

Appendix E – Adaptive Management Plan

Lower Yellowstone Passage Project Monitoring and Adaptive Management Plan

Intake Diversion Dam Modification, Lower Yellowstone Project

U.S. Bureau of Reclamation

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Introduction

The proposed Intake Dam modifications (Project) described in the 2015 Lower Yellowstone Intake Dam Modifications Supplemental Environmental Assessment (EA) and Reclamation's 2015 Amended Biological Assessment (BA) are based on the best available scientific information. Nonetheless, uncertainty exists regarding assumptions about the biological response to the bypass channel and the relative effectiveness of the bypass channel to improve fish passage around Intake Diversion Dam.

The purpose of this monitoring and adaptive management plan (AMP) is to validate assumptions and address Project uncertainties through monitoring of physical and biological responses to management actions, assess progress towards Project objectives, and identify potential adjustments to achieve and maintain Project performance. This Plan will be used to address uncertainties or validate assumptions identified in either the EA, BA, or BO. This AMP may be modified in the future as necessary in response to new data and information, such as the final Biological Opinion.

Adaptive management is a decision-making process that provides for implementing management actions in the face of uncertainty. The purpose of this AMP is to define objectives, metrics, and targets for proposed management actions and potential adjustments that may be warranted based on monitoring. This AMP also describes the cycle for analysis and decision-making that will be used to implement the plan. This approach allows for monitoring and implementation of management scenarios to better understand the effects of operation of the Lower Yellowstone Irrigation Project (LYIP) and Intake Dam modifications. The AMP is focused on monitoring and improving passage at Intake to avoid jeopardizing the continued existence of pallid sturgeon, and addressing uncertainties associated with the proposed action.

Background

Construction of the LYIP began in 1905 under the Reclamation Act of 1902. The Intake Diversion Dam is a 12 ft tall wood and stone structure that is submerged in and spans the Yellowstone River. Intake Diversion Dam, which is technically a weir, raises the water level for diversion of water into the LYIP Main Canal. Intake Diversion Dam has impeded upstream migration of pallid sturgeon and other native fish for more than 100 years.

Reclamation is required to complete consultation under Section 7(a)(2) for operation of the LYIP. Reclamation has contractual obligations to deliver water to continue effective operation of the LYIP.

Project Features

The Project is intended to improve fish passage with a long, low-gradient channel around the proposed weir, existing dam, and rubble field. 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. The figures provided below, depict the locations of major Project features. The following is a summary of the major Project features.

1. Headworks – a new headworks was completed in 2012 and has been in operation since its completion. The structure spans 300 ft and is equipped with 12 rotating drum screens that reduce entrainment of fish larger than 40mm into the LYIP's Main Canal.
2. Bypass channel – the bypass channel would be excavated from the inlet of the existing side channel to just downstream of the existing diversion dam. The proposed bypass channel alignment is approximately 11,150 feet long at a slope of 0.0007 ft/ft. The channel cross section has a 40-foot bottom width with side slopes varying from 1V:12H to 1V:3H. The bypass channel would divert on average 13-15% of the total flow of the Yellowstone River (Figure 1).

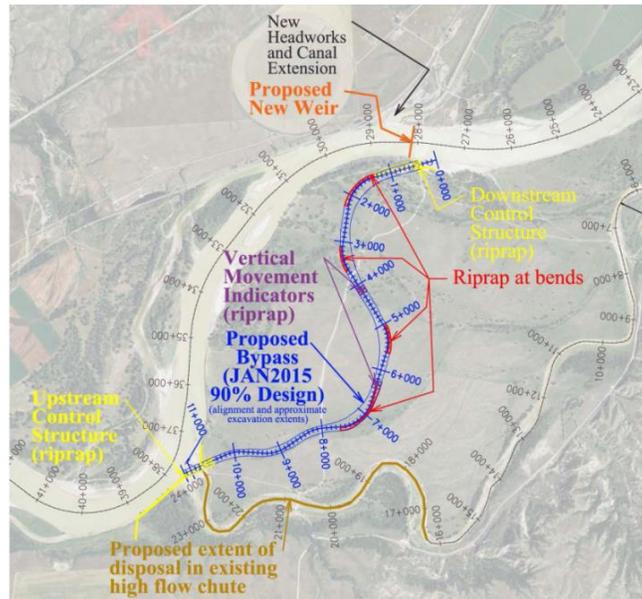


Figure 1 - Bypass Channel Alignment

3. Upstream control structure – a riprap control structure designed to control discharge and stabilize the entrance to the bypass channel would be situated on the upstream end of the channel.
4. Existing side channel plug – a channel plug would be constructed in the existing side channel to keep all flow within the proposed bypass channel.

5. Vertical control structures – two vertical control structures (riprap sills) are proposed for maintaining channel slope and allowing for early identification of channel movement.
6. Downstream vertical control structure – a riprap sill is proposed at the downstream end of the bypass channel to maintain channel elevations.
7. 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 armor layers in the Yellowstone River.
8. New diversion weir – to maintain irrigation and bypass channel diversion capabilities a new concrete weir would be constructed. The new weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities (Figure 2).



Figure 2 - Cross-section of New and Existing Weir

9. Weir Notch – The new weir will include a notch with a top width of 125 feet and bottom width of 85 feet to help provide downstream passage over the weir.
10. Downstream Fill – Fill is proposed near the downstream entrance of the bypass channel to reduce eddy formation and to increase attraction flows (Figure 3).

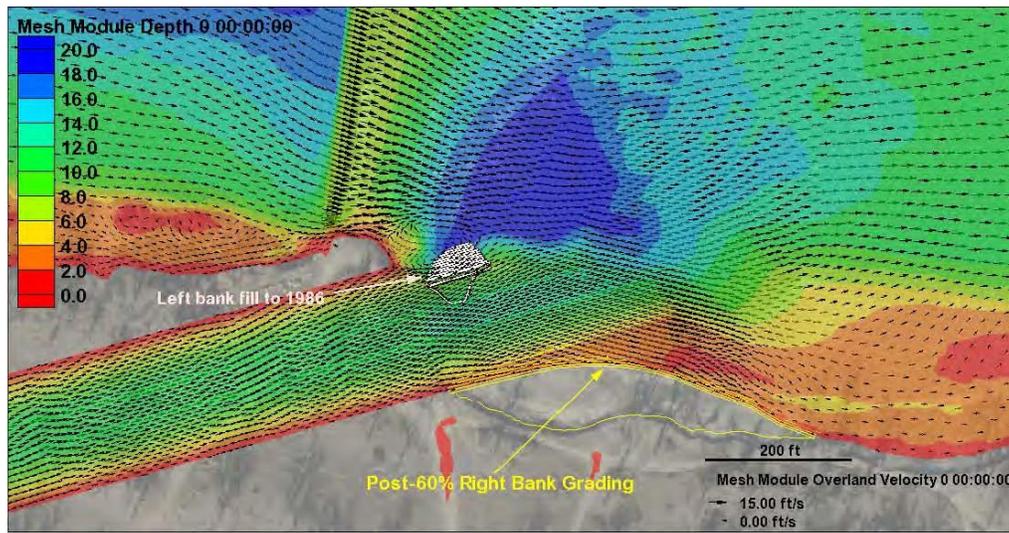


Figure 3 - Computer Modeling Showing Extent of Downstream Fill Area

Project Uncertainties

There are uncertainties related to the design, performance, and biological response to the Bypass Channel Alternative that could affect its ability to meet stated goals and objectives for the Project. The uncertainties associated with the bypass channel alternative are presented below.

1. Bypass Channel Design and Performance
 - Will the bypass channel consistently perform within physical criteria parameters?

2. Pallid Sturgeon
 - Are pallid sturgeon able to locate the bypass channel?
 - Do pallid sturgeon use the bypass channel to migrate upstream?
 - Does the bypass channel and weir provide downstream passage of adult, juvenile, free embryo and larval pallid sturgeon?

3. Native Fish
 - Are native fish able to migrate upstream and downstream of the proposed weir and bypass channel?

Project Goal

Goal: The goal of the Project is to provide pallid sturgeon fish passage at the Intake Diversion Dam. This would make approximately 165 miles of additional habitat for pallid sturgeon migration and spawning in the Yellowstone River. The majority of the spawning activity currently takes place within the first 10 miles of the Yellowstone River (Bramblett 1996), which is downstream of the Project. This does not allow for adequate drift distance for floating free embryos and larval pallid sturgeon to mature before they reach the headwaters of Lake Sakakawea, where larvae are believed to succumb to hypoxia (Guy et al. 2015). By providing passage at Intake, adult pallid sturgeon would be able to migrate further upstream increasing the available drift distance for their resulting young.

Objective 1: Maintain bypass channel within physical criteria parameters. The physical criteria are:

- **Depth**
 - 1) Minimum cross-sectional depths 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 ft across 30 contiguous feet of the measured channel cross section profile.
 - 2) Minimum cross-sectional depth over 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.

- **Main Channel Cross-sectional Velocities**
 - 1) Mean bypass channel cross-sectional velocities at all sampled locations must be equal or greater than 2.0 feet per second or 0.61 meters per second, but less than or equal to 6.0 ft/s over the discharge range of 7,000 cfs to 14,999 cfs.
 - 2) Mean bypass channel cross-sectional velocities (measured as mean column velocities) at all sampled cross-sections must be equal or greater than 2.4 ft/s, but less than or equal to 6.0 ft/s over the discharge range of 15,000 cfs to 63,000 cfs.

- **Entrance and Exit Velocities**
 - 1) To provide sufficient attraction flows, the downstream fish entrance should have a mean cross sectional velocity of greater than or equal to 2.0 ft/s (measured as mean column velocity) through the lower discharge range of 7,000 cfs to 14,999 cfs.
 - 2) The entrance should have a mean cross-sectional velocity greater than or equal to 2.4 ft/s (measured as mean column velocity) through the range of discharges from 15,000 cfs to 63,000 cfs.
 - 3) Mean cross-sectional velocities (measured as mean column velocity) at both the upstream and downstream channel openings should be less than or equal to 6.0 ft/s for river discharges ranging from 7,000 cfs to 63,000 cfs.

- **Flow Split**
 - 1) At least a 12% flow split over the discharge range of 7,000 to 14,999 cfs; 13% to greater than 15% over the discharge range of 15,000 cfs to 63,000 cfs.

Table 1 - Tabular Summary of Design Criteria

Criteria	7,000 – 14,999 cfs	15,000 – 63,000 cfs
Bypass Channel Flow Split	≥12%	13% to ≥15%
Bypass Channel Cross-sectional Velocities (measured as mean column velocity)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Depth (minimum cross-sectional depth for 30 contiguous feet at measured cross-section)	≥4.0 ft	≥6.0 ft
Bypass Channel Fish Entrance (measured as mean column velocity)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Fish Exit (measured as mean column velocity)	≤6.0 ft/s	≤6.0 ft/s

Objective 2: Upstream and Downstream Passage of Pallid Sturgeon

- (Criteria to be developed by the Service’s Biological Review Team)

Objective 3: Upstream and Downstream Passage of Native Fish

- Ensure native fish are able to migrate upstream and downstream of the new weir and bypass channel.

Monitoring

The following monitoring plan will be used to ensure the bypass channel is maintained as designed and constructed, and that biological assumptions were correct.

Objective 1: Maintain bypass channel within physical criteria parameters.

After construction of the new weir and bypass channel, the U.S. Army Corps of Engineers (Corps) will be responsible for the first year of physical criteria monitoring to ensure the bypass channel performs as it was designed. Once the one year warranty period is complete, Reclamation through the LYIP will be responsible for maintaining the bypass for the life of the Project.

An acoustic Doppler current profiler (ADCP) will be deployed at strategic locations along the bypass channel to analyze depths, velocities, and discharge within the bypass channel. These locations include:

1. Downstream entrance of the bypass channel
2. Representative straight section of the bypass channel
3. Representative corner section of the bypass channel
4. Upstream exit of the bypass channel

Years 1 – 3 (Baseline)

An ADCP unit will be deployed by boat within the bypass channel during the spring, peak runoff, and summer baseline. This will give Reclamation information on how the bypass channel is performing during three different hydraulic scenarios.

Years 3 – 6 (Intermediate)

The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff and then again during summer baseline flows to provide data on pre-migration and post-migration bypass channel conditions.

Years 6 – Beyond (Long-term Monitoring)

Once a baseline has been established and an understanding how the bypass channel performs under different hydraulic scenarios the monitoring program will be scaled back. It is assumed after several years of service the bypass channel will become stable and will remain stable under

“normal” conditions. If a severe or unique event occurs (major flooding or ice jam) the ADCP unit will be deployed to ensure that the physical and hydraulic characteristics have not changed.

Objective 2: Upstream and Downstream Passage of Pallid Sturgeon

Reclamation will be responsible for ensuring passage monitoring occurs once the bypass channel and new weir are complete. Below is a description of monitoring that will take place.

Upstream Adult Monitoring

Currently, the U. S. Geological Survey (USGS), U.S. Fish and Wildlife Service (Service) and Montana Fish, Wildlife & Parks (FWP) conduct capture activities during the spring of the year to tag adult and juvenile pallid sturgeon. 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 on a given year.

Reclamation will locate four telemetry stations at strategic locations to track the movement of these tagged fish. These stations will be located at:

1. One mile downstream of the new diversion weir and the bypass channel
2. Along the bypass channel
3. One mile upstream of the new diversion weir and the bypass channel
4. On the new or existing headworks structures

Because the LYIP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only tagged pallid sturgeon that come within one mile of 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 will be used to establish the base number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) within the bypass channel will be used to determine whether pallid sturgeon are using the bypass channel. The station located one mile upstream from the Project will confirm how many tagged fish successfully migrated upstream.

Downstream Adult Monitoring

Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of tagged pallid sturgeon attempting to move downstream either over the new weir or through the bypass channel. If pallid sturgeon attempt to move back downstream over the weir they will be monitored using that station located on either the new headworks or old headworks. The station(s) 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 back downstream.

Downstream Free Embryo and Larval Monitoring

As mentioned above, FWP currently monitors movements of adult pallid sturgeon in the Yellowstone River and this effort is expected to continue. Once adult pallid sturgeon migrate past the Project, FWP will be monitoring for spawning activities that may occur upstream. If FWP confirms spawning has taken place upstream, and Reclamation has sufficient lead time, Reclamation will monitor for free embryos and larval pallid sturgeon downstream of the new weir and bypass channel to ensure these organisms are successfully passing downstream. Larval nets will also be deployed in the main canal to track entrainment through the new headworks.

Objective 3: Upstream and Downstream Passage of Native Species

Below is a description of native species monitoring that will take place. This monitoring effort was identified through the 2015 supplemental NEPA process and is separate from the current ESA process.

Upstream and Downstream Monitoring

Currently, Montana Fish, Wildlife & Parks (FWP) conduct capture activities during the spring of the year to tag native species and species of special concern. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring.

As mentioned above, Reclamation will locate four telemetry stations at strategic locations to track the movement of tagged native fish. These stations will be located at:

1. One mile downstream of the new diversion weir and bypass channel
2. Along the bypass channel
3. One mile upstream of new diversion weir and bypass channel
4. On the new or existing headworks structures

Reclamation and FWP 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. The telemetry station 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 new weir they will be monitored using that station located on either the new or old headworks.

Potential Adaptive Management Measures

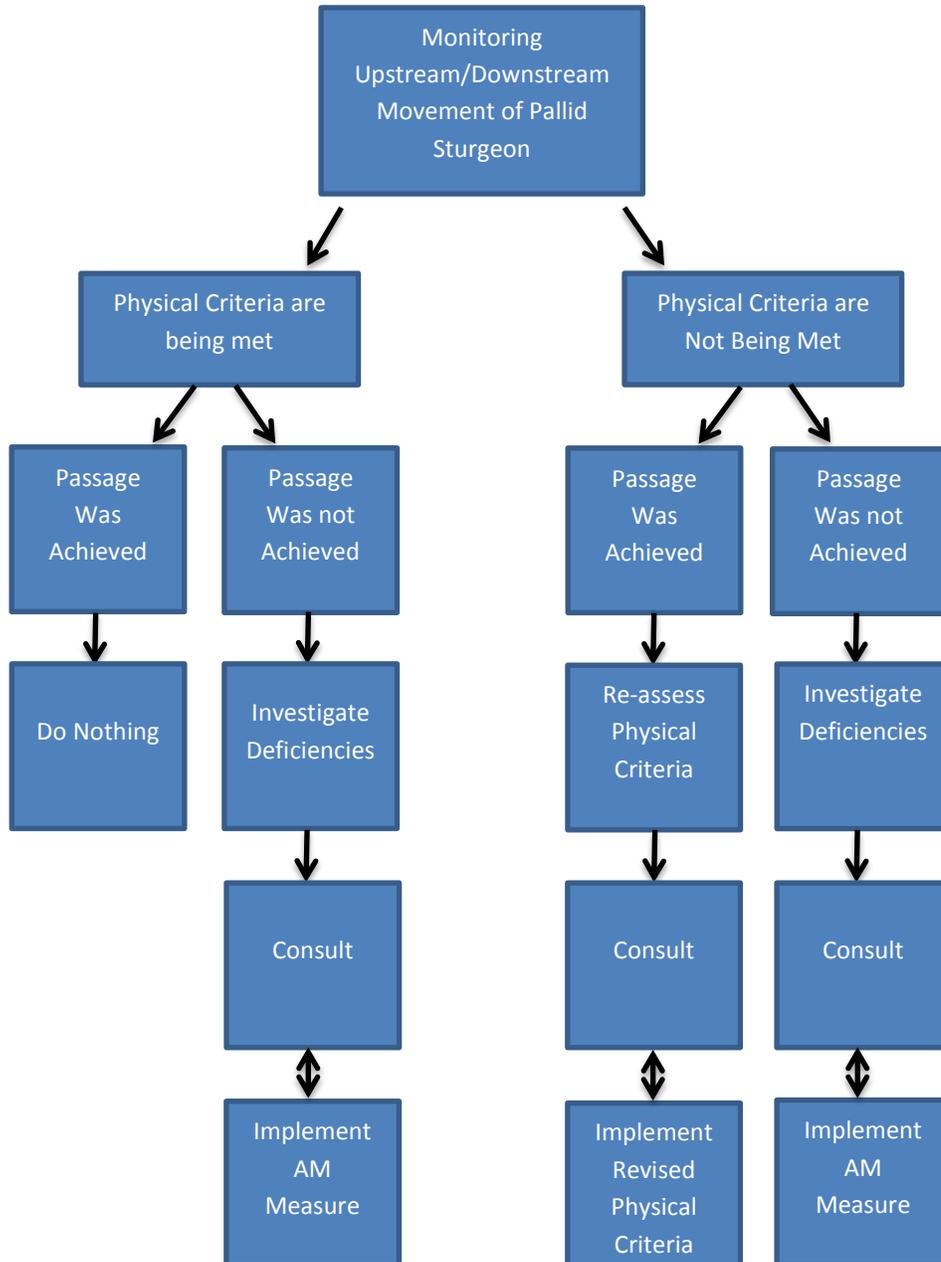
Data collected from hydraulic monitoring would be evaluated and compared to the data collected from biological monitoring. If objectives are not met, Reclamation may implement the following measures, or variations or combinations of these measures, based on the monitoring results:

1. Bypass Channel Main Channel
 - Modifications to upstream and downstream control structures, vertical control structures or lateral stability structures to address physical or hydraulic issues.
 - Modifications to riprap sections within the bypass channel, either to enhance stability of the channel or to reduce passage barriers.
2. Bypass Channel Entrance
 - Downstream fill modification to improve attraction flows, alleviate sheer flows, and/or minimize eddy formation near the channel entrance.
 - Construction of a wing wall or training structure that guides upstream migrating fish towards the bypass channel entrance.
3. Existing Side Channel
 - Removal of fill material and channel plug in the existing side channel to provide a supplemental passage option.
4. Manipulation of Existing Rock Field
 - Removal of existing rock in the river near the entrance of the bypass channel to alleviate passage barriers.
 - Removal or re-positioning of existing rock in the river to improve downstream passage conditions.
5. Weir Notch
 - Construction of a wing wall or training structure that guides adults, juveniles, free embryos, and larval pallid sturgeon toward the weir notch.
6. Headworks
 - Construction of a wing wall or training structure that guides adults, juveniles, free embryos, and larval pallid sturgeon away from the new headworks structure.
7. Supplemental Pumps
 - Installation of smaller gauge screens on the supplemental pumps.
 - Changes in the season of use for supplemental pumps.

Implementation of the above measures would be based on results of physical and computer monitoring including: depth, velocity, and width; and observation of pallid sturgeon migration upstream and downstream of the Project. Implementation would also depend on funding availability and the feasibility of each.

Assessment and Implementation of Adaptive Management Measures

Assessment of Project objectives will be coordinated by Reclamation with the assistance of the Service. Reclamation will review data from monitoring of the physical parameters and compare that to pallid sturgeon passage results. It will be Reclamation's responsibility, in coordination with the Service, to determine whether or not the bypass channel alternative is meeting the objectives established in this document and provide recommendations to remedy potential problems.



Monitoring of the physical criteria and the biological responses to these criteria would begin the first full year the bypass channel is in operation. Physical and biological monitoring is expected to take place from April 1 – July 15. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the Project. Once the field season is complete Reclamation will work with FWP to compile monitoring results and begin assessing the effectiveness of the project to meet stated objectives.

During the yearly assessment Reclamation will determine how well the bypass channel met the design criteria. Once this has been established Reclamation will compare this to the biological monitoring results for that year.

1. All Objectives Met

If the bypass channel met the physical criteria objective (Objective 1) and the passage objective for pallid sturgeon (Objective 2) then Reclamation will not implement an adaptive management measure. Reclamation will submit these results to the Service for concurrence and the monitoring program will continue as planned.

2. If One or All Objectives Are Not Met

If one or more of the stated objectives are not being met Reclamation will conduct further analysis. Questions that may need to be addressed include:

- Were runoff conditions in the basin a factor? (Extreme high flow or drought conditions)
- Were fish able to find the entrance to the bypass channel? If not, why?
- Did fish use the entire bypass channel? If not, where did they turn around?
- Are there hydraulic conditions these fish encountered that discouraged passage?
- Were fish able to migrate back downstream through the project? If not, why?

Once a problem has been identified Reclamation will look at possible measures to address the identified issue(s). Once an adaptive management measure has been identified it will be subject to one or all of the following:

- Feasibility Study
- Physical Modeling
- Computer Modeling
- NEPA Analysis
- ESA Consultation

If it is determined that the adaptive management measure identified is the appropriate solution, then Reclamation will implement the measure within one field season if possible. Once the measure has been implemented Reclamation will resume monitoring activities or, if necessary, revise monitoring activities in consultation with the Service.

Reporting

Reclamation will provide annual reports documenting monitoring results and previous management actions. Recommendations for changes to monitoring or management actions will be proposed as necessary.

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.

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 Adaptive Management Plan, all data, results of analyses, and reports will be archived.

Literature Cited

- Guy, C., H.B. Treanor, K.M. Kappenman, E.A. Scholl, J.E. Ilgen, and M.A.H. Webb, 2015. Broadening the Regulated-River Management Paradigm: A Case Study of the Forgotten Dead Zone Hindering Pallid Sturgeon Recovery. *Fisheries* 40(1)
- Bramblett, R. G. 1996. Habitats and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. PhD dissertation. Montana State University, Bozeman.