The LYP irrigation canal system would be upgraded through a variety of measures to reduce water consumption and leakage, including lining the canals, converting open canals to pipes, and converting on-farm irrigation systems to pivot sprinklers and other more efficient mechanisms. These measures are proposed to reduce the need to divert more than 608 cfs of water into the LYP.

6.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the pumping alternative that could affect whether the project meets the goal and objectives. As mentioned above only a portion of the existing weir would be removed down to river grade, if the channel begins to migrate or head cutting occurs the remaining portion of the structure may need to be removed.

Also, pump and water delivery reliability is uncertain with this alternative. Channel migration, sedimentation, and aquifer draw down are concerns that could have a large impact on the success of this alternative.

6.2 Monitoring

The following monitoring plan is proposed to evaluate if the Multiple Pumps with Conservation Measures Alternative as designed and constructed, meets the water delivery criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the biological responses to these criteria would begin the first migration season after construction is complete. Because this alternative would provide an open river no physical criteria will be monitored (Objective 1a and 1b).

As mentioned under Section 1.3.2 and 6.1 pump and water reliability (Objective 4) are uncertain under this alternative. Pump and water reliability would be monitored from April 15 – October 15 (typical irrigation season). This monitoring would also begin the first year of operation.

Table 13: Monitoring Plan – Multiple Pump w/ Conservation Measures Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Three telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the former weir location 2. At the former weir location 3. One mile upstream from the former weir location Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the project and over the former weir location. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Objective 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate three land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Reliable Delivery of Water for Irrigation (Objective 4)	
1-8	Under this alternative water would be delivered through eight primary locations: 1. Headworks structure 2. Pump site #1 3. Pump site #2 4. Pump site #3 5. Pump site #4 6. Pump site #5 7. Pump site #6 8. Pump site #7 When water is being diverted through the existing headworks structure the flows would be measured at the Main Canal Bridge located approximately .5 miles down the Main Canal. When water is diverted through Ranney Wells, flows would be measure in the discharge pipes that lead from each pumping site to the Main Canal. Once in the Main Canal, water diversions will be measured and monitored using a SCADA system and several flow measuring devices (weirs or flumes). Additional monitoring wells would be installed and monitored to determine affects to ground water levels around each pump site.	LY Irrigation Project Board of Control

6.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 14 and 15 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 14: Biological Criteria – Potential Multiple Pump w/ Conservation AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)		
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage – no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Significant Entrainment occurring at headworks • Modify Screen structure • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations)

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

Table 15: Water Delivery Criteria – Potential Multiple Pump w/ Conservation AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Reliable Delivery of Water for Irrigation (Objective 4)		
Reduced diversions to LYP/Less than 608 cfs delivered	1-3	1) Sediment accumulation • Install a back flush system • Install additional Ranney Wells 2) Yellowstone River channel migration • Increase bank protection on either side of the river 3) Physically unable to divert full water right (reduced aquifer recharge) • Install additional Ranney wells • Investigate surface water diversions 4) Unable to maintain Main Canal elevations • Modify canal operations • Install additional check structures • Reduce size of main canal • Pump water from main canal into laterals
	3-8	1) Conduct modeling and value engineering study to identify further adaptive management measures
Diversion Requirement Met	1-8	No adaptive management measures required

7.0 References

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