# Intake Diversion Dam Modification
# Lower Yellowstone Project, Montana

## Draft Supplement to the
## 2010 Final Environmental Assessment

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Prepared by Joint Lead Agencies:


U.S. Department of the Interior
Bureau of Reclamation
Billings, Montana

U.S. Army
Corps of Engineers
Omaha, Nebraska

# Executive Summary

The U.S. Army Corps of Engineers (Corps) and the Bureau of Reclamation (Reclamation) prepared this Draft Supplement to the April 2010 Final Environmental Assessment (EA) for the Intake Diversion Dam Modification Project. Reclamation and the Corps are joint lead agencies for preparation of the Supplemental EA.

The proposed federal action would modify Intake Diversion Dam to improve passage for endangered pallid sturgeon and other native fish in the lower Yellowstone River. Intake Diversion Dam has impeded upstream migration of pallid sturgeon and other native fish for more than 100 years. The best available science suggests that the diversion dam is a partial barrier to some fish species and is likely a total barrier to other fish species, such as pallid sturgeon. The proposed fish passage project is anticipated to play a major role in assisting in recovery of pallid sturgeon by providing access to an additional 165 miles of the Yellowstone River for migration, spawning and rearing.

The Intake Diversion Dam is used to divert water from the Yellowstone River into the Lower Yellowstone Project's main irrigation canal on the north side of the river at a location 18 miles downstream of Glendive, Montana. The irrigation canal system roughly parallels the Yellowstone River to its confluence with the Missouri River. The system conveys water to irrigate approximately 54,300 acres on about 398 farms along the canal system in Montana and North Dakota.

The U.S. Fish and Wildlife Service (Service) listed the pallid sturgeon as endangered under the Endangered Species Act (ESA) in 1990. Section 7(a)(1) of the ESA authorizes all federal agencies to use their resources for the conservation and recovery of federally listed species and the ecosystems upon which they depend, and Section 7(a)(2) requires federal agencies to consult with the Service to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of any federally listed species or to modify designated critical habitat. The lower Yellowstone River has been identified by the Service as an area of priority for pallid sturgeon recovery because:

- the Yellowstone River, with its near natural hydrograph and associated temperature and sediment regimes, provides the best habitat in the upper Missouri River Basin;
- additional ecosystem and connectivity restoration efforts could further increase the amount of habitat available for larval drift in the Yellowstone River;
- the Yellowstone River provides 35-50% more area of slow current velocity habitat patches than the Missouri River during periods when larval drift occurs, which may result in slower larval drift rates than those modeled in the Missouri River;
- none of the irrigation diversion structures on the Yellowstone River (i.e. Cartersville or Intake Diversion dams) significantly trap sediment and alter the resultant seasonally high turbidity levels on the Yellowstone River, thereby potentially reducing predation of larvae; and
- the Yellowstone River requires no active river management for natural flows or temperature regime.

Reclamation constructed the Lower Yellowstone Project beginning in 1905 under the Reclamation Act/Newlands Act of 1902 (Public Law 161). As is the case for most authorized Reclamation projects, the long-term operation and maintenance of project facilities is the financial responsibility of the water users, which is the case for the Lower Yellowstone Project water users. Reclamation retains ownership of the Lower Yellowstone Project facilities, but the facilities are operated and maintained under a contract with the Lower Yellowstone Irrigation Districts (District) through the Board of Control of the Lower Yellowstone Project.

The Corps is a joint lead agency for the project because this proposed project is a Reasonable and Prudent Alternative (RPA) in the 2003 Missouri River Amended Biological Opinion. Section 3109 of the 2007 Water Resources Development Act authorizes the Corps to use funding from the Missouri River Recovery and Mitigation Program to assist Reclamation with design and construction of modifications to the Lower Yellowstone Project for the purpose of ecosystem restoration. The intent of ecosystem restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system (Engineer Regulation [ER] 1165-2-501, 30 Sep 99).

Proposed modifications for entrainment protection and fish passage were described and analyzed in the April 2010 Final Environmental Assessment[1] (hereafter referred to as the 2010 EA). In the April 26, 2010 Finding of No Significant Impact[2] (2010 FONSI), Reclamation and the Corps made a joint finding that an Environmental Impact Statement (EIS) was not required for the proposed project and decided to implement the proposed action to reduce entrainment and improve fish passage. The selected alternative to improve fish passage was the rock ramp alternative. In addition, installation of fish screens and new main canal headworks was chosen as the preferred alternative to reduce entrainment.

The modifications to reduce entrainment, construction of the new main canal headworks and installation of fish screens, began in October 2010 and have been completed. Irrigation deliveries using the new headworks began in April 2012. The second part of the proposed dam modifications to provide fish passage by installing a rock ramp is being reevaluated by the lead agencies, in coordination with the Service, Montana Fish, Wildlife and Parks (MFWP), Montana Department of Natural Resource Conservation, Montana Department of Environmental Quality, and the District. The reevaluation is necessary because of significant new information on the rock ramp design, pallid sturgeon movement, as well as the constructability and sustainability of the proposed rock ramp since the 2010 EA and FONSI were released.

Several fish passage alternatives were initially identified for further analysis based on previous studies of the Lower Yellowstone Project. Using input from cooperating agencies these alternatives were analyzed using screening criteria. As a result of the screening process, the number of alternatives was reduced to three, which are described in Chapter 2 and Appendix A.1. The alternatives evaluated are No Action (Continue Present Operation), 15% Bypass Channel and Rock Ramp.

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[1] Final Environmental Assessment, Intake Diversion Dam Modification, Lower Yellowstone Project, Montana, April 2010, U.S. Department of the Interior, Bureau of Reclamation and U.S. Army Corps of Engineers
[2] Finding of No Significant Impact, Intake Diversion Dam Modification, Lower Yellowstone Project, April 26, 2010

- No Action (Continue Present Operation) - Under this alternative, Reclamation would continue present operation of the dam and headworks to divert water from the Yellowstone River for irrigation purposes, as authorized. This means operating the irrigation project without any modifications to improve fish passage.

- Bypass Channel - The primary feature of this alternative would be constructing a bypass channel from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. It would also replace Intake Diversion Dam with a concrete weir to raise the surface elevation of the river in front of the proposed bypass channel as well as the irrigation headworks. The bypass channel is intended to improve fish passage and contribute to ecosystem restoration.

- Rock Ramp - The primary features of this alternative would be replacing Intake Diversion Dam with a concrete weir and boulder and cobble rock ramp. This would raise the surface elevation of the river upstream of the weir for diversion into the main canal, and be expected to improve fish passage and contribute to ecosystem restoration.

The potential impacts and benefits that may result from the proposed action and alternatives are described in Chapter 4. The actions to minimize effects of the proposed action are explained in Chapter 4 and compiled in Appendix I. There would be consequences if Reclamation decides to continue present operation of the Lower Yellowstone Project. In general, incidental take of pallid sturgeon at Intake Diversion Dam would continue. Permitting and minimization of incidental take of pallid sturgeon for operation of the Lower Yellowstone Project under No Action would require either a Board of Control-negotiated habitat conservation plan (HCP) under Section 10(a) of the ESA or completion of Section 7(a)(2) consultation by Reclamation. Either scenario to address incidental take would not diminish Reclamation's legal responsibility to comply with the ESA and correct the existing passage impacts caused by the Intake Diversion Dam.

Both action alternatives are intended to meet the purpose and need for the proposed action, which is to contribute to ecological restoration and improve passage for the endangered pallid sturgeon and other native fish up and downstream at Intake, Montana, opening up to 165 miles of the Yellowstone River for migration, spawning, and rearing.

Neither action alternative is expected to have long-term impacts on surface water quality. When compared to the Rock Ramp Alternative, the larger footprint of the Bypass Channel Alternative would result in more acres permanently affected in the channel migration zone (50 acres versus 26 acres). The larger footprint would also result in more lands, vegetation, and wildlife impacts, although it is expected that these impacts can be minimized or offset. Both action alternatives would have potentially adverse effects on historic properties, but measures would be taken to minimize such effects. The action alternatives are not expected to have more than slight positive effects on the regional economy. Lower operation and maintenance (O&M) costs under the Bypass Channel Alternative may slightly increase farm revenues, while increased O&M costs under the Rock Ramp Alternative may slightly decrease farm revenues. The Rock Ramp Alternative would result in closure and relocation of the boat ramp at Intake; the Bypass Channel Alternative would diminish access to a portion of Joes Island but the effects are expected to be limited.  However, in general, recreation opportunities are expected to improve under both action alternatives in the long term.  The action alternatives would both be expected to improve fish passage for pallid sturgeon and other native fish, and are not expected to result in any long-term adverse impacts to any threatened or endangered species, or species of special concern.

Reclamation and the Corps have identified the Bypass Channel as the preferred alternative.  The agencies believe that in addition to consideration of the relative resource impacts, the more straight-forward construction, ability to withstand ice forces, and cost effectiveness of the Bypass Channel lead to a preference over the Rock Ramp Alternative.  As such, the Bypass Channel Alternative is Reclamation's and the Corps' preferred alternative.

**Table of Contents**

## List of Figures

## List of Tables

## List of Appendices

# List of Abbreviations and Acronyms

| | |
|---|---|
| ACS | American Community Survey |
| AM | adaptive management |
| APE | area of potential effect |
| ADCP | Acoustic Doppler Current Profiler |
| BA | biological assessment |
| BiOp | biological opinion |
| BRT | biological review team |
| CBA | choosing by advantages |
| CEQ | Council on Environmental Quality |
| cfs | cubic feet per second |
| CE/ICA | cost effectiveness/incremental cost analysis |
| CFR | Code of Federal Regulations |
| CMZ | channel migration zone |
| CRREL | U.S. Army Cold Regions Research and Engineering Laboratory |
| CWA | Clean Water Act |
| DEQ | Department of Environmental Quality |
| DIDSON | Dual Frequency Identification Sonar |
| DNRC | Department of Natural Resources and Conservation |
| EA | Environmental Assessment |
| ER | Engineer Regulation |
| ERT | environmental review team |
| ESA | Endangered Species Act |
| EIS | Environmental Impact Statement |
| FAS | fishing access site |
| FEMA | Federal Emergency Management Agency |
| FONSI | Finding of No Significant Impact |
| FPCI | Fish Passage Connectivity Index |
| FWCA | Fish and Wildlife Coordination Act |
| fps | feet per second |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| HCP | habitat conservation plan |
| HEC-RAS | Hydrologic Engineering Center – River Analysis System |
| HU | habitat unit |
| HQUSACE | U.S. Army Corps of Engineers Headquarters |
| IDC | interest during construction |
| IMPLAN | Impact Analysis for Planning Model |
| ITA | Indian trust assets |
| IWR | Institute for Water Resources |
| LYIP | Lower Yellowstone Irrigation Project |
| MEPA | Montana Environmental Policy Act |
| MFWP | Montana Fish, Wildlife & Parks |
| MOA | memorandum of agreement |
| MOU | memorandum of understanding |

| | |
|---|---|
| MTNHP | Montana Natural Heritage Program |
| NAVD88 | North American Vertical Datum of 1988 |
| NEPA | National Environmental Policy Act |
| NESP | Navigation and Ecosystem Sustainability Program |
| NFIP | National Flood Insurance Program |
| NHPA | National Historic Preservation Act |
| NLCD | National Land Cover Database |
| NWI | National Wetlands Inventory |
| O&M | operations and maintenance |
| OHWM | ordinary high water mark |
| P&G | Principles & Guidelines |
| PEM | palustrine emergent |
| PEMC | palustrine emergent seasonally flooded |
| PFOA/C | palustrine forested temporarily to seasonally flooded |
| PGA | peak ground acceleration |
| R2UBG | riverine lower perennial unconsolidated bottom intermittently exposed |
| RBF | riverbank filtration |
| RPA | reasonable and prudent alternative |
| RO | Regional Office |
| RPMA | Recovery-Priority Management Area |
| SHPO | State Historic Preservation Office |
| $U_{crit}$ | critical current velocities |
| UMRS | Upper Mississippi River System |
| USGS | U. S. Geological Survey |
| WRDA | Water Resources Development Act |
| WUS | Waters of the U.S. |

# 1. Purpose and Need

## 1.1. Introduction

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps), joint lead agencies under the National Environmental Policy Act (NEPA), are continuing evaluation of the proposed modifications to Intake Diversion Dam, a feature of the Lower Yellowstone Project. The proposed modifications are intended to reduce fish entrainment and provide improved fish passage. Those modifications were described and analyzed in the April 2010 Final Environmental Assessment[3] (hereafter referred to as the 2010 EA). In the April 26, 2010 Finding of No Significant Impact[4] (2010 FONSI), Reclamation and the Corps made a joint finding that an Environmental Impact Statement (EIS) was not required for the proposed project and decided to implement the proposed action to reduce entrainment and improve fish passage. The selected alternative to improve fish passage was the rock ramp alternative.

The modifications to reduce entrainment, construction of the new main canal headworks and installation of fish screens, began in October 2010 and have been completed. Irrigation deliveries using the new headworks began in April 2012. The second part of the proposed dam modifications to provide fish passage by installing a rock ramp is being reevaluated by the lead agencies, in coordination with the U.S. Fish and Wildlife Service (Service), Montana Fish, Wildlife and Parks, Montana Department of Environmental Quality, and the Lower Yellowstone Irrigation District (District). The reevaluation is necessary because significant changes are being proposed and new information has become available regarding the proposed rock ramp since the 2010 EA and FONSI was released.

Agencies prepare supplements to environmental documents such as an EA if there are substantial changes in the proposed action that are relevant to environmental concerns or there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts[5]. This Supplemental EA explains and addresses the changes, and includes new or updated information related to improving fish passage at Intake Diversion Dam. It describes and discloses the changes in potential effects that could result from other alternatives that have been considered to improve fish passage. This supplemental EA is tiered[6] to the 2010 EA in order to reduce paperwork and eliminate repetitive discussions; it adopts and combines information[7] from the 2010 EA. It also incorporates by reference[8] the relevant portions of that document, especially information pertaining to the need to improve fish passage. Incorporated material is cited and briefly described in this document. The topics described in the 2010 EA that have not changed and those elements of the modifications that have been completed, i.e. entrainment reduction, are not repeated in this supplemental EA. Further, the

[3] Final Environmental Assessment, Intake Diversion Dam Modification, Lower Yellowstone Project, Montana, April 2010, U.S. Department of the Interior, Bureau of Reclamation and U.S. Army Corps of Engineers
[4] Finding of No Significant Impact, Intake Diversion Dam Modification, Lower Yellowstone Project, April 26, 2010
[5] 40 CFR Part 1502.9(c), Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA)
[6] 40 CFR Part 1502.20 and 1508.28
[7] 40 CFR Part 1500.4(n) and (o)
[8] 40 CFR Part 1502.21

document describes minor clarifications of information that have become available since the 2010 EA.

## 1.2. The Proposed Action (Improve Fish Passage)

The proposed action considered in this document is to identify and implement an alternative to improve fish passage at Intake Diversion Dam.

## 1.3. Purpose of and Need for the Proposed Action

The purpose of the proposed modifications to Intake Diversion Dam described in the 2010 EA was to reduce entrainment and improve fish passage for the endangered pallid sturgeon and other native fishes. This purpose remains unchanged; however, since the entrainment reduction portion of the project's purpose has been accomplished with completion of the new headworks and fish screens, the main purpose addressed in this EA is improving fish passage.

Both Reclamation and the Corps have general responsibility under section 7(a)(1) of the Endangered Species Act (ESA) to utilize their authorities to conserve and recover federally listed species and ecosystems upon which they depend. In addition, both agencies also need to avoid jeopardizing the pallid sturgeon in funding or carrying out any agency action per 7(a)(2) of the Act as described in the 2010 EA. Thus, the need for the proposed action is to improve fish passage because the existing diversion dam is an impediment to successful upstream and downstream movement of the endangered pallid sturgeon and other native fishes. The need for entrainment reduction has been satisfied with operation of the new headworks and screens (pending monitoring of its operation to assure its biological effectiveness). The other needs related to fish passage described in the 2010 EA continue to apply to the proposed action in this document: (1) to continue effective operation of the Lower Yellowstone Project and; (2) contribute to ecosystem restoration.

Meeting these needs through the proposed action is anticipated to play a major role in assisting in the recovery of pallid sturgeon in the Yellowstone River - Missouri River confluence area. This in turn would help both agencies meet their conservation, recovery and consultation responsibilities under ESA as well as provide both agencies a less constrained environment in which to carry out their authorized purposes, including Reclamation's continued operation of the Lower Yellowstone Project and the Corps' continued operation of the Missouri River mainstem projects.

## 1.4. Background Information

The lead federal agencies made a decision in April 2010 to proceed with the project and the Corps awarded a contract to construct the new headworks and fish screens in July 2010. The Corps also proceeded with activities needed to develop the final design of the rock ramp and issue a contract for its construction in 2011. The conceptual design level cost estimate for the rock ramp was approximately $18 million. In late 2010 and early 2011, the estimated costs for the conceptual rock ramp design increased dramatically. The primary reasons for the increased cost estimate included:

1. The amount of rock needed for the rock ramp significantly increased. The length of the rock ramp would need to be longer than originally considered in the conceptual designs and cost estimates. Input from the Biological Review Team (BRT) regarding the design criteria (principally flow velocity and water depth) indicated that the slope of the rock ramp should be 0.4%, which is more gradual than the 1% slope the Corps used during development of the conceptual design phase. The more gradual slope means the rock ramp would need to be longer, which means significantly more rock would be needed to extend the length of the ramp.

2. Additional rock would also be required for the rock ramp to provide more point-to-point rock contact in the structure of the ramp needed to maintain its stability given the wide range of flow and environmental conditions in the Yellowstone River.

3. The construction of the rock ramp would likely need to be conducted "in the dry" to ensure that careful placement of the rock is accomplished so that the ramp would be sufficiently stable to withstand the wide range of flow conditions. River diversions and dewatering would be needed which would increase costs.

4. The source of rock for the ramp had not been well-defined previously. Local rock sources would likely not have acceptable qualities for use in the ramp. Cost estimates to import rock from suitable sources would likely involve long haul distances. Hauling rock from distant sources would significantly increase costs.

As a result of this information it appeared that the estimated cost of the rock ramp could approach $90 million. The Corps and Reclamation, in coordination with the Service, considered the implications of this new information in early 2011. Under authority of the Water Resources Development Act of 2007 (WRDA 2007) and consistent with the joint agency decision in April 2010, the Corps had committed up to $40 million in Missouri River Recovery Program funding to the entire dam modification project. The potentially significant increase in the cost of the rock ramp, combined with the design and constructability issues described above, led the lead agencies to reconsider the decision to implement the rock ramp alternative for fish passage. In April 2011, the lead agencies determined that further evaluation of other alternatives for improving fish passage was needed to address the new/additional information and issues that had arisen since 2010. In addition to new cost information, new information regarding pallid sturgeon behavior also became available. Originally, because of uncertainties in pallid sturgeon movement, one of the requirements of the BRT's passage criteria was full river width passage. Since the long low gradient alternative, a previous version of the bypass channel, would not meet this criterion it was not carried forward in earlier analysis. Based on new technical information documenting pallid sturgeon use of side channels (McElroy et. al., 2012; Service, 2012), the BRT relaxed this criterion in 2011. The lead agencies believed there was merit in revisiting a bypass alternative that was previously considered but eliminated from detailed study. Through collaborative efforts, further information, and preliminary design reviews, the lead agencies and stakeholders supported further analysis of a bypass alternative. Changes to the project were substantive enough to trigger preparation of supplemental NEPA[9] prior to a joint lead agency decision regarding how to proceed with the fish passage portion of the project.

[9] 40 CFR 1502.9(c)

Reclamation, the Corps and the Service remain committed to improving fish passage. All three agencies believe it is prudent to revisit both the rock ramp design and other fish passage alternatives, especially a bypass channel alternative, to determine if there are ways to significantly reduce the cost and improve fish passage. See Appendix A.1 for a detailed description of all alternatives considered.

## 1.5. Nature of Decisions to be Made

Reclamation and the Corps will make the decision whether to proceed with the proposed federal action in a FONSI upon completion of this supplemental EA, in conjunction with the 2010 EA and other information, provided no significant issues are identified in the final supplemental EA. News releases and public service announcements will be distributed to the media announcing the availability of the FONSI. The document will be available on the Omaha District's public web site, and copies will be available upon request.

## 1.6. Purpose and Scope of the Supplemental EA

The purpose of the supplemental EA is to comply with NEPA and assist the agencies in determining whether the proposed action for improving fish passage, would have a significant impact on the human environment. If significant impacts are identified in the supplemental EA, then an EIS would be prepared. This document will also be used to inform decision makers and the public of proposed actions, reasonable alternatives considered, and their environmental impacts before final decisions are made. The supplemental EA addresses the key issues of pallid sturgeon protection and recovery, examines alternatives for fish passage, and evaluates the environmental impacts of each of the fish passage alternatives.

The scope of this supplemental EA is to identify, evaluate and address changes in the proposed action related to improving fish passage since completion of the 2010 EA; evaluate the effects of any new alternative(s) considered in detail in the supplemental EA, and disclose the direct, indirect and cumulative effects of the changes that are relevant to improving fish passage. It also describes minor clarifications of information that have become available since the 2010 EA.

## 1.7. Scoping, Issues and Public Involvement

The issues and resources potentially affected by and relevant to providing improved fish passage are similar to those identified during the scoping for the 2010 EA. Scoping for this supplemental EA identified the following issues and resources as being the most relevant to providing fish passage.

Aquatic communities
Federally listed species
Historic properties
Lands and vegetation
Geomorphology
Recreation
Social and economic conditions
Surface water quality
Wildlife

The affected environment (Chapter 3) and environmental consequences (Chapter 4) in this supplemental EA focus primarily on how changes in the proposed action for improving fish passage result in changes in potential effects. Reclamation and the Corps intend to conduct public involvement activities similar to what was done for the 2010 EA. A draft supplemental EA will be distributed for public review and comment prior to preparation of a final supplemental EA. Public meetings will be held to describe the proposed action and its effects and to receive public comments on the proposed action. Agency responses to comments received on the draft document will be included with the final supplemental EA. Partner agencies, including the Service, Montana Fish, Wildlife & Parks (MFWP), and Montana Department of Natural Resources (DNRC) reviewed the preliminary draft supplemental EA prior to its release to the public. A table of agency responses to their comments is located in Appendix L.

# 2. Alternatives

## 2.1. Introduction

This chapter describes alternatives developed to meet the purpose and need of the proposed action. Because entrainment protection has been achieved through the construction and operation of the new headworks and fish screens, the alternatives described in this chapter are limited to those that will improve fish passage in conjunction with the new facilities in place. The alternatives included for analysis are No Action, Bypass Channel and Rock Ramp. A thorough listing of history and detail regarding alternatives that were considered but not analyzed in detail is described in Appendix A.1 and a brief summary is provided later in this chapter. The costs of the alternatives described below are in 2012 dollars.

## 2.2. No Action (Continue Present Operation)

This alternative best fits the definition of a "no action" alternative described in the CEQ and Department of the Interior regulations (43 CFR 46.30). In this case, Reclamation would continue present operation of the dam and headworks to divert water from the Yellowstone River for irrigation purposes, as authorized. Under this scenario it is likely that Reclamation would be obligated to continue consultation with the Service under Section 7(a)(2) of the ESA, with fish passage being a requirement at Intake Diversion Dam. However, for purposes of the analysis contained in the 2010 EA, and further analysis conducted herein, the future without project condition consists of continued operation of Intake Diversion Dam without modification for improved fish passage. This no action provides a baseline from which to measure benefits and impacts of implementing fish passage improvement alternatives considered in this document.

Reclamation and the Corps selected the on-river headworks and associated removable rotating drum fish screens during the 2010 EA/FONSI process. Construction of the entrainment protection project began in the fall of 2010 and was completed and put into operation in April of 2012.

The new headworks structure (shown in Figure 2-1 with fish screens down) controls diversions of water into the canal and includes 12 removable rotating drum screens located in the river to minimize fish entrainment. The headworks structure supporting the screens measures 310 feet. Because screen design criteria specific to pallid sturgeon are lacking, the fish screens were constructed to meet salmonid criteria established by the Service and National Marine Fisheries Service. Each drum screen measures approximately 6.5 feet in diameter and 25.2 feet in length. Maximum approach velocity in front of the screen is designed at 0.4 feet per second, which will provide an even velocity distribution across the rotating screens. Water gravity flows through the cylindrical screens from the lower half of the water column, through the gates and into the canal.

**Figure 2-1. New headworks and fish screens at Intake Dam with screens submerged**

The removable rotating drums allow each screen unit to be adjusted on a track and be raised above the river when not in use to minimize damage from ice and debris flows. The screen cylinders rotate against fixed brushes to clean and remove debris that could impede flow through the screen and to remove fish and other aquatic organisms potentially impinged on the screens.

Under this No Action Alternative, it is assumed that rock would continue to be added to the existing timber crib diversion structure as needed to create the necessary water elevation for diversion of 1,374 cubic feet per second (cfs), acknowledging that authorization from the Corps of Engineers under Section 10 of the Rivers and Harbors Act would be required for this activity in the future. The top of the existing timber crib weir is at elevation 1,988 feet North American Vertical Datum of 1988 (NAVD 88).

The primary features of this alternative (see Figure 2-2) include the continued operation, maintenance and repair of the existing diversion dam and new screened headworks by the Lower Yellowstone Irrigation Project Joint Board (LYIP) of Control, as Reclamation’s authorized agent under the O&M transfer and repayment contracts Ilr-103 and Ilr-104. This would include the annual placement of 1-2 feet of rock on the crest of the dam, using the existing cableway, to replace rock moved by ice and high flow events. The trolley system is old and there is continual risk of failure, which would require repair /replacement by the LYIP in order to maintain required water surface elevations. Additionally, the operation and maintenance of the screened headworks, will occur as described in the original EA and in the Service concurrence letter dated March 7, 2012, to effectively minimize entrainment of fish from the Yellowstone River. Reclamation and the LYIP would most likely need to amend the existing O&M transfer contract to address operation and maintenance of the new headworks.

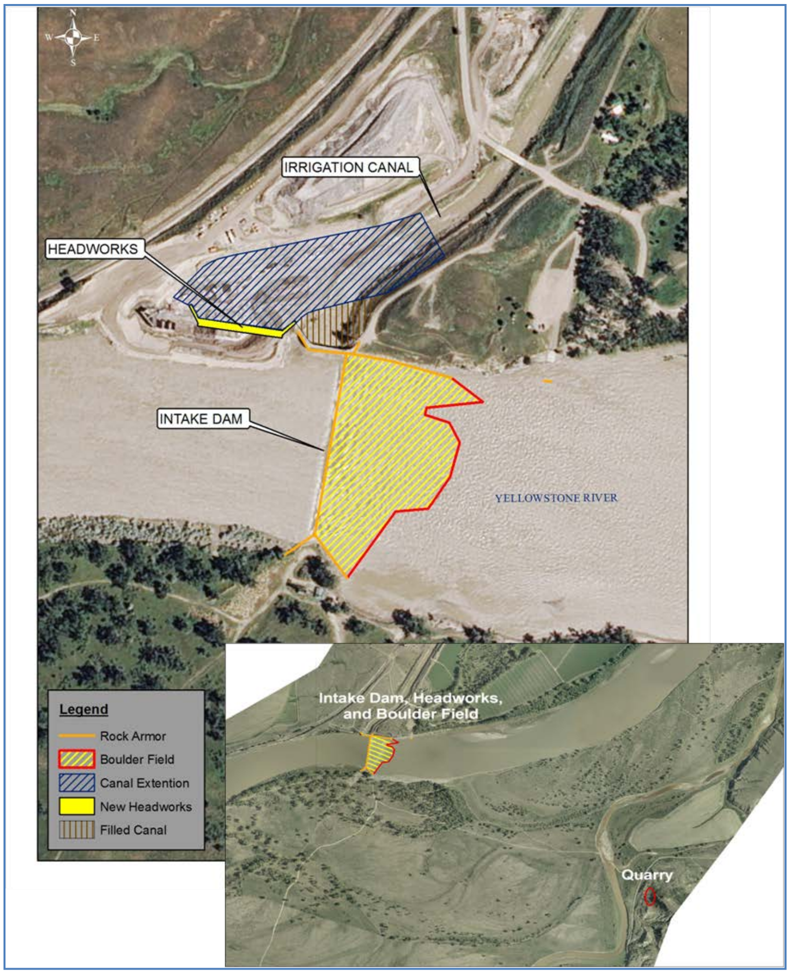


**Figure 2-2. No action alternative**

The annualized cost estimate for O&M of the existing diversion dam, newly constructed headworks and first mile of the canal is approximately $253,000, including: $121,000 for rock placement on the diversion dam; $92,000 for the headworks, $2,000 for the main canal, and $38,000 for diversion dam timber crib rehabilitation. Both the main canal and the dam would be repaired every 12 years on average.

The LYIP is responsible for diversion dam, headworks and canal O&M costs consistent with the authorizing legislation (Reclamation Act of June 17,1902, as amended; Water Conservation and Utilization Act of August 11, 1939, as amended), the current O&M contract between Reclamation and the LYIP, and Reclamation policy.

## 2.3. Bypass Channel Alternative (Preferred)

This alternative is intended to improve passage for pallid sturgeon around Intake Diversion Dam by means of a bypass channel. This alternative was originally conceived during the Value Planning Study process conducted by Reclamation and others (Reclamation, 2005) and was referred to as the long low gradient channel alternative. It was originally envisioned to take advantage of an existing side channel as a fish bypass. However, the use of the existing side channel in its entirety was not deemed feasible for fish passage due to fish attraction issues associated with the side channel's downstream entrance being nearly a mile downstream of the dam. In light of this fact, this initial concept recognized the need for such an alternative to place the entrance closer to Intake Diversion Dam. As such, one of the primary features of this current alternative would be the construction of a bypass channel from the upper end of the existing side channel, to just downstream of the existing diversion dam and associated rubble field. By locating the fish entrance to the bypass channel at the downstream end of the dam, fish are thought to be more likely to find the bypass channel and utilize it in their movement upstream. A concrete weir would be constructed in order to provide adequate water surface elevations for water diversion into the new bypass channel and delivery of irrigation water. The bypass channel is intended to improve fish passage and contribute to ecosystem restoration.

Features of this alternative would be located primarily on Joe's Island. This land was acquired by Reclamation during construction of the original Intake project and is still administered by Reclamation. All construction, staging and disposal would occur on Reclamation lands.

A primary feature of this alternative would be the construction of a bypass channel to divert approximately 15% of total river flows (see Figure 2-3). While the channel will typically divert 15% of the total flow from the main channel during typical spring and summer discharges, diversion percentages would vary from 10% at extreme low flows on the Yellowstone River to 17% at extreme high flows as indicated in Appendix A2 ((Engineering), Attachment 6, Appendix B, Table 3). This would require the excavation of approximately 1.2 million cubic yards of earthen material from Joe's Island as shown in figure 2.3. The proposed bypass channel alignment extends approximately 15,500 feet in length at a slope of approximately 0.0006 feet/feet (natural Yellowstone River slope is approximately 0.0004feet/feet to 0.0007 feet/feet). The channel cross section would have a bottom width of 40 feet, a top width of 150-250 feet, and side slopes varying from 1V:12H to 1V:3H. The upstream third of the channel is on the same alignment as the existing high flow chute.

The excavation would be accomplished by using scrapers for soils located above the water table and using large backhoes and trucks for materials below the water table. Initially a small pilot ditch would be excavated along the length of the new channel alignment. The excavation for the four rock structures would then be performed. Water encountered during this excavation would be pumped into the pilot ditch, where it would gravity flow to the river. Following completion of the rock structures, the remainder of the channel would be excavated and disposed of in the spoil area located on the south side of the new channel. The spoil pile would be approximately 60 acres in size and reach a height of approximately 12 feet and would be located outside the 100-year floodplain (Figure 2.4). Specific traffic and fill plans will be designed to avoid infilling of existing drainage ways within the waste pile area.

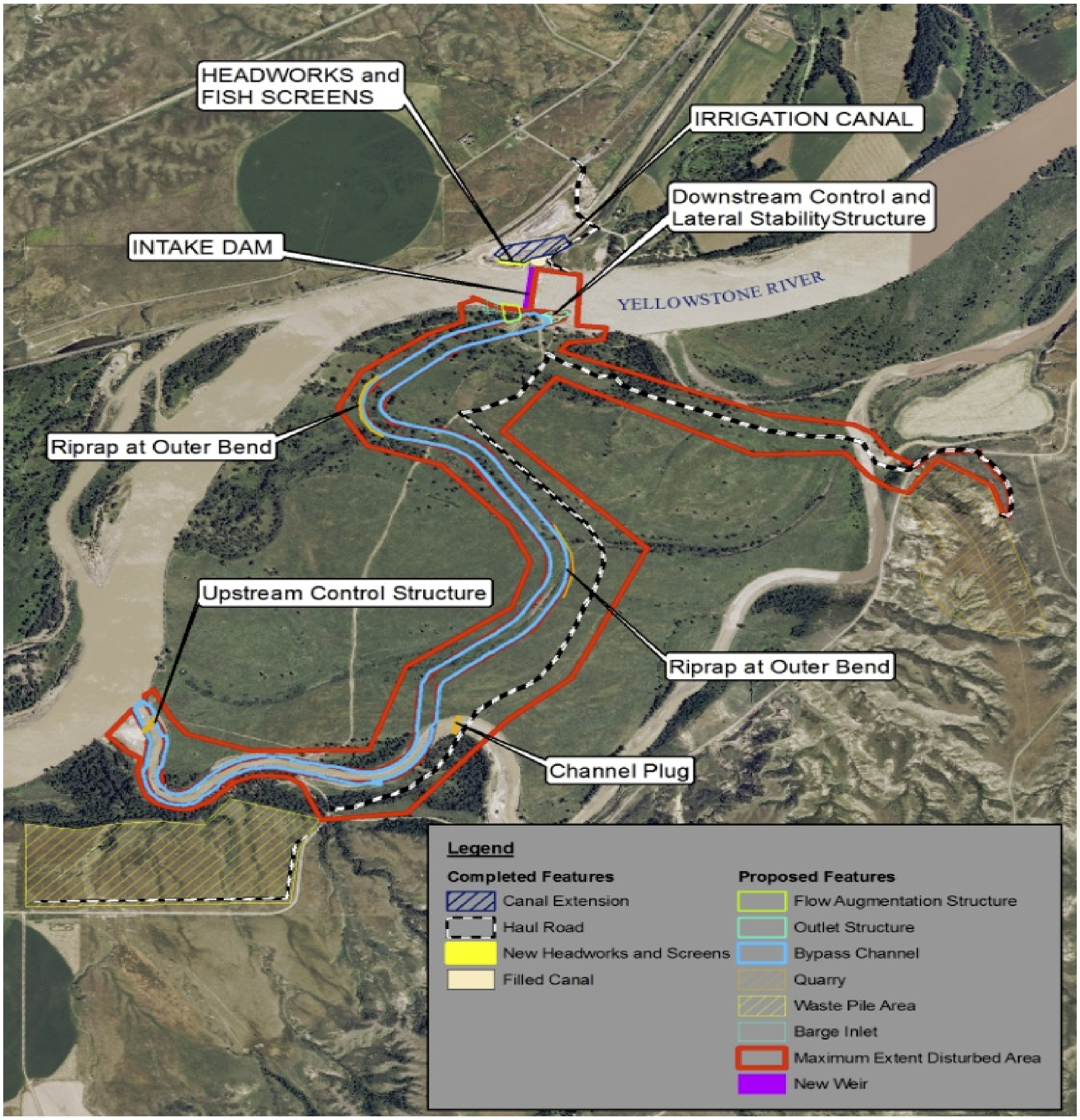


**Figure 2-3. Bypass channel alternative**

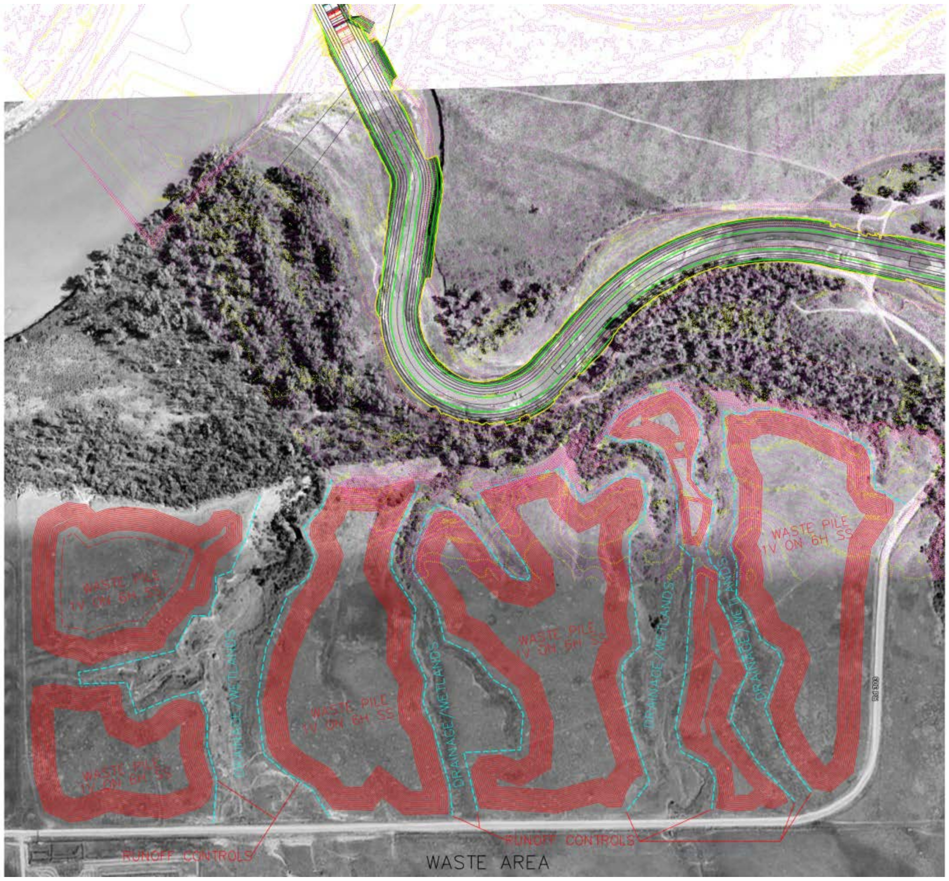


**Figure 2-4. Waste area**

This work would be protected by a cofferdam at the upstream entrance and downstream exit of the proposed bypass channel, which would be constructed early in the construction sequence. The cofferdams will consist of sheet piles driven below grade into the large alluvium material to prevent under seepage.

Grade control structures are included at the downstream (Figure 2-5) and upstream (Figure 2-6) ends of the bypass channel as well as at two intermediate locations to prevent excessive degradation that would impact passage success. The upstream end includes a 60-foot wide by 30-foot long (upstream to downstream) by 6-foot thick concrete sill necessary to prevent ice damage while the remaining grade control structures consist of riprap.

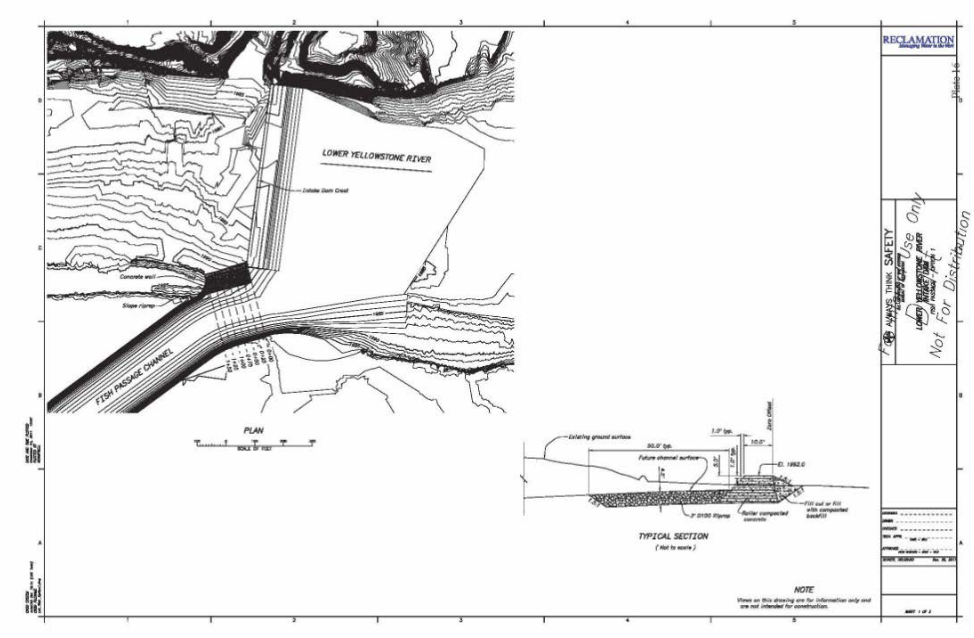


**Figure 2-5. Downstream grade control structure**

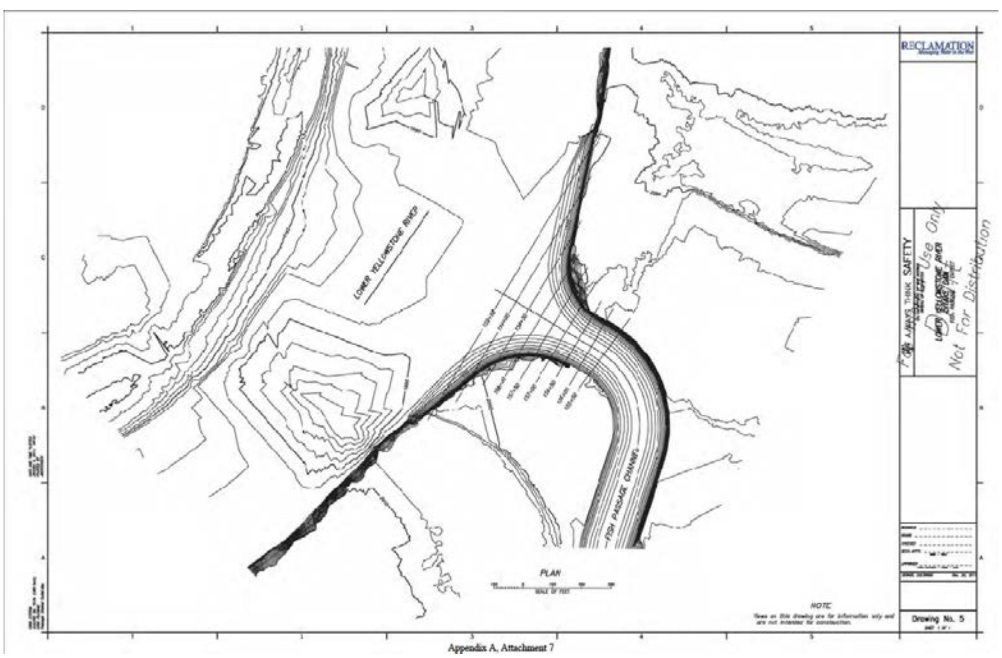


**Figure 2-6. Upstream grade control structure**

Two vertical control structures (riprap sills) are proposed for maintaining channel slope and allowing for early identification of channel movement (Figure 2.7). Similar to the upstream control structure, these would be over-excavated and backfilled with natural river rock to give the appearance of a seamless channel invert while providing stability during extreme events. A riprap sill is also proposed for the downstream end of the channel to maintain channel elevations.

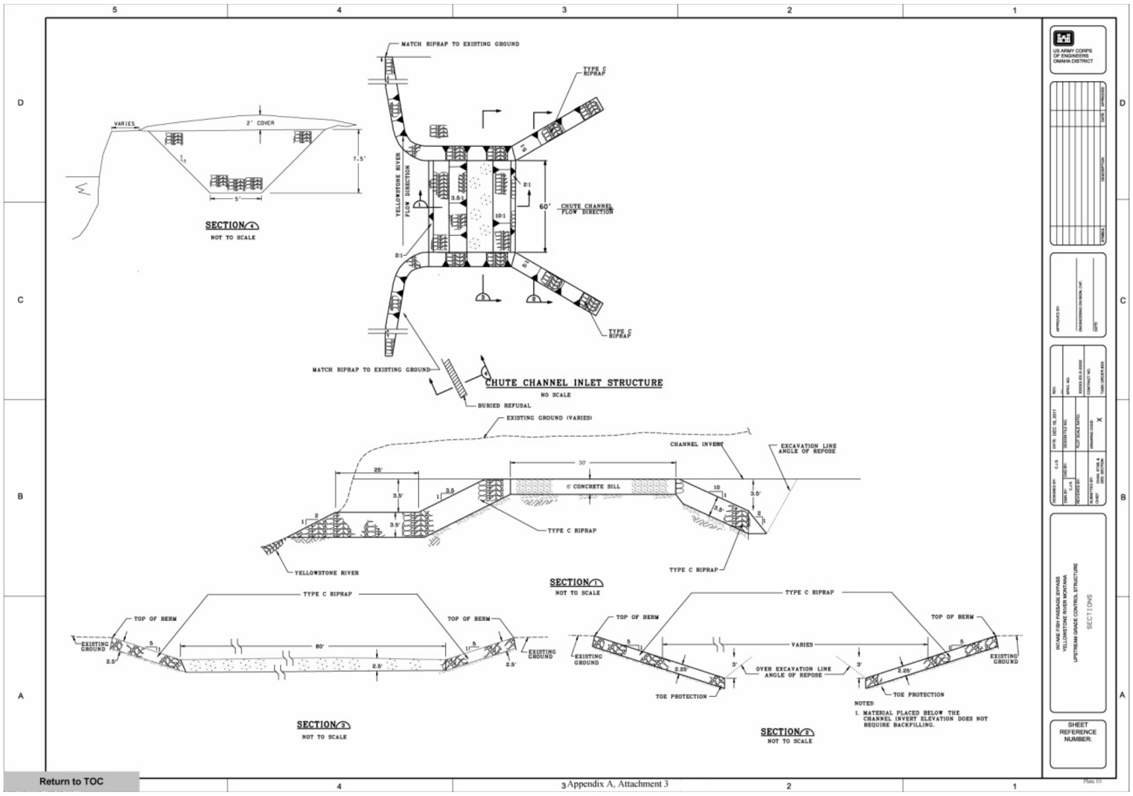


**Figure 2-7. Vertical control structures**

Additionally, bank riprap is proposed at two outside bends identified as having higher potential for failure to minimize the risk of losing the bypass channel planform. It was assumed that the portion of the historic high flow chute used for the bypass will be stable. It is possible that additional protection could be required in the future if assumptions about channel stability are proven incorrect and excessive channel migration or degradation begins to impact passage effectiveness. Approximately 65,000 tons of riprap would be required for the bypass channel.

Current modeling efforts indicate a degradational trend within the bypass channel. Modeling also shows that an increase in size of bypass bed material minimizes the expected degradation; therefore construction of an armor layer is proposed. The armor layer would consist of large gravel to cobbles, similar in size to the naturally occurring course channel material found on Yellowstone River point and mid-channel bars and similar to what would be expected to occur naturally over time. Approximately 64,000 tons of armor layer material (15,500 linear feet by 90-feet wide by 9-inch layer thickness) would be screened from the alluvial material excavated from the bypass channel and placed in the channel bottom to achieve final design grade.

Diversion of flow from the existing high flow channel into the constructed bypass channel will be facilitated by a channel diversion constructed approximately 1 mile downstream from the upstream end of the bypass. The conceptual design of the channel diversion would include a culvert sized to minimize impacts to fish passage in the existing high flow channel. The culvert would maintain a minimal amount of flow to the existing high flow channel and would be designed for overtopping during high flow events to take advantage of the high flow channel's current functionality and to reduce stress on the new channel.  The culvert would be covered in riprap to maintain stability and resist erosion (see Figure 2-8).

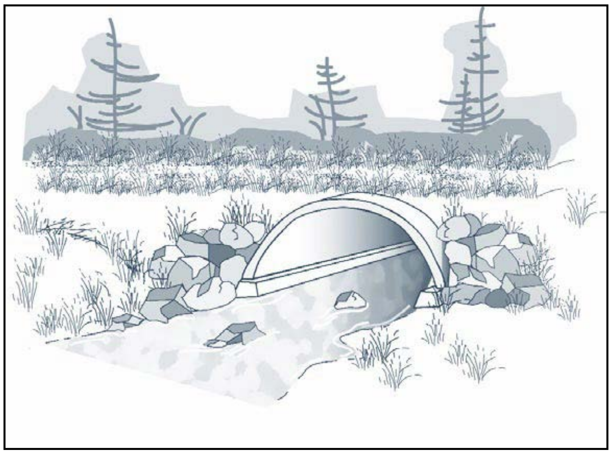

**Figure 2-8.  Channel diversion conceptual design**

The various bypass alignments were developed based on length required to obtain the desired channel slope as well as to minimize excavation quantities.  Four alignments are shown in Figure 2.9.

Alignments 1 and 3 have similar lengths (≈15,500 feet) and Alignment 2 is slightly shorter (≈13,500 feet).  Alignment 3 was developed to maximize the use of historic channel scars and swales following a site visit in August 2011 and supersedes Alignment 1.  Alignment 4 is 1.5 times longer than Alignment 3, representing a slope of 0.0004 feet/feet vs. the 0.0006 feet/feet slope of Alignment 3.  Alignments 1 and 2 are shown only because they were discussed in the original concept evaluation (April 2011).  The longest, Alignment 4, was only recently considered based on comments from the BRT pertaining to the pallid sturgeon’s preferred substrate and the natural armor layer that would be expected to develop for the flatter slope.

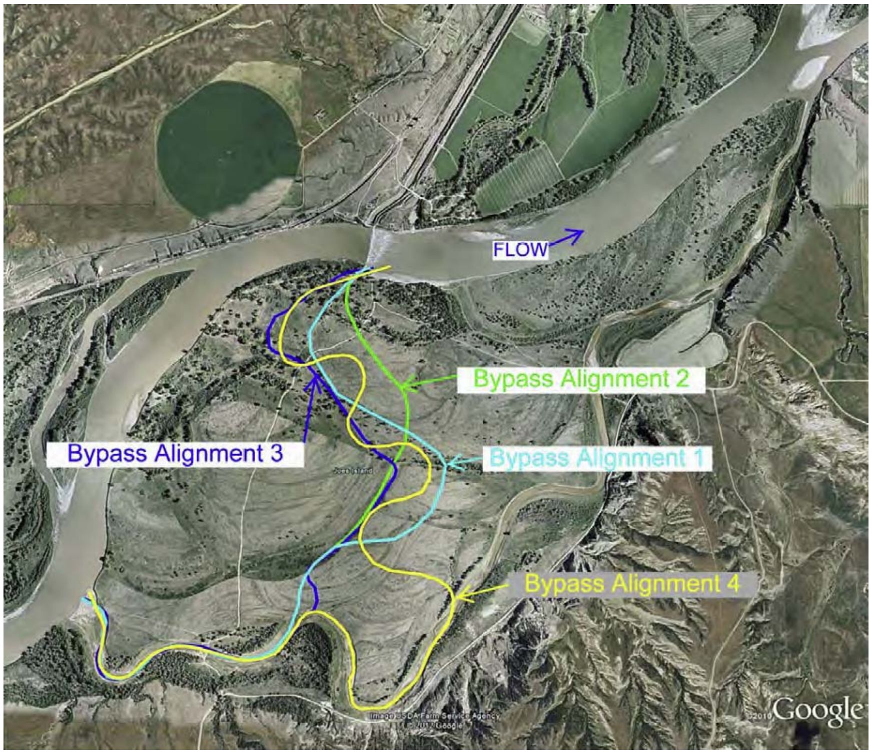

**Figure 2-9. Bypass channel alignments**

Hydraulic modeling was completed to evaluate the alternative alignments and channel cross section configurations. The proposed channel configuration, based on input from the Biological Review Team (BRT), utilizes Alignment 3. Channel depth ranges from 3-5 feet on the upstream end to nearly 20 feet towards the downstream end. The resultant flow split is approximately 15% of total Yellowstone River flows. Analysis of the flows splits is shown in Table 2-1.

The rock riprap needed during construction would be purchased from commercial sources. A new, raised concrete weir is proposed just upstream from the existing rock weir at elevation 1990.5 feet (NAVD 88) in order to provide sufficient water surface elevations to divert the appropriate flows through the bypass channel and maintain irrigation diversion. Construction of a new concrete weir would eliminate the need to repeatedly place rock along the crest of the existing dam in order to maintain head requirements for both the bypass channel and the new headworks. While head requirements could be met through yearly rock placement, a permanent structure provides for long-term sustainability of flows into the bypass channel. It also eliminates the concern as to whether continued displacement of rock from the crest of the dam by ice flows could adversely affect the entrance to the bypass channel. The new river-wide concrete weir would be constructed approximately 40 feet upstream of the existing dam (Figure 2.10).

**Table 2-1. Bypass channel flow splits and configurations**

| Recurrence interval (annual, post-Yellowtail flows) | Total Yellowstone River discharge | **BASE** (existing right bank chute assuming new headworks with existing dam) | | **10% Diversion** | | **15% Diversion** | | **30% Diversion** | | **Long Alignment** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flow Splits for Base and Alternatives | | | | | | | | | |
| | (cfs) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) |
| <2-yr | 3000 | 0 | 0 | 220 | 7 | 310 | 10 | 890 | 30 | 273 | 9 |
| <2-yr | 7000 | 0 | 0 | 650 | 9 | 860 | 12 | 2220 | 32 | 755 | 11 |
| <2-yr | 15000 | 0 | 0 | 1550 | 10 | 2140 | 14 | 4770 | 32 | 1897 | 13 |
| <2-yr | 30000 | 790 | 3 | 3220 | 11 | 4510 | 15 | 9290 | 31 | 4019 | 13 |
| 2-yr | 45300 | 2280 | 5 | 5180 | 11 | 7170 | 16 | 13720 | 30 | 6417 | 14 |
| 5-yr | 60600 | 4050 | 7 | 7340 | 12 | 9900 | 16 | 18130 | 30 | 8937 | 15 |
| 10-yr | 70100 | 5220 | 7 | 8770 | 13 | 11690 | 17 | 20780 | 30 | 10558 | 15 |
| 20-yr | 78700 | 6090 | 8 | 9990 | 13 | 13210 | 17 | 23240 | 30 | 11919 | 15 |
| 50-yr | 89400 | 7280 | 8 | 11540 | 13 | 14940 | 17 | 26260 | 29 | 13534 | 15 |
| 100-yr | 97200 | 8090 | 8 | 12650 | 13 | 16280 | 17 | 28170 | 29 | 14815 | 15 |
| 500-yr | 114000 | 9920 | 9 | 15570 | 14 | 19290 | 17 | 32490 | 29 | 17760 | 16 |

Pertinent Bypass Channel Parameters

| | 10% Diversion | 15% Diversion | 30% Diversion | Long Alignment |
|---|---|---|---|---|
| Alignment | 3 | 3 | 3 | 4 |
| Bypass Channel Length (ft) | 15500 | 15500 | 15500 | 23250 |
| Bypass Channel Longitudinal Slope | 0.00060 | 0.00060 | 0.00060 | 0.00040 |
| Bypass Channel Bottom Width | 20 | 40 | 200 | 40 |
| Bypass Channel Side Slopes | Vary from 1V:12H to 1V:3H | | | |
| Approximate Excavation Quantity (cubic yards) | 800,000 | 1,200,000 | 2,600,000 | 1,700,000 |

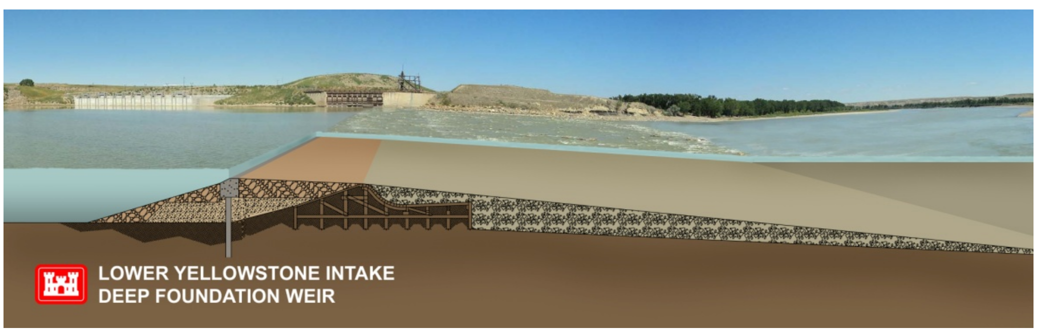


**Figure 2-10. Weir rendering**

The weir structure would consist of a cantilevered structural wall created by a deep foundation of either driven piles or drilled shafts with a concrete cap. Because of the river water level, if drilled shafts were used, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The piles or shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around them, and for purposes of retaining wall design, a bridge between them. The top of the structure would be a reinforced concrete cap to protect it and allow for a smooth crest surface for ice to pass over. Fill would be placed between the downstream side of the crest and the existing weir. Fill would also be placed upstream of the new weir structure and sloped to include rock protection. The weir crest may include at least one low-flow channel for fish passage. This would offer an array of depth-velocity habitat zones for fish migration under a wide range of flows, which are typical on the lower Yellowstone River. The channel(s) in the weir crest would be designed to provide fish passage during late summer and early fall low flows. It is likely that some maintenance of the rock field between the old and new weirs would be necessary over the long term. However, the riprap placed between weirs would not be subject to the same level of displacement experienced with the current weir since it will not be subject to direct impact from ice flows. An access road would be constructed along the north side of the river to allow access for heavy equipment during construction. Following completion, the road may be left in place for long-term O&M use. Existing access roads to Joe’s Island would be improved as needed to allow access. Access by motor vehicle across the newly constructed bypass channel would be limited at most flows. For major O&M actions, temporary access would need to be built, work would have to be done when the chute is iced-over, or equipment would need to be brought in by way of boat or barge.

Construction of this alternative would likely take two to three years depending on funding. The preliminary cost estimate is $58.9 million, which includes: $21.2 million to excavate the bypass channel; $13.6 million for bank stabilization; $11.0 million for the concrete weir; and $6.2 million for adaptive management and monitoring. The remaining $6.9 million would include planning, engineering, design and construction management. Cost savings could occur if sufficient funding were made available to construct the project in one year. The preliminary cost estimate for O&M for the Bypass Channel Alternative would be $140,000 annually, including approximately $10,000 for repairs to concrete weir, $57,000 for bypass channel (including rock replacement), $10,000 for sediment removal in front of headworks, $2,000 for the main canal and $61,000 in administrative costs. Annual O&M of the newly constructed headworks and fish screens is approximately $92,000.00, therefore annual O&M for Phase I (entrainment protection) and Phase II (fish passage) of the project would be approximately $232,000.

Reclamation and the LYIP would most likely need to amend the existing O&M transfer contract to address operation and maintenance of the new headworks and bypass channel consistent with the authorizing legislation (Reclamation Act of June 17,1902, as amended; Water Conservation and Utilization Act of August 11, 1939, as amended) and Reclamation policy. Funding responsibility for O&M, monitoring, and any necessary adaptive management measures would depend on a number of factors including applicable laws, regulations, and policies; opportunities for cooperative funding; the nature of the activity; and likely other factors specific to a given O&M, monitoring or adaptive management measure.

## 2.4. Rock Ramp Alternative

The primary feature of this alternative would be replacement of the existing rock and timber crib structure at Intake Diversion Dam with a concrete weir and a shallow-sloped, un-grouted boulder and cobble rock ramp. The rock ramp would be designed to mimic natural river function and would lower velocities and turbulence so that migrating fish could pass over the dam, thereby improving fish passage and contribution to ecosystem restoration.

The replacement concrete weir would be located downstream of the new headworks to create sufficient water height to divert 1,374 cfs into the main canal. This concrete weir would replace the existing timber and rock-filled dam providing long-term durability lacking in the current structure. The concrete weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream, sloping face of the concrete weir would be designed to withstand damage from blocks of ice moving up and over the dam in the spring. The historic headworks have been preserved in place and would serve as a weir abutment on the north (left) bank of the river, while a new concrete weir abutment would be constructed on the south (right) bank at the lateral extent of the new weir. It would anchor into adjacent ground (see Figure 2-11). The weir crest would vary in elevation, including at least one low-flow channel for fish passage. The variable crest would offer an array of depth-velocity habitat zones for fish migration under a wide range of flows, which are typical on the lower Yellowstone River. The channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1 - 2 feet deep. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

A rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp, followed by placement of rock riprap. The ramp would be constructed to provide flow characteristics consistent with BRT criteria for pallid sturgeon, so the endangered fish would have improved access to habitat upstream of the weir. A wide range of slopes have been evaluated to simulate performance and predict reliability of fish passage, as shown in Figure 2-12.

During optimization of a full width rock ramp alternative, hydraulic and physical modeling efforts focused primarily on meeting the swim criteria developed by the BRT as outlined in Appendix E. These criteria reflected the potential hydraulic needs of the pallid sturgeon to pass over the weir. Fourteen iterations of a rock ramp that spanned the width of the river were modeled. The first modeling effort used a 1-dimensional Hydrologic Engineering Center – River Analysis System (HEC-RAS) model to develop the initial configuration. Then a 2-dimensional ADH model was used to refine and optimize the preliminary design. The preliminary design, as presented in this amended EA, provides the best combination of depth and velocity results over a wide range of flow conditions. This conforms to the criteria set forth by the BRT while minimizing the footprint and fill in the river channel. Preliminary design refinement, which was on-going concurrent with the draft EA review, incorporated physical (1:20 scale) modeling of the diversion headworks and screens and the rock ramp.

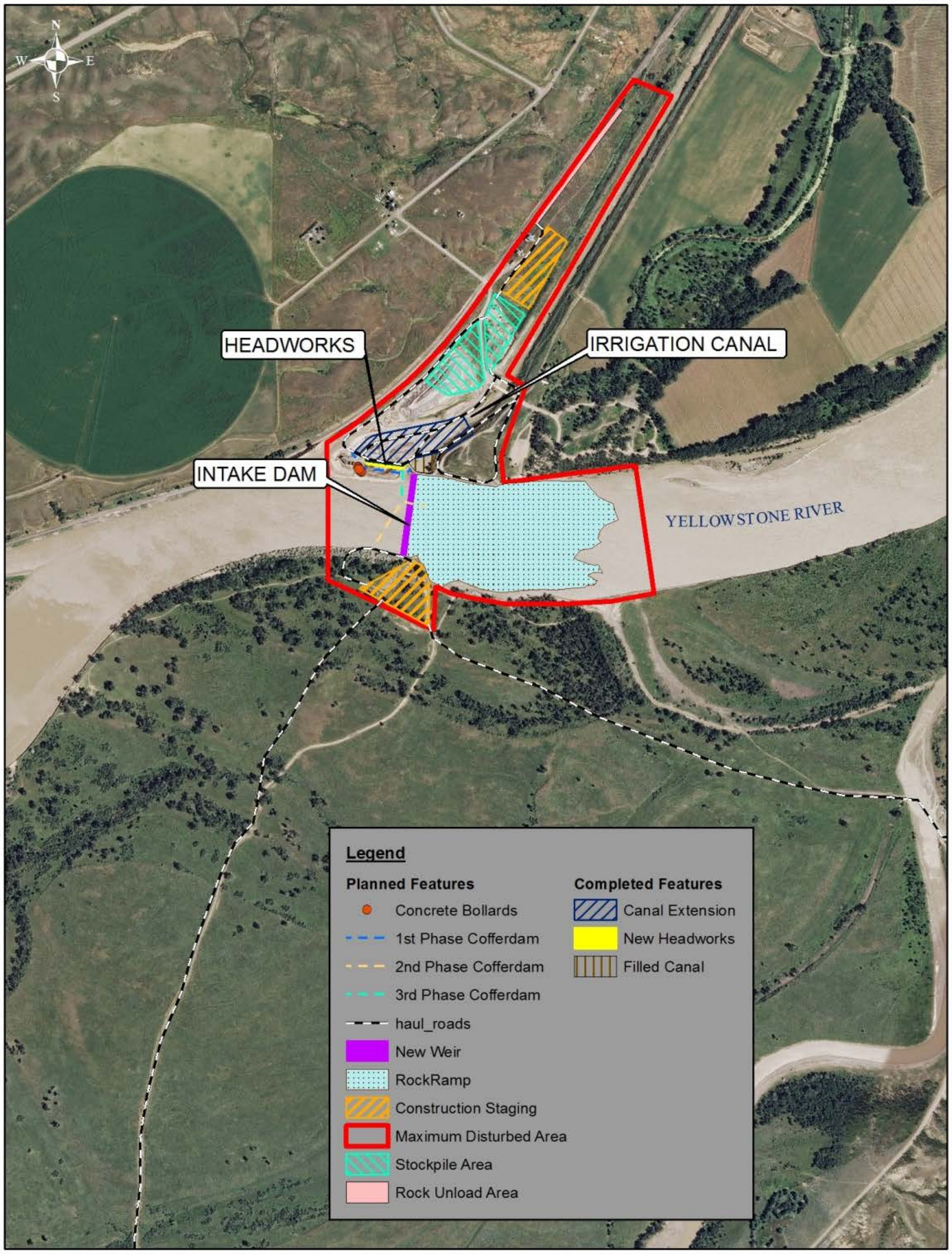


**Figure 2-11. Rock ramp alternative**

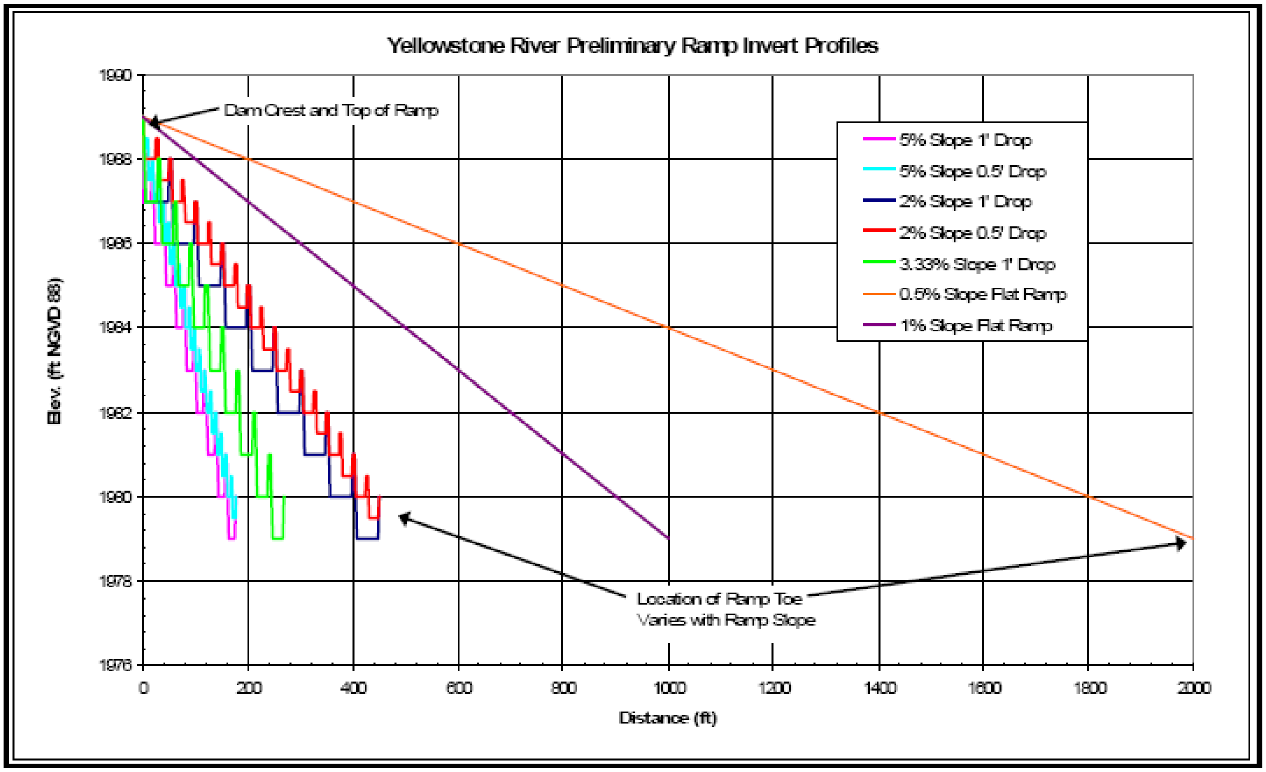


**Figure 2-12. Range of ramp slopes evaluated for the rock ramp alternative**

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat (approximately 0.4% slope) over much of its width to keep flow velocities as low as possible. For comparison purposes, the natural slope of the lower Yellowstone River varies, but typically ranges from between .05% - .065%. The final configuration of the rock ramp would be optimized for pallid sturgeon passage using ongoing computer modeling. If selected, the Service's BRT would be consulted during design of this alternative, including but not limited to reviewing results and making recommendations on hydraulic modeling and final alternative design.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. Because the existing dam's rock field has washed downstream, part of the existing dam crest might be removed and rock moved to accommodate construction of a ramp. The rock ramp would include at least one low flow channel in conjunction with the low flow channel on the crest, which would allow fish migration during low flows. The rocks in the ramp would be sized to withstand high flows and ice jams and would range from 1 - 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 450,000 tons of rock riprap and 75,000 tons of fill material would be needed to construct the ramp. The rock would be purchased from existing commercial quarries. Staging areas identified in the original EA would be used for storage of the rock, which would be transported by truck or rail depending upon the source.

A temporary crossing would be constructed across the current main canal to prevent damage to the existing county bridge from heavy equipment use. The new crossing would use six, 10-feet by 10-feet box culverts with sufficient width and length to bridge the existing canal.

Depending on funding, it is anticipated that the overall construction would take three years and be conducted in three primary phases. During the first year a concrete weir would be constructed on the south half of the river using similar methods to placement of the weir in the bypass alternative. In year two, a cofferdam would be constructed extending from the old headworks, across the end of the concrete weir and return to the north bank below the area of rock ramp placement to allow construction to occur in the dry. After the north half of the concrete weir is in place, rock ramp construction would begin working from the north bank across the river in parallel segments. Construction of the remainder of the rock ramp would be the final phase of this alternative. It would be completed by working incrementally across the river from the north bank building sections of the ramp.

The preliminary cost estimate is $80.0 million, which includes: $60.3 million for the rock ramp, $10.6 million for the concrete weir; and $3.9 million for adaptive management and monitoring. The remaining $5.2 million would include planning, engineering, design and construction management. The preliminary cost estimate for O&M for the rock ramp alternative would be $201,000 annually, including approximately $10,000 for repairs to concrete weir, $128,000 for rock ramp (including rock replacement), $2,000 for the main canal and $61,000 in administrative costs. Annual O&M of the newly constructed headworks and fish screens is approximately $92,000.00, therefore annual O&M for Phase I (entrainment protection) and Phase II (fish passage) of the project would be approximately $293,000.

Reclamation and the LYIP would most likely need to amend the existing O&M transfer contract to address operation and maintenance of the new headworks and rock ramp consistent with the authorizing legislation (Reclamation Act of June 17,1902, as amended; Water Conservation and Utilization Act of August 11, 1939, as amended) and Reclamation policy. Funding responsibility for O&M, monitoring, and any necessary adaptive management measures would depend on a number of factors including applicable laws, regulations, and policies. Reclamation intends to work cooperatively with the state of Montana and LYIP to identify funding resources for monitoring and adaptive management to avoid significant adverse financial or other impacts to the LYIP.

## 2.5. Identification of the Preferred Alternative

Reclamation and the Corps considered several factors in determining the preferred alternative for improving fish passage. The natural resources, social, and economic impacts of each of the alternatives were considered, along with the following specific factors:

### 2.5.1 Purpose and Need

Both the Rock Ramp and Bypass Channel Alternatives are designed to meet the purpose and need for the proposed action of improving fish passage. The No Action Alternative would not meet the purpose and need.

### 2.5.2 Fish Passage Analysis

A Fish Passage Connectivity Index (FPCI) was used to evaluate the fish passage effectiveness of the three alternatives (see Appendix E). The following findings were important considerations in determining the preferred alternative:

- The Rock Ramp and Bypass Channel Alternatives produced much higher connectivity index scores than the No Action Alternative.
- The Rock Ramp Alternative had a higher connectivity index score overall than the Bypass Channel Alternative for all species with much higher connectivity index scores for walleye and paddlefish (strong swimmers) and moderately higher connectivity index scores for weaker swimming sturgeon.
- The connectivity index does not account for turbulence or the need for fish to swim at near burst speed levels for the length of the rock ramp which are important considerations for pallid sturgeon. These factors likely reduce actual passage success of the rock ramp.
- The connectivity index also does not account well for the relative magnitude of attraction flows which is a concern for the Bypass Channel Alternative where fish must find the channel entrance. Attraction flows are not an issue for the Rock Ramp Alternative.

### 2.5.3 Constructability

Construction of the bypass channel is considered more straightforward than construction of a rock ramp which would require working in the river when there is water present, using a lengthy cofferdam to dewater half the river channel for work, or diverting the entire river flow during construction.

### 2.5.4 Ice Forces

The substantial river ice forces in the vicinity of Intake Dam (see Appendix A2, Attachment 1A) create uncertainty for the sustainability of the rock ramp. There does not appear to be precedence for providing ice protection for an entire river channel as needed for the rock ramp. This reduces confidence that the rock ramp design would withstand the substantial ice forces at Intake and makes determining a suitable design to withstand the ice forces uncertain. Designing and maintaining the bypass channel to withstand ice forces is more straightforward and there is higher confidence in these designs.

### 2.5.5 Cost Effectiveness

The analysis presented in Appendix E indicates that the Bypass Channel Alternative is more cost effective at meeting the purpose and need than the Rock Ramp Alternative.

### 2.5.6 Pallid Side Channel Use

There is increasing information about pallid sturgeon use of side channels during spawning migrations, but the information is incomplete. The percentage of river flow in the bypass channel and the complex flows at the downstream entrance to the bypass channel create uncertainty about the ability of pallid sturgeon to locate and enter the bypass channel. The rock ramp would presumably be easier for pallids to locate and access.

### 2.5.7 Risk and Uncertainty

Each action alternative has risks and uncertainties. Some of these are mentioned above. Risks and uncertainties with potential for a significant consequence, whether the probability is high, moderate or low, is of particular concern to the agencies.

The following are risks/uncertainties resulting in potentially significant consequences identified for the Bypass Channel Alternative:

- Attraction Flow – Inadequate attraction flow or attraction flows that are disrupted by eddies or sheer flows.
- Length of Bypass Channel – There is no evidence of pallids using side-channels the length of the proposed bypass channel.
- Bypass Channel Flooding – The bypass channel would be located on a flood plain submerged during high runoff events. This could result in large volumes of debris and/or sediment in the bypass channel, or structural damage, significantly reducing or eliminating passage.

The following are risks/uncertainties resulting in potentially significant consequences for the Rock Ramp Alternative:

- Ice Damage/High Flows – Ice and high flows have the potential to damage, dislodge, and move strategically placed rocks and boulders on the rock ramp creating undesirable water velocities and flows, and resulting in impaired or loss of pallid sturgeon passage.
- Rock Ramp Avoidance – The rock ramp would be designed and constructed using the best available scientific information, but pallids may not use it resulting in lack of fish passage.

Potential options to address some of the potential high consequence results, likely include:

- Attraction Flows – If pallids fail to enter the bypass channel, it may be difficult to determine the cause, but attraction flow would likely initially be considered a reason. Designs will continue to be developed to address the complex flows at the bypass entrance that may disrupt bypass channel attraction flows. Augmentation flows are another option to address attraction concerns.

- Flooding/Ice Damage/High Flows – If events significantly damage or impair the bypass channel or rock ramp, reconstruction and repair would be necessary for continued compliance with ESA.
- Length of Bypass Channel/Rock Ramp Avoidance – If pallids fail to use the bypass channel or rock ramp, it may be difficult to determine the cause. Solutions may involve evaluating and implementing entirely new alternatives for fish passage to achieve compliance with ESA.

### 2.5.8 Preferred Alternative

There are no resource impacts that distinguish the Bypass Channel or Rock Ramp Alternative as having a distinct advantage over the other. The agencies believe that the more straight-forward construction, ability to withstand ice forces, and cost effectiveness advantages of the Bypass Channel lead to a preference over the Rock Ramp Alternative. As such, the Bypass Channel Alternative is Reclamation's and the Corps' preferred alternative.

## 2.6. Alternatives Considered but Not Analyzed in Detail

Appendix A.1 (Plan Formation) contains detailed information about alternative development for the 2010 EA as well as information related to alternative development for this Supplemental EA. A number of alternatives have been considered during the course of this project. Design improvements and alternatives continue to be assessed through project design processes, such as value engineering studies and the recent re-planning effort that was undertaken by Reclamation in July of 2013. Scoping comments on the Supplemental EA from cooperating agencies and others also identified a number of previously considered alternatives, as well as a few variations of alternatives.

### 2.6.1 Relocated Diversion Upstream Alternative

Construction of a new facility, including excavation of an additional canal, acquisition of real estate, working with the railroad, and other issues in combination with a rock ramp redundant to the Rock Ramp Alternative eliminated this alternative from further consideration.

### 2.6.2 Single Pumping Plant Alternative

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir to raise and divert water during low flow. Because the new dam/weir would be a fish passage impediment similar to the existing dam, a rock ramp would be needed to provide fish passage over it, making this alternative redundant with the Rock Ramp Alternative.

### 2.6.3 Multiple Pumping Stations Alternative

Because the irrigation canal system was designed for gravity flow of water primarily from a single water source at Intake, this alternative would require some restructuring of the lower Yellowstone Project canal system to accommodate a water supply from multiple points along the canal. Preliminary construction costs and annual O&M costs were both estimated to be greater than the Single Pumping Plant Alternative. Annual O&M costs associated with this alternative would be a substantial increase over the cost of the current water delivery system and most likely beyond the capacity of the irrigation districts (see Chapter 4, Social and Economic Conditions section). The O&M of this alternative would exceed all the other alternatives, as it would have the additional requirements of maintaining and operating new check structures in the main canal, increased sediment removal in the main canal, maintaining access roads to each pump site, removing sediment in the inlet channels from the river to the pumping stations, as well as from the sediment traps, maintaining pumps and pump motors, maintaining rock jetties in the river, and paying power costs. Power costs would be expected to be much greater than the Single Pumping Plant Alternative, which was estimated to be $315,000 per year.

### 2.6.4 Infiltration Gallery Alternative

Removing Intake Diversion Dam and constructing an infiltration gallery was eliminated from further consideration, because this alternative would require at least one and most likely multiple pumping plants, which makes it redundant with the Single Pumping Plant Alternative. In addition, the same reasons for eliminating the Single Pumping Plant Alternative would apply to the Infiltration Gallery Alternative. For example, power demand would be as high as or higher than the Single Pumping Plant Alternative, but unlike the Single Pumping Plant, back-flushing would also be required. Its only advantage over the Single Pumping Plant Alternative would be elimination of fish screens in a new headworks; however, excavation and construction of the infiltration gallery likely would be as costly and would disturb much more river channel than the Single Pumping Plant Alternative.

### 2.6.5 Relocated Main Channel Alternative

Relocating the main channel was an alternative considered in detail in the 2010 EA. The cost estimate for this alternative was $50 million, however many of the cost increases that were found in the earlier rock ramp alternative would apply here as well, therefore the cost estimate is expected to be considerably higher. Due to logistical incompatibility with Phase I of the project, which has already been constructed, this alternative has been eliminated from further detailed consideration and an updated cost estimate was not conducted.

### 2.6.6 Open Channel with Multiple Ranney Wells Alternative

This alternative was dropped because of the high cost to install the Ranney Well System and the high energy costs that would be placed upon the district. Concerns with service reliability, brownouts and power outages were also discussed. These issues could cause disruption in canal flows and affect operation of the whole system. It was determined that there were cheaper, potentially more effective alternatives remaining.

### 2.6.7 Rock Ramp with Reduced Weir Elevation Alternative

The lower ramp elevation was to help improve fish passage success at the same time reducing the cost of construction. Analysis was done at such a low level, engineers could not confidently say what impacts a lower rock ramp and weir elevation would have on fish passage as it pertained to velocities. Significant cost savings were not achieved in the preliminary estimate for this alternative.

### 2.6.8 Combination Rock Ramp and Weir Alternative

This alternative was dropped because it was very comparable in cost to the original rock ramp but only provided half the river passage. The original thought was if you cut the ramp width in half you could potentially cut the cost in half from the original rock ramp. Estimates from preliminary cost analysis did not validate this assumption. The primary factor this alternative did not prove to be cheaper was that in order to keep the water on the half rock ramp, a very large retaining wall would need to be constructed from the weir crest to the toe of the ramp. This increased costs back to the cost levels estimated for the original rock ramp design.

### 2.6.9 Island Alternative

This alternative was dropped because it was technically infeasible without constructing a weir/dam across the full width of the Yellowstone River. There were additional concerns regarding the river migrating away from the newly constructed headworks when the diversion dam was removed and that O&M cost would be considerable for the new dike system required on the outside bend of the river. It was also a concern that the hydraulics of this alternative would not allow the district to receive its full water right when the river flows dropped close to 3,000 cfs. Issues of sediment and fish entrainment were also discussed but not resolved.

# 3. Affected Environment

## 3.1. Introduction

The environment of the area to be affected by the alternatives is described in this chapter. The discussion focuses on the existing conditions of resources that could be affected by the proposed fish passage alternatives.

The existing conditions of resources potentially affected by the Intake Project, for the most part, have not changed since release of the 2010 EA. Existing condition descriptions will not be repeated here but can be found in the 2010 EA. The resources discussed in this chapter are limited to those where new information exists relevant to the fish passage alternatives and is necessary to provide context for the effects analysis in Chapter 4. The resources discussed in this chapter include:

- Aquatic communities
- Federally-listed species and state species of special concern
- Social and economic conditions
- Lands and vegetation
- Historic properties

## 3.2. Aquatic Community

In the 2010 EA, a literature search identified fish, mussels, and macroinvertebrates currently inhabiting areas that could be affected by the Intake Project. The lists of species were obtained from the MFWP website and other sources. Consideration was also given to the types of habitats and how these habitats might be impacted, either from construction or alterations that could occur through geomorphologic changes by any of the alternatives. The species lists have not changed since the original document but new information has been obtained through new or continued research on some of the species. The lists of species that can be currently found near the project area are in Chapter 3, “Aquatic Communities,” in the 2010 EA.

### 3.2.1 Fish

Instream habitats of the lower Yellowstone River include main channel pools, runs, riffles, side channels, and backwaters. Most pools are 5 feet–10 feet in depth with some pools exceeding 18 ft during the summer flows. There are many islands and braided channels with associated backwaters, except in the reaches from Miles City to Cedar Creek and from Sidney to the confluence with the Missouri River. At the Intake site, the river is comprised of the main channel, Joe’s Island, and a long side channel that carries flows seasonally, during the high water periods. Side channels are considered to be important habitat for young fish, for both rearing and winter habitat (Ragland, 1974; Ellis et al., 1979; Mesick, 1995). Preliminary data analysis on a study that has been undertaken since the drafting of the 2010 EA indicates that fish densities are greater in side channels than in the main channels during runoff (Reinhold, 2011).

Fifty-two species of fish have been recorded in the lower Yellowstone River (Montana Fisheries Information System, http://fwp.mt.gov/fishing/mFish/). Of these 52 species, 31 species are native to the lower Yellowstone River and 21 are species that have been introduced.

Intake Diversion Dam impedes upstream movement of fish to and from traditional spawning grounds, and the degree to which passage is prevented varies from species to species. It has been noted that stronger swimming fish such as walleye and sauger have been known to make it past the diversion dam (Helfrich et al., 1999), whereas weaker swimming fish such as pallid sturgeon have been unable to pass the dam for many years (Backes et al., 1994).

The Yellowstone River experienced extremely high flows in 2011. During the high flows, a considerable amount of rock was displaced from the diversion dam that created large notches along the crest. Monitoring by MFWP showed a significant increase in passage past the dam by many of the native species which is likely due to the displacement of rock (Backes, personal communication).

The large amount of rock displaced during 2011 resulted in the LYIP placing 1,493 cubic yards of new rock on the diversion dam to raise the water surface high enough to divert its full water right. A below-average water year occurred in 2012 so this placement of the rock is believed to have created additional passage problems. It is still unknown what effect the additional rock has had on passage at Intake.

Based on their physiology, shovelnose and pallid sturgeon are built to hold station and swim along the bottom of fast flowing rivers (body appression to flat, horizontal substrate), and have burst swimming speeds in currents between 15–25 feet per second (Hoover et al., 2011; Adams et al., 1999). Their body form however is likely not built for maintaining position in highly turbulent waters. Horizontal turbulence and vertical turbulence were tested by White and Mefford (2002) in pallid sturgeon fish passage studies. Although both types of turbulence ("eddies") were able to be negotiated, larger eddies tended to cause delays in upstream movement of the fish, with larger turbulence being most problematic. Helfrich et al. (1999) tagged 29 shovelnose sturgeon on the lower Yellowstone River. No tagged shovelnose sturgeon were recaptured upstream of any of the low-head diversions. Although pallid sturgeon were not used in their study, the similarities of shovelnose and pallid sturgeon suggests that neither of these closely related species may be adapted to negotiate turbulent water over large rock river bottom with high slopes. The U.S. Geological Survey (USGS) (2002) found shovelnose and pallid sturgeon have similar swimming abilities but found that shovelnose sturgeon are less motivated to move upstream. Radio telemetry studies have documented pallid sturgeon moving up to the Intake Diversion Dam, turning around, and moving downstream (Bramblett, 1996, Bramblett & White, 2001; Fuller et al., 2008) and extensive netting efforts up and downstream of the diversion suggest that it is a barrier to adult pallid sturgeon (Backes et al., 1994).

While most fish passage studies focus on the hydraulic constraints at dams (velocity, turbulence, etc.), some concern exists that metal construction material found within dams or fish passage structures could prevent passage for fish that have highly developed electro reception. The paddlefish is one such species. Gurgens et al. (2000) showed that in a laboratory, paddlefish exhibit an unambiguous avoidance behavior elicited by aluminum obstacles, and noted that such results may suggest that large metallic structural work within dams (such as locks and dams) have the potential to interfere with paddlefish migrations. Similar considerations would also apply to shovelnose and pallid sturgeon, which also possess a passive electrosense (Teeter et al., 1980) and migrate long distances. Intake Diversion Dam is known to have extensive amounts of metal in its structural make-up. While the notion of metal avoidance is often cited by fisheries biologists, very little in the way of actual field data are available. In an ongoing fish movement study on the Mississippi River between lock and dam 26 and lock and dam 24, tagged white bass, blue catfish and carp were shown to move freely through lock and dams, but tagged paddlefish did not (Garvey, personal communication, 2012).

The Intake Diversion has created issues in the past regarding entrainment of fish. Hiebert et al. (2000) estimated that about 500,000 fish of 36 species are annually entrained into the main canal at Intake Diversion, of which as many as 8% were sturgeon. Jaeger et al. (2005) estimated that 86% of the sauger that are entrained die, and up to 78% of annual non-fishing mortality of sauger in the lower Yellowstone River was related to entrainment into the main canal at Intake. Because the canal headworks at Intake have recently been rebuilt, and have incorporated removable rotating drum screens that meet screening criteria standards for minimizing entrainment, it is anticipated that entrainment is no longer a substantive issue. Reclamation is monitoring the effectiveness of the screens to confirm this and will continue entrainment monitoring in 2013 and 2014.

### 3.2.2 Mussels

Very little is known about mussel populations in Montana, but the best available data indicate that three native and three introduced mussels can be found in the Yellowstone River.

### 3.2.3 Macroinvertebrates

Macroinvertebrates of the lower Yellowstone River are very silt tolerant and very abundant. Seven species of caddisflies and seventeen species of mayflies can be found in large numbers near the Intake project area (Zelt et al., 1999; Newell, 1977). Also other true flies, mostly non-biting midges and seven species of stoneflies can be found but are not as abundant as the caddisflies and mayflies.

### 3.2.4 Aquatic Invasive Species

Very few aquatic invasive species have become established in the lower Yellowstone River. Whirling disease and iridovirus are two diseases of great concern in this stretch of the river. In 2005, Miles City State Fish Hatchery workers detected an extremely low level of whirling disease in samples taken from trout being kept at the hatchery, however this proved to be a false positive according to MFWP.

Iridovirus is of great concern for sturgeon species. Iridovirus can cause mortality in hatchery-reared sturgeon (Kurobe et al., 2011) and its effects to free-ranging sturgeon species in the Missouri and Yellowstone Rivers are still unknown. Iridovirus was recently documented in hatchery-rear pallid sturgeon at the Garrison Dam National Fish Hatchery Complex. These fish have been stocked in Recovery-Priority Management Areas (RPMAs) 1 and 2 in 2013 (R. Wilson, personal communication, April 8, 2013).

Mudsnails are found near the confluence of the Bighorn River, with eventual spread to the lower Yellowstone River likely. Common carp are present in the Yellowstone River both upstream and downstream of Intake Diversion Dam. Carp are strong swimmers and can probably pass upstream at Intake under most flows. Bighead carp, silver carp, black carp, and grass carp, collectively referred to as Asian carp, are invasive species that were either accidentally or intentionally introduced into the Mississippi River basin. They have subsequently become established within the lower Missouri River (Wanner & Klumb, 2009). Dams, while detrimental to many native migratory species, have provided some protection from Asian carp establishment in the upper Missouri River system. The Montana Aquatic Nuisance Species Management Plan (2002) acknowledges the fact that while they are not currently present, it is possible that Asian carp will eventually make their way up the river, and could impact native fish due to competition for habitat and food. However, like common carp, Asian carp are strong swimmers, and Intake Dam would likely not afford protection to the upper Yellowstone River should they become established below the dam.

## 3.3. Federally Listed Species and State Species of Special Concern

### 3.3.1 Introduction

Federal and state lists and Montana and North Dakota Natural Heritage Program databases were searched to determine if any of these species had been recorded in the Intake Project area. A literature search for life history information was completed for species recorded in the Intake Project area. State agencies with responsibilities for listed species and Service field offices were contacted for current information on locations, life histories, and current research information. Federally listed species or state species of concern likely to be in the Intake Project area are discussed below.

The Service, as required by the ESA, confirmed a list of federally-listed endangered, threatened and proposed species that are or may be present in the Intake Project area. The same species that were looked at in the 2010 EA were also considered under the new alternatives. Species status and biology can all be located in the 2010 EA. With the exception of the discussion below, all species biology and status has stayed the same.

In 2012, Reclamation completed a Biological Assessment (BA) on the operations and maintenance of the new headworks and associated fish screens. The 2012 BA list included the endangered pallid sturgeon, endangered interior least tern, endangered whooping crane, endangered black footed ferret, and the candidates greater sage-grouse and Sprague's pipit. The greater sage-grouse and Sprague's pipit were designated as candidates in 2010 (March and September, respectively) after having been petitioned for listing. Although the Service determined that the petition presented substantial information indicating that their listing was warranted, their listing was precluded by higher listing priorities (Service, 2010). Because neither species was designated as candidates during the 2010 EA or 2010 BA, neither was addressed (although the Sprague's pipit was discussed as a species of special concern in the 2010 EA). New information, where it is pertinent, has been added to this supplemental EA to include information regarding these newly designated candidate species. In addition, pertinent new information has been obtained on pallid sturgeon since the release of the 2010 EA and has also been included.

***Pallid Sturgeon (Endangered)***

Pallid sturgeon occupy the Missouri and Yellowstone Rivers in Montana and North Dakota. These sturgeon use the Missouri River year-round and the Yellowstone River primarily during spring and summer spawning. Klungle and Baxter (2005) estimated 158 wild adult pallid sturgeon inhabit RPMA 2. This includes the Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea and the Yellowstone River below Intake Diversion Dam (Service, 1993).

Several population estimates have been developed for the Fort Peck and Yellowstone River reaches (Krentz, 1995; Kapuscinski, 2003; Klungle & Baxter, 2005), with the most recently developed estimate showing 158 wild adults in 2004 (Klungle & Baxter, 2005). This estimate and current sampling efforts indicate the reproductive adults in the Yellowstone and Missouri Rivers remain very rare. Supplemental stocking of pallid sturgeon has been ongoing sporadically since 1998, with various numbers being stocked based on hatchery success for any given year (Service, 2006) in the upper Missouri River basin. Hatcheries involved with propagation of Missouri River pallid sturgeon stocked a combined 15,781 fingerling and yearling-sized pallid sturgeon during 2011, with approximately 4,000 of those being stocked in the RPMA 2, which includes the lower Yellowstone River and Missouri River between Fort Peck and Lake Sakakawea Reservoirs. Pallid sturgeon are stocked to ensure survival of the species in the short term and preserve existing genetics of the wild population. Monitoring data collected through the Pallid Sturgeon Population Assessment Program indicate that stocked pallid sturgeon are surviving, growing, and reaching a size and age that is capable of spawning. Recent survival estimates for hatchery fish stocked into the Missouri River show relatively high rates of survival (Hadley & Rotella, 2009; Steffensen et al., 2010) that are similar to other sturgeon species (Irelands et al., 2002).

Bramblett (1996) speculates that pallid sturgeon prefer the Yellowstone River over the Missouri River below Fort Peck, and that pallid sturgeon spawning occurs in the lower 6–9 river miles of the Yellowstone River (Bramblett & White, 2001; Fuller et al., 2008; Braaten, personal communication, 2011). Evidence includes higher numbers of ripe pallid sturgeon moving into the lower Yellowstone River compared to the Missouri River during spawning season and fish aggregating during the spawning season (late May and early June). Other more recent telemetry studies have also documented gravid pallid sturgeon moving up to the Intake Diversion Dam, turning around, and moving downstream (Bramblett & White, 2001; Fuller et al., 2008; Braaten, personal communication, 2011; Delonay et al., 2013). It is assumed that fish would likely have continued upstream had the barrier not been there. Extensive netting efforts up and downstream of the diversion suggest that it is a barrier to adult pallid sturgeon (Backes et al., 1994). There is recent evidence that pallid sturgeon have spawned in the Yellowstone River based on a single larval fish collected in 2012 (Braaten & Rhoten, personal communication, 2012). While spawning has been confirmed in the Yellowstone River, there is no evidence that any resulting young survived into adulthood and reproduced. During the 2011 spawning season, fewer telemetered fish than typical migrated up the Yellowstone River, likely as a consequence of high runoff in the Missouri River (Braaten, personal communication, 2013). This atypical run up the Missouri River resulted in the first documented naturally-reproduced pallid sturgeon above

Gavins Point Dam. A naturally-spawned pallid sturgeon was confirmed when a day old larvae was found in the Missouri River upstream of Wolf Point, Montana (Fuller, 2012).

The spawning strategy used by pallid sturgeon illustrates the importance of passage at Intake Diversion Dam. The lower Yellowstone River upstream of Intake contains some of the best remaining habitat thought to be important for successful spawning (Service, 2000a, 2003; USGS, 2007; Delonay et al., 2009). The near-natural hydrograph and associated temperature and sediment regimes characteristic of the Yellowstone River combine to provide one of the most natural habitats available to sturgeon (White & Bramblett, 1993).

Pallids in the Yellowstone River prefer sandy substrates and deep channels and select reaches with numerous islands (Bramblett & White, 2001). They primarily inhabit about a 70-mile stretch of river below Intake Diversion Dam. More recently radio-tagged hatchery-reared pallid sturgeon have been placed above the dam (Jaeger et al., 2005). Most of these fish stayed above the Intake Diversion Dam, but some were found in the main canal of the Lower Yellowstone Irrigation Project (Jaeger et al., 2004).

On the lower Yellowstone River, pallid sturgeon are presumed to utilize bluff pools and terrace pools as spawning habitats based on current knowledge of past use in the lower Yellowstone and Missouri Rivers (Jaeger et al., 2005). Bluff and terrace pools are unique geomorphic units associated with bedrock and boulder substrate. Table 3.1 shows the number and acreage of these pools in the Yellowstone River below Cartersville Diversion Dam, as defined by Jaeger et al. (2005). Suitable spawning habitat is much more prevalent above Intake. The ability to spawn as far upstream as habitat and conditions permit may be critical to development and survival of larval and immature fish and to survival, recruitment, and recovery of the species. Providing passage at Intake Diversion Dam would open approximately 165 miles of additional habitat in the Yellowstone River to pallid sturgeon, as well as providing access to the confluences of the Powder and Tongue Rivers.

**Table 3-1. Summary of bluff pool and terrace pool habitats on the lower Yellowstone River**

| Reach | Bluff Pools | | Terrace Pools | |
|---|---|---|---|---|
| | number | acres | number | acres |
| Below Intake Dam | 8 | 342 | 4 | 125 |
| Between Cartersville Dam and Intake Dam | 17 | 1293 | 39 | 1764 |

Braaten et al. (2008) suggests larval drift distance presently available below Intake Diversion Dam is insufficient in length and settling habitat. Braaten et al. (2012) recently showed via a recapture study that pallid sturgeon originally released as free embryos and larvae can survive beyond the first year of life, indicating the importance and ability of the Missouri River to provide conditions that support survival, feeding, and growth of pallid sturgeon early life stages. Many of these released fish that survived would have been at or near the age when drifting slows or ceases (i.e. 11-17 days post-hatch), and so drift distance may not have played a major role in their survival, but clearly habitat conditions provided suitable conditions for their survival. This being the case, it could be expected that the Yellowstone River might likewise support habitat needs of pallid sturgeon. Without sufficient drift distances though, larvae could drift into the headwaters of Lake Sakakawea where it is thought that survival is unlikely.

***Greater Sage Grouse (Candidate)***
As their name implies, sage grouse are dependant year-round on sagebrush-grassland for survival. Historically, sage grouse occupied portions of 16 states and three Canadian provinces. Currently, the species is limited to 11 western states and two provinces, including Washington, Oregon, Idaho, Montana, North Dakota, South Dakota, Wyoming, Colorado, Utah, Nevada, and California. A 2004 status review estimated range wide populations between 100,000 to 500,000 individuals (Service, 2005).

In Montana, greater sage grouse inhabit roughly 27 million acres spanning 39 counties in the eastern half and southwestern corner of the state (Montana Sage Grouse Work Group, 2005). Grazing and agricultural development led to a 50% decrease in populations by the 1930s (Montana Natural Heritage Program (MTNHP), 2012). Evidence suggests that habitat fragmentation and destruction across much of the species' range has contributed to significant population declines over the past century. Other important factors in the species' decline include fire and invasive plant species. Statewide, sage grouse populations increased from the mid-1960s through 1973 and fluctuated slightly until peaking in 1984. Sage grouse populations again declined from 1991 through 1996 before increasing through 2001 to a level above 30 males per lek (Montana Sage Grouse Work Group, 2005). Population estimates from 2003 indicated approximately 27.7 males per lek (Montana Sage Grouse Work Group, 2005). If current trends persist, many local populations may disappear in the next several decades, with the remaining fragmented population vulnerable to extinction (Service, 2011).

Of the 27 million acres currently inhabited by sage grouse, MFWP refined these acres into 13 separate "core" sites, totaling 8.9 million acres (see ftp://ftp-fc.sc.egov.usda.gov/MT/www/technical/biology/SageGrouseStrategy/SageGrouseStudyMap.pdf). These core areas provide habitat for 75% of all known breeding sage grouse in Montana, and provide a target area for conservation efforts. According to the *Management Plan and Conservation Strategies for Sage Grouse in Montana* (Montana Sage Grouse Work Group, 2005), the following bulleted list provides a summary of seasonal habitats that are important to the survival of greater sage grouse:

- *Breeding Habitat*—Strutting grounds or "leks," where breeding actually occurs, are key activity areas and most often consist of clearings surrounded by sagebrush cover. Findings from research in central Montana reported a sagebrush canopy cover at feeding and loafing sites in the vicinity of leks of 20-50% with an average of 32%.
- *Nesting Habitat*— Sage grouse invariably prefer sagebrush for nesting cover, and quality of nesting cover directly influences nest success. Successful nesting requires concealment provided by a combination of shrub and residual grass cover. Sage grouse most frequently select nesting cover with a sagebrush canopy of 15-31%. Research findings in central Montana suggest that about two-thirds of nests occur within 2 miles of a lek.
- *Brood-Rearing Habitat*—Areas providing an abundance and diversity of succulent forbs, an important summer food source for young sage grouse, provide key brood-rearing habitat. Research in central Montana indicated that sage grouse broods prefer relatively open stands of sagebrush during summer, generally with a canopy ranging from 1-25%.

As palatability of forbs declines, sage grouse move to moist areas that still support succulent vegetation, including alfalfa fields, roadside ditches, and other moist sites. During summers of high precipitation, sage grouse in Montana may remain widely distributed throughout the entire summer due to the wide distribution of succulent forbs. Sage grouse in southwest Montana and eastern Idaho often move to intermountain valleys during late summer where forbs remain succulent through summer and early fall. Reported sagebrush canopy on these sites varied from 8.5-14%.

- *Winter Habitat*— Sage grouse generally select relatively tall and large expanses of dense sagebrush during winter. Wintering areas in central Montana included sagebrush stands on relatively flat sites with a 20% canopy and an average height of 10 inches. The importance of shrub height increases with snow depth. Thus, snow depth can limit the availability of wintering sites to sage grouse.

***Sprague's Pipit (Candidate)***

The Sprague's pipit is endemic to the mixed-grass prairies of the northern Great Plains, including breeding habitat in Minnesota, Montana, North Dakota and South Dakota as well as south-central Canada. Wintering occurs in Arizona, Texas, Oklahoma, Arkansas, Mississippi, Louisiana, and New Mexico. Long-term surveys have indicated a range wide population decline of 3.9% annually (Jones, 2010). Global population estimates have projected as many as 870,000 breeding birds, although this calculation is unverified with existing data and is likely a maximum estimate (Jones, 2010).

The breeding range extends through the north-central and eastern counties of Montana. Breeding in the southeastern and south-central counties was last reported in 1991 (Jones, 2010). Breeding population estimates range from as many as 400,000 in Alberta, Canada to as few as 3,000 in South Dakota (Jones, 2010). Generally, pipits prefer to breed in well-drained native grasslands with high plant species richness and diversity (Jones, 2010).

The principal causes for the declines in Sprague's pipit range and populations are habitat conversion (to seeded pasture, hayfield, and cropland) as well as overgrazing by livestock. In addition to the habitat losses from changes in land use, energy development, introduced plant species, nest predation and parasitism, drought, and fragmentation of grasslands are all threats that currently impact Sprague's pipit populations throughout their present range (Jones, 2010). Anecdotal accounts from early naturalists suggest that Sprague's pipits were one of the most common grassland songbirds in the northern Great Plains. Since its discovery, the Sprague's pipit has suffered greatly throughout its breeding range from conversion of short- and mid-grass prairie to agriculture (Jones, 2010).

Sprague's pipits are likely influenced by the size of grassland patches and the amount of grassland in the landscape. Pipits had a 50% probability of occurring on patches ≥ approximately 400 acres; pipits were absent from grassland patches <72 acres. The shape of the habitat is also important; sites with a smaller edge-to-area ratio had higher pipit abundance and were an important predictor of their occurrence. No consistent effect of patch size was found on nest success. Sprague's pipits rarely occur in cultivated lands and are uncommon on non-native planted pasturelands. They have not been documented to nest in cropland, in land in the

Conservation Reserve Program, or in dense nesting cover planted for waterfowl habitat (Jones, 2010).

The conversion, degradation, fragmentation, and loss of native prairie are the primary threats to Sprague's pipit populations. The once abundant grasslands of the Great Plains have been drastically reduced, altered, and fragmented by intensive agriculture, roads, tree plantings, encroachment by woody vegetation, invasion of exotic plants, and other human activities, including the removal of native grazers and a change in the natural fire regime. In the United States, about 60% of native mixed-grass prairies in Montana, North Dakota, and South Dakota have been converted to cropland. Grassland conversion has greatly reduced the quality and availability of suitable habitat for Sprague's pipits (Jones, 2010).

Fragmentation of native prairie has likely contributed to the decline of Sprague's pipit populations through a reduction in average patch size, increased isolation of habitat patches, and increase in the ratio of edge-to-interior in habitat and potentially, an increase in parasitism. In fragmented landscapes, habitat interior species such as Sprague's pipits may experience lower reproductive success when nesting near habitat edges, where they are more susceptible to nest predators and brood parasites (e.g., brown headed cowbird). Sprague's pipits, like many other grassland endemics, tend to prefer areas with <20% shrubs, and are negatively associated with trees on a local territory scale. Sprague's pipit abundance has also been inversely correlated with distance to cropland and to water (Jones, 2010).

Sprague's pipits may avoid roads and trails during the breeding season and the increased road densities associated with energy development may have negative effects on Sprague's pipit habitat. The type of road (e.g., secondary or tertiary, the presence of deep ditches on the sides, heavily graveled) and the level of traffic are the potential issues in determining the degree of effect roads and trails have on Sprague's pipit populations. In Saskatchewan, Sprague's pipits were significantly more abundant along trails (wheel ruts visually indistinct from surroundings) than along roadsides (fenced surfaced roads with adjacent ditches), which may be attributed to the reduction of suitable habitat associated with the road right-of-way. Sprague's pipit's avoidance of roads may also be due to the roadside habitat which tended to have non-native vegetation, dominated by smooth brome (*Bromus inermis*) (Jones, 2010).

***Montana and North Dakota Species of Special Concern***
This list has not changed from the 2010 EA. A complete list of species along with biology of each species can be found in the 2010 EA in Chapter 3, Federally-Listed and State-Listed Species of Special Concern section.

## 3.4. Lands and Vegetation

### 3.4.1 Introduction

- What lands and vegetation (wetlands, grasslands, woodlands, riparian areas, and noxious weeds) in the area could be affected by the alternatives?

Lands and vegetation include wetlands, grasslands, woodlands, riparian areas and noxious weed areas. The following discussion centers on habitat types within the Northwestern Great Plains Ecoregion in the Intake Project's area of potential effects in the Yellowstone River basin.

### 3.4.2 Methods

Prior to field verification, various Geographic Information System (GIS) layers were used to inventory lands and vegetation in potential construction zones for each action alternatives. The potential construction zone relates to the maximum extent of disturbance as depicted in figures in Chapter 2. Thus, the tables in this section identify acres of specific resource types that could be affected upon implementation of an alternative and are not meant to identify impacts themselves. A specific impacts analysis is provided in Chapter 4. The GIS layers were developed using state and federal agency land use databases.

A Waters of the U.S. (WUS) delineation and general field investigation was completed on August 16 and 17, 2012. The investigation was used to ground truth the GIS desktop analysis. Wetlands, grasslands, woodlands and riparian areas were quantified and mapped based on findings. See Appendix K for the results of this investigation. Additional details on baseline data and methodology are presented in the 2010 EA.

### 3.4.3 Existing Conditions

***Wetlands***

A diversity of wetland types were identified during the desktop investigation within the project area (National Wetland Inventory (NWI) Map, 2012), including riverine wetlands and palustrine wetlands. The field investigations confirmed the presence of these habitats. Wetlands most likely to be affected are those located within the riparian areas.

A seepage spring, wetlands, and intermittent waterway were identified near the western boundary of the waste pile site in a drainageway that connects to a side channel of the Yellowstone River. The side channel of the Yellowstone River had a gravel/cobble bed that was intermittently exposed and contained patchy emergent wetlands. Flow was not apparent during the investigation. It appears that the size of the wetlands in this area fluctuate based on the depth and velocity of flows through the side channel. Approximately 0.5 acres of palustrine emergent (PEM) wetlands were found within the Bypass Channel Alternative. Dominant vegetation in PEM wetlands consisted of buttercup, silverweed cinquefoil, smartweed, wild mint and sedges. Approximately 55 acres of riverine wetland were found within the Rock Ramp Alternative. Table 3.2 lists wetlands within the construction area footprint that were identified during the investigation for each alternative. Because each alternative could affect riverine wetlands, those acres are also identified in Table 3.2.

**Table 3-2. Wetlands within the construction footprint of proposed action alternatives**

| Alternative | Palustrine (acres) | Riverine (acres) | Total Wetlands (acres) |
|---|---|---|---|
| **Bypass Channel Alternative** | 0.5 | 20 | 20.5 |
| **Rock Ramp Alternative** | 0 | 55 | 55 |

### *Riparian Areas*

In order to identify and evaluate potential impacts of the alternatives, riparian areas were defined by the MNHP who mapped wetland and riparian areas along the Yellowstone River using the *System for Mapping Riparian Areas in the Western United States* (Service, 1997). Mapped riparian types may not be jurisdictional wetlands but have vegetation affected by the hydrology of a nearby water body (river, stream, or lake). The field investigation confirmed that outside wetlands identified in the previous section, riparian areas were dominated by upland forbs, shrubs and grasses. Table 3.3 lists acres of riparian areas within the construction area footprint for each alternative.

**Table 3-3. Riparian areas currently in construction footprint of alternatives**

| Alternatives | Riparian Acres | | | |
|---|---|---|---|---|
| | Emergent | Forested | Scrub-shrub | Total |
| **Bypass Channel Alternative** | 0 | 63 | 7 | 70 |
| **Rock Ramp Alternative** | 0 | 5 | 0.1 | 5.1 |

### *Woodlands*

The National Land Cover Database (NLCD) was utilized to identify non-riparian woodlands within the project area. Woodlands include areas with trees usually greater than 19 ft tall with a tree canopy covering 25-100%. Within the Intake Project area this includes deciduous and evergreen forests and shrubland. Deciduous woodlands are generally made up of cottonwood, green ash, Russian olive, and box elder trees. Although some of the deciduous woodland species are hydrophytic and could be found in wetlands, the herbaceous understory consisted of upland vegetation and no wetland hydrology or soil indicators were present in the forested areas. The evergreen forest consists mostly of juniper species and ponderosa pine. Shrublands are areas dominated by shrubs with a shrub canopy covering 25-100% of the area. In the Intake Project area this includes sagebrush communities dominated by silver sagebrush, common snowberry, chokecherry shrubland, buffaloberry shrubland, and some drier willow shrub areas.
Table 3.4 lists acres of wooded areas within the construction area footprint for each alternative.

**Table 3-4. Woodlands currently in construction footprint of alternatives**

| Alternatives | Woodland Acres | | | |
|---|---|---|---|---|
| | Deciduous | Evergreen | Shrubland | Total |
| **Bypass Channel Alternative** | 18 | 76 | 90 | 184 |
| **Rock Ramp Alternative** | 0 | 5 | 7 | 12 |

### *Grasslands*

The grasslands in this ecoregion include crested wheatgrass, Japanese brome, leafy spurge, and bluebunch wheatgrass on the heavy, slowly permeable bottomlands and threadleaf sedge and needle and thread on the gravelly soils of hill slopes. Both little bluestem and buffalo grass are found along flat-bottomed channels. The NLCD was also utilized to identify acres of grassland in the project area and the field investigations confirmed map findings.

Table 3.5 lists acres of grasslands that are currently within the construction area footprint for each alternative.

**Table 3-5. Grasslands currently in construction footprint of alternatives**

| Alternatives | Grassland Acres |
|---|---|
| **Bypass Channel Alternative** | 321 |
| **Rock Ramp Alternative** | 21 |

### *Noxious and Invasive Plants*

Currently 15 different noxious weeds infest counties in the Intake Project area (Table 3.6).

**Table 3-6. Noxious weeds currently in counties in the Intake Project area**

| Noxious Weeds | MT Category | MT Dawson County[1] | MT Richland County | ND McKenzie County[2] |
|---|---|---|---|---|
| Absinth wormwood | | | | X |
| Baby's breath | | | | X |
| Black henbane | | | | X |
| Canada thistle | 2B | X | X | X |
| Common burdock | | | | X |
| Common tansy | 2B | X | | |
| Dalmatian toadflax | 2B | X | X | X |
| Diffuse knapweed | | | | X |
| Dyer's woad | 1B | X | | |
| Field bindweed | 2B | X | X | |
| Halogeton | | | | X |
| Hoary cress (Whitetop) | 2B | X | X | |
| Houndstongue | 2B | | | X |
| Leafy spurge | 2B | X | X | X |
| Musk thistle | | | | X |
| Purple loosestrife | 1B | X | | X |
| Russian knapweed | 2B | X | X | X |
| Russian Olive[3] | invasive | X | X | X |
| Saltcedar | 2B | X | X | X |
| Spotted knapweed | 2B | X | X | X |
| St. Johnswort | | X | | |
| Yellow toadflax | 2B | X | | X |

[1]Data accessed (May 2012) through http://agr.mt.gov/agr/Programs/Weeds/PDF/weedList2010.pdf, http://www.eddmaps.org/, and http://plants.usda.gov/java/noxious?rptType=State&statefips=30. Montana Category 1B noxious weed species have limited presence in Montana. Montana Category 2A noxious weed species are common in isolated areas of Montana. Montana Category 2B noxious weed species are abundant in Montana and widespread in many counties.
[2]Data accessed (March 2012) through http://www.nd.gov/ndda/files/resource/CountyandCityListedNoxiousWeedsFeb2012.pdf and http://plants.usda.gov/java/noxious?rptType=State&statefips=38.
[3] Included based on Yellowstone River Conservation District Council Best Management Practice adopted June 21, 2007.

## 3.5. Social and Economic Conditions

### 3.5.1 Introduction

- What are the current social and economic conditions in the Intake Project area that could be affected by the proposed alternatives?

The social and economic affected area includes counties that have social and economic links to the region that would be directly impacted by the alternative actions. The affected area includes Dawson, McCone, Prairie, Richland, Roosevelt, and Wibaux Counties in Montana and McKenzie and Williams Counties in North Dakota. This section describes the current demographic, economic, and educational aspects of the regional economy from the U.S. Census Bureau, U.S. Department of Agriculture and Bureau of Labor Statistics but due to the recent oil and gas production, these numbers may be under-represented. Indicators of regional social and economic conditions include population, value of output, percentage output value by sector, household income, per capita income, labor force, and employment.

### 3.5.2 Method

An evaluation of social and economic conditions requires data on current baseline conditions from which the significance of economic impacts can be measured. Data were obtained from the U.S. Census Bureau, U.S. Department of Agriculture, and Bureau of Labor Statistics. Oil and gas information was obtained from the North Dakota Industrial Commission, Department of Mineral Resources, Oil and Gas Division and from the Montana Board of Oil and Gas Conservation.

### 3.5.3 Existing Conditions

***Population***

The eight-county impact area is rural in nature, with a total 2010 population of slightly over 61,800 people. The regional population has declined by 2.8% over the last 20 years. All of the counties except Williams County, North Dakota experienced a loss in population. The largest percentage decreases were in the three lowest population counties (McCone, Prairie, and Wibaux). The region as a whole experienced population growth from 2000 to 2010 due to growth in the North Dakota counties. County level population estimates are presented in Table 3.7.

The largest municipalities in the region are Williston, North Dakota, and Sidney and Glendive, Montana. Each of these communities experienced population growth over the 2000 to 2010 period. Williston and Glendive are the only two communities that have a larger population in 2010 than in 1990. Municipal population estimates are in Table 3.8.

**Table 3-7. County level population estimates for the Intake Project area (U.S. Census Bureau, 2009a, 2009b, 2009c, 2009d)**

| COUNTIES | 1990 | 2000 | 2007 | 2008 | 2010 | PERCENTAGE CHANGE 1990 - 2010 | 2000 - 2010 |
|---|---|---|---|---|---|---|---|
| **Montana** | | | | | | | |
| Dawson | 9,505 | 9,059 | 8,558 | 8,490 | 8,966 | -5.67 | -1.03 |
| McCone | 2,276 | 1,977 | 1,724 | 1,676 | 1,734 | -23.81 | -12.29 |
| Prairie | 1,383 | 1,199 | 1,044 | 1,064 | 1,179 | -14.75 | -1.67 |
| Richland | 10,716 | 9,667 | 9,182 | 9,270 | 9,746 | -9.05 | -0.82 |
| Roosevelt | 10,999 | 10,620 | 10,148 | 10,089 | 10,425 | -5.22 | -1.84 |
| Wibaux | 1,191 | 1,068 | 898 | 866 | 1,017 | -14.61 | -4.77 |
| **North Dakota** | 6,383 | 5,737 | 5,617 | 5,674 | 6,360 | -0.36 | +10.86 |
| McKenzie | 21,129 | 19,761 | 19,540 | 19,846 | 22,398 | +6.04 | +13.35 |
| Williams | | | | | | | |
| **Study Area Total** | **63,582** | **59,088** | **56,711** | **56,975** | 61,825 | **-2.76** | +4.63 |

**Table 3-8. Study area county seat populations (U.S. Census Bureau, 2009a, 2009b, 2009c, 2009d)**

| COUNTY | 1990 | 2000 | 2007 | 2010 | PERCENTAGE CHANGE 1990 - 2010 | 2000 - 2010 |
|---|---|---|---|---|---|---|
| Circle (McCone) | 805 | 644 | 558 | 615 | -23.60 | +4.50 |
| Glendive (Dawson) | 4,802 | 4,729 | 4,615 | 4,935 | +2.77 | +4.36 |
| Sidney (Richland) | 5,217 | 4,774 | 4,746 | 5,191 | -0.50 | +8.73 |
| Terry (Prairie) | 659 | 611 | 534 | 605 | -8.19 | -0.98 |
| Watford City (McKenzie, ND) | 1,784 | 1,435 | 1,373 | 1,744 | -2.24 | +21.53 |
| Wibaux (Wibaux) | 628 | 567 | 481 | 589 | -6.21 | +3.88 |
| Williston (Williams) | 13,131 | 12,512 | 12,393 | 14,716 | +12.07 | +17.62 |
| Wolf Point (Roosevelt) | 2,880 | 2,663 | 2,525 | 2,621 | -9.00 | -1.58 |

The relatively small, shrinking population indicates a decline in economic activity needed to support the population, as well as a decrease in the potential labor supply, which may inhibit future long-term commercial activity. The most recent population data are available for 2007. As a result, the increase in population associated with the recent increase in oil and gas production is not reflected in Tables 3.7 and 3.8. However, unless oil and gas prices increase and remain high enough over the long term to support increased oil and gas production, the population increase associated with oil and gas production will be temporary and will not reverse the long-term downward trend.

***Sectors of Economic Activity***

The primary sectors of economic activity in the region include agriculture, recreation, transportation and utilities, government, wholesale and retail sales, and mineral extraction (Figure 3-1). Oil and natural gas production are the primary sources of mining revenues. Table 3.9 shows the percentages of total employment attributable to the primary sectors of activity in each county, as defined by the U.S. Department of Commerce, Bureau of the Census 2010 American Community Survey (ACS) five-year estimates. The five-year estimates are representative of conditions over the 2006 to 2010 time period. There are many more sectors that generate earnings other than those shown in Table 3.9, but these are relatively small compared to the primary sectors. Median earnings provided in the 2010 ACS for a 12-month period (to represent annual earnings) are presented in Table 3.10 to indicate the value of employment in each sector.

**Figure 3-1. A major sector of economic activity in the region is agriculture**

The transportation, warehousing, and utilities sector employment percentages are relatively low, however, earnings in this sector are consistently higher than for the other sectors. The transportation, utilities, mining, and government sectors are based on the availability of natural resources and infrastructure in the region and, therefore, represent a larger percentage of employment in the region. The wholesale, retail, and education/health care sectors represent population services which are driven by changes in population levels and income.

### *Agriculture*

Agriculture is also an important sector of economic activity in the region, as indicated by Table 3.9. Income from farm related total receipts as reported in the 2007 Census of Agriculture totaled about $26.5 million in 2007 for the eight-county study region. Table 3.11 shows irrigated crop acreage for all sources of irrigation water for the three counties in which the Lower Yellowstone Project is located.

**Table 3-9. Employment as a percentage of total employment for the years 2006 to 2010**

| COUNTY | AGRICULTURE, FORESTRY, FISHING AND HUNTING, MINING | TRANSPORTATION, WAREHOUSING, AND UTILITIES | ALL GOVERNMENT WORKERS | WHOLESALE AND RETAIL | EDUCATION, HEALTH CARE, SOCIAL ASSISTANCE |
|---|---|---|---|---|---|
| | (percentage) | (percentage) | (percentage) | (percentage) | (percentage) |
| **Montana** | 16.4 | 14.5 | 18.4 | 12.6 | 26.4 |
| Dawson | 36.9 | 6.0 | 24.1 | 7.1 | 20.6 |
| McCone | 34.4 | 4.7 | 22.7 | 11.0 | 19.2 |
| Prairie | 21.0 | 6.5 | 12.5 | 15.2 | 19.6 |
| Richland | 13.4 | 4.0 | 43.8 | 14.3 | 30.6 |
| Roosevelt | 24.8 | 2.7 | 23.6 | 11.4 | 23.0 |
| Wibaux | | | | | |
| **North** | 25.4 | 3.8 | 20.4 | 9.1 | 20.7 |

| | | | | | |
|---|---|---|---|---|---|
| **Dakota** | 22.7 | 5.6 | 13.8 | 15.9 | 21.5 |
| McKenzie | | | | | |
| Williams | | | | | |

Source: 2006 – 2010 American Community Survey 5-year Estimates

**Table 3-10. Median earnings per full time job over the past 12 months in 2010 dollars for the years 2006 to 2010**

| COUNTY | AGRICULTURE, FORESTRY, FISHING AND HUNTING | MINING | TRANSPORTATION, WAREHOUSING, AND UTILITIES | WHOLE-SALE | RETAIL | EDUCATION, HEALTH CARE, SOCIAL ASSISTANCE |
|---|---|---|---|---|---|---|
| **Montana** | | | | | | |
| Dawson | | $61,362 | | | | |
| McCone | $16,029 | - | $54,597 | $21,154 | $22,917 | $24,605 |
| Prairie | $22,056 | - | $19,375 | $33,000 | $20,938 | $26,471 |
| Richland | $16,818 | $56,389 | $22,813 | - | $13,056 | $21,250 |
| Roosevelt | $21,453 | $38,500 | $52,037 | $13,482 | $17,619 | $25,056 |
| Wibaux | $41,616 | $47,411 | $55,833 | $27,000 | $26,050 | $29,423 |
| | $32,813 | | $59,375 | - | $24,107 | $25,917 |
| **North** | | | | | | |
| **Dakota** | | $49,904 | | | | |
| McKenzie | $32,303 | $65,338 | $39,196 | $55,833 | $17,083 | $28,262 |
| Williams | $30,714 | | $34,318 | $45,295 | $18,057 | $26,961 |

Source: 2006 – 2010 American Community Survey 5-year Estimates

**Table 3-11. Irrigated crop acreage by county**

| COUNTY | SUGAR BEETS (2010) | HAY (2008) | WHEAT (2008) | BARLEY (2008) |
|---|---|---|---|---|
| Dawson (Montana) | 1,700 | 6,600 | - | 2,600 |
| McKenzie (North Dakota) | 9,200 | 3,500 | 6,800 | 700 |
| Richland (Montana) | 12,600 | 15,400 | 15,900 | 16,100 |

### *Income and Poverty*

An important economic measure of impacts associated with an action is the effect on income and related impacts on poverty rates. Frequently used measures of income include median household income and per capita income. Median household income is a good measure of the total available resources a household has to spend on goods and services as a total unit, although per capita income is a better measure of the economic resources available to each person for goods and services.

Large households may have greater income as a unit, but may be relatively poor in terms of providing goods and services for each individual; therefore, both measures of income provide important information. The poverty rate indicates the percentage of the population that falls below the official threshold of poverty. The poverty threshold varies according to household size and location. The poverty guideline used by the U.S. Department of Health and Human Services in 2011 for a family of four in the 48 contiguous states was $22,350. Median household income, per capita income, and the poverty rate for the study area are shown in Table 3.12 for each county and in Table 3.13 for the county seats. The source of data for Tables 3.12 and 3.13 is the 2006-2010 five-year ACS.

Table 3-12. Income and poverty data for study area counties for 2006 to 2010

| COUNTY | MEDIAN HOUSEHOLD INCOME $ | PER CAPITA INCOME $ | PERSONS BELOW POVERTY % |
|---|---|---|---|
| **Montana** | **43,872** | **23,836** | **14.5** |
| Dawson | 50,752 | 24,602 | 9.3 |
| McCone | 48,167 | 23,265 | 8.6 |
| Prairie | 34,896 | 21,296 | 16.9 |
| Richland | 52,516 | 26,888 | 13.5 |
| Roosevelt | 37,451 | 17,821 | 21.5 |
| Wibaux | 40,417 | 22,579 | 11.8 |
| | | | |
| **North Dakota** | **46,781** | **25,803** | **12.3** |
| McKenzie | 48,480 | 27,605 | 10.0 |
| Williams | 55,396 | 29,153 | 8.7 |

Table 3-13. Income and poverty data for study area counties for 2006 to 2010

| CITY (COUNTY) | MEDIAN HOUSEHOLD INCOME $ | PER CAPITA INCOME $ | PERSONS BELOW POVERTY % |
|---|---|---|---|
| Circle (McCone) | 30,417 | 17,833 | 8.5 |
| Glendive (Dawson) | 46,843 | 23,293 | 8.6 |
| Sidney (Richland) | 52,460 | 24,752 | 14.2 |
| Terry (Prairie) | 34,028 | 21,301 | 11.1 |
| Watford City (McKenzie) | 51,056 | 29,587 | 5.3 |
| Wibaux (Wibaux) | 32,132 | 17,381 | 16.5 |
| Williston (Williams) | 52,926 | 28,707 | 10.0 |
| Wolf Point (Roosevelt) | 40,819 | 16,492 | 20.6 |

As an overall region, the study area has relatively high income and low poverty rates compared to overall state averages with the exception of Prairie, Roosevelt, and Wibaux Counties in Montana. The data show that Prairie County, Montana, has the lowest median household income but that Roosevelt County, Montana has the lowest per capita income and the highest poverty rate of the study area counties. Wolf Point, Montana, which is the Roosevelt County Seat, also shows low income and a relatively high poverty rate. Prairie County, Montana has the second lowest per capita income and the second highest poverty rate of the study area counties. The two North Dakota counties have relatively high incomes and low poverty rates compared to the Montana counties in the study region.

### ***Labor Force, Unemployment, Educational Attainment***

Labor force, unemployment, and educational attainment are indicators of the number of workers potentially available to support current and future economic activity and the population's level of training to provide skilled labor for commercial activities. The small population of the study region limits the size of the available labor force. Large demands for labor would need to be supplied from outside the region. The study region provides about 3.34% of the total labor force of the state of Montana and 4% of the labor force of North Dakota. Labor force data are presented in Table 3.14.

Table 3-14. Labor force, unemployment, and educational attainment for 2006 to 2010

| | LABOR | ANNUAL AVERAGE | HIGH SCHOOL DIPLOMA OR | BACHELORS |
|---|---|---|---|---|

| STATE/COUNTY | FORCE | UNEMPLOYMENT% | EQUIVALENT% | DEGREE % |
|---|---|---|---|---|
| **Montana** | **508,615** | **5.7** | **91.0** | **27.9** |
| Dawson | 4,597 | 2.5 | 89.6 | 18.4 |
| McCone | 972 | 3.0 | 91.0 | 18.6 |
| Prairie | 538 | 1.1 | 85.3 | 13.4 |
| Richland | 5,363 | 4.2 | 84.9 | 16.6 |
| Roosevelt | 4,673 | 8.5 | 89.1 | 17.3 |
| Wibaux | 552 | 6.3 | 75.1 | 15.9 |
| | | | | |
| **North Dakota** | **370,984** | **3.6** | **89.4** | **26.3** |
| McKenzie | 3,088 | 4.0 | 88.4 | 21.2 |
| Williams | 11,913 | 1.5 | 87.9 | 19.3 |

In addition, from 2006 to 2010 the unemployment rate in the study region was below the state averages for all counties except Roosevelt and Wibaux counties in Montana. Unemployment was 4.2% or less for each of the study region counties except for Roosevelt and Wibaux counties. This indicates that there are limited unemployed resources available in the region for expansion of commercial activities in the present. Unemployment rates for the study area are presented in Table 3.14.

Educational attainment is an indicator of the skill level of the labor force and the attractiveness of the area to businesses and industry considering expanding or locating in the area. This can influence the future labor force and income potential of the region. The percentage of the population 25 years of age or older with a high school diploma or the equivalent for each county and the percentage with a Bachelor's degree or higher is shown in Table 3.14.

The percentage of the population 25 years of age or older in each study area county that has a high school diploma or the equivalent ranges from 75.1% in Wibaux County to 91.0% in McCone County. This compares to 91.0% for all of Montana and 89.4% for all of North Dakota. The percentage of the population in the study area counties that have a Bachelor's degree or higher ranges from 13.4% in Prairie County to 21.2% in McKenzie County. This can be compared to 26.3% for all of North Dakota and 27.9% for all of Montana. The lower level of bachelor's degrees in the region may limit some employment opportunities to the current population.

## 3.6. Historic Properties

### 3.6.1 Introduction

- What types of historic properties (significant cultural resources) have been previously recorded in the area of potential effects?

This section presents an inventory of cultural resources in the area that could be affected by Intake Project alternatives. Cultural resources are the physical remains of a site, building, structure, object, district, or property of traditional religious and cultural importance to Native Americans. Historic properties are significant cultural resources that are either included on or have been determined eligible for listing on the National Register of Historic Places. Because some of the cultural resources have not been evaluated to determine if they are eligible for listing, the more generic term "cultural resources" is used in this discussion. The terms used in this section are defined in Figure 3-2.

Because the proposed Intake Project is a federal action, it must comply with federal legislation concerning historic properties, specifically Section 106 of the National Historic Preservation Act of 1966, as amended. Appendix G includes correspondence documenting consultation under this act.

**Cultural Resource Terms**

**Archaeological Site** – is physical evidence or remains of past human activity at a specific location. Prehistoric archaeological sites predate written records and historic archaeological sites generally are associated with European exploration and settlement of the area.

**Architectural Site –** is a building, which is a structure created to shelter any form of human activity (such as a house, barn, church, or hotel) or a structure, which is a work composed of interdependent and interrelated parts in a definite patter or organization (such as bridges, tunnels, canals, or fences).

**Cultural Resource –** The physical remains of a site, building, structure, object, district, or property of traditional religious and cultural importance to Native Americans.

**Historic Property –** Any prehistoric or historic site, building, structure, object, district, or property of traditional religious and cultural importance to Native Americans that is included on or has been determined eligible for listing on the National Register of Historic Places. Only historic properties are protected under the National Historic Preservation Act.

**Isolated Find** – is a location with fewer than five artifacts, which shows little potential for additional finds. Finds are generally not considered to qualify as historic properties.

**National Register of Historic Places** – A registry maintained by the Secretary of the Interior of sites, buildings, structures, objects, or districts or properties of traditional religious and cultural importance to Native Americans that have local, state, regional, or national historic or prehistoric significance.

**Site Lead –** is a site that was insufficiently recorded or reported by the public but not professionally verified. Site leads are generally not considered to qualify as historic properties without verification.

**Figure 3-2. Cultural resource terms**

### 3.6.2 Methods

The Lower Yellowstone Project was inventoried for cultural resources during the fall of 1996 and 1997 in anticipation of pending legislation to transfer title of the Lower Yellowstone Reclamation projects from Reclamation to the appropriate irrigation districts. The legislation did not pass; however, the University of North Dakota assisted by Renewable Technologies, Inc., completed an inventory of cultural resources under contract with Reclamation (Table 3.15).

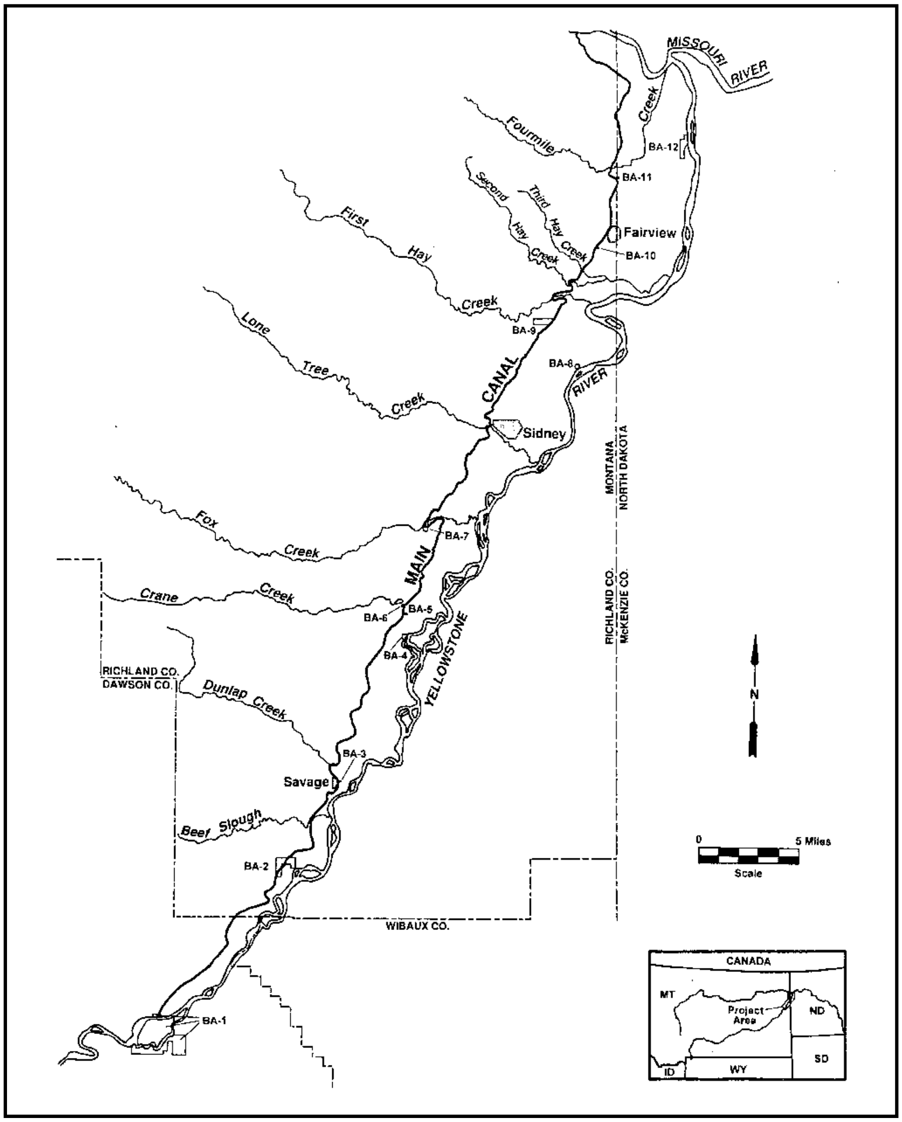


**Figure 3-3. Lower Yellowstone Project main canal (Kordecki et al., 1991: 1.3)**
**Note: Areas marked with BA are survey blocks.**

A search of records, called a Class I inventory, was completed to identify all previously recorded cultural resources in the Lower Yellowstone Project area. This was followed by an intensive pedestrian inventory (Class III) of selected areas to locate unrecorded resources (Figure 3.3). During the Class III inventory, the selected areas were walked, and cultural resources in these tracts were recorded. The Class III inventory covered most of the area of potential effects of the proposed Intake Project (see Figure 3.3 BA-1). In addition to the pedestrian survey, local residents were interviewed to find site leads, and county title records were searched to identify historic persons associated with any of the recorded historic archaeological sites or structures (Kordecki et al., 1999).

The northern portion of the quarry area presently used by the District will not be used as part of construction of either action alternative. It was surveyed in 1991 by Reclamation in advance of reactivation of the rock quarry used to construct Intake Diversion Dam (Coutant, 1991).

### 3.6.3 Existing Conditions

The cultural resources inventories located and recorded 15 cultural resources within or adjacent to the area of potential effects of the three alternatives described in Chapter 2. These are listed in Table 3.15. Of the 15 resources, 7 are significant and eligible for listing on the National Register of Historic Places, and the significance of 2 prehistoric archaeological sites have not been determined.

**Table 3-15. Cultural resources located within the area of potential effects of the action and no action alternatives[10]**

| Site Number | Type | Description | National Register Eligibility |
|---|---|---|---|
| 24DW287 | Architectural structure | Lower Yellowstone main canal and headworks constructed in 1905-1909 | Eligible for listing |
| 24DW295 | Prehistoric archaeological site | Scatter of stone tools, flaking debris, rock cairn, and fire-cracked rock | Unknown eligibility |
| 24DW296 | Historic and prehistoric archaeological site | Historic rock quarry used for construction of Intake Diversion Dam and two small flaking debris and fire-cracked rock scatters. | Eligible for listing |
| 24DW298 | Historic archaeological site | Depressions marking locations of former structures at Old Cameron and Brailey Sub-Camp occupied in 1906 by workers building the main canal. | Eligible for listing |
| 24DW299 | Historic archaeological site | Two depressions with metal scraps and wooden fence posts | Not eligible |
| 24DW429 | Prehistoric archaeological site | Lithic scatter | Recommended not eligible |
| 24DW300 | Historic archaeological site | Two sod rimmed dugout depressions with rusted wire, granite block, and concrete | Not eligible |
| 24DW430 | Prehistoric archaeological site | Late Plains Archaic campsite | Eligible |
| 24DW431 | Historic archaeological site | Three depressions and dump | Not eligible |
| 24DW432 | Prehistoric archaeological site | Lithic scatter of stone tools and flaking debris | Recommended not eligible |
| 24DW433 | Prehistoric archaeological site | Scatter of stone tools and flaking debris – possible stone tool workshop | Unknown eligibility |
| 24DW434 | Prehistoric archaeological site | Middle Plains Archaic artifact scatter | Eligible for listing |
| 24DW435 | Prehistoric archaeological site | Low density lithic scatter | Recommended not eligible |
| 24DW436 | Historic archaeological site | Possible homestead site, although no patent was ever issued | Not eligible due to lack of integrity |
| 24DW437 | Historic archaeological site | Log foundation of a former structure – possible attempt at homesteading | Not eligible due to lack of integrity |
| 24DW438 | Prehistoric archaeological site | Lithic scatter of stone tools and flaking debris | Recommended not eligible |
| 24DW443 | Architectural structure | Intake Diversion Dam built in 1906-1910, dike, cableway system and engineer's house, and abandoned power plant | Eligible for listing |

[10] National Register of Historic Places eligibility based upon consensus determinations with the Montana State Historic Preservation Office.

| Site Number | Type | Description | National Register Eligibility |
|---|---|---|---|
| 24DW444 | Historic archaeological site | Archaeological remains of two cabins | Not eligible due to lack of integrity |
| 24DW447 | Architectural buildings and historic archaeological site | Headworks Camp/Gate Tender Residence, garage, and outhouse | Eligible for listing |

***Historic Properties***

Three of the cultural resources eligible for listing on the National Register of Historic Places (24DW287, 24DW443, and 24DW447) within the area of potential effects are architectural sites associated with the Lower Yellowstone Project. These include the main canal and headworks, Intake Diversion Dam, and the Headworks Camp and Gate Tender Residence. Another important site is Old Cameron and Brailey Sub-Camp (24DW298) that was occupied by workers building the main canal. Finally, the Lower Yellowstone Rock Quarry (24DW296) is the original source of rock used to build Intake Diversion Dam. It also has a prehistoric archaeological component. These five sites, along with other features of the Lower Yellowstone Project, are part of an historic district significant for its association with the broad pattern of federal reclamation efforts in the early twentieth century and agricultural development of the lower Yellowstone valley. When consulted by Reclamation, the Montana State Historic Preservation Office agreed these sites are significant under the National Historic Preservation Act (NHPA).

Based on consultation with the Montana State Historic Preservation Office (SHPO), two prehistoric archaeological sites in the area of potential effects are eligible for listing on the National Register of Historic Places. Site 24DW430 is an extensive scatter of stone tools, pieces of bone, and fire-cracked rock. It appears to be a campsite occupied during the Late Plains Archaic, a period dating to 3,000 to 1,500 years ago. Finally, the second (24DW434) is a multi-component campsite with prehistoric stone tools and pottery from the Middle Plains Archaic, which dates 5,000 to 3,000 years ago.

Site 24DW295, a scatter of stone tools, flaking debris, rock cairn, and fire-cracked rock; the prehistoric component of 24DW296; and a prehistoric stone tool workshop (24DW433) are of unknown significance and have been recommended for archaeological testing. Sites 24DW429, 24DW432, 24DW435 and 24DW438, are all lithic scatters which do not meet the criteria of eligibility under NHPA. SHPO concurrence with these recommended determinations will be requested before consultation is complete. The remaining six sites in Table 3.15 are ineligible due to lack of integrity or the ability to yield important information (Kordecki et al., 1999).

# 4. Environmental Consequences

## 4.1. Introduction

This chapter describes the anticipated beneficial and/or adverse impacts of the proposed action alternatives on the relevant environmental resources described in Chapter 3. The chapter evaluates direct, indirect, and cumulative effects and quantifies these effects whenever possible. Actions and commitments intended to minimize environmental impacts are also described.

Reclamation and the Corps believe the consequences of the No Action Alternative (Continue Present Operation) are adequately evaluated and disclosed in the 2010 EA. As such, information on the No Action Alternative is not repeated in this chapter.

Issues or resources described in Chapter 3 and analyzed in this chapter are:

- Geomorphology
- Surface water quality
- Aquatic communities
- Federally-listed species and state species of special concern
- Recreation
- Social and economic conditions
- Lands and vegetation
- Wildlife
- Historic properties (cultural resources)

The action alternatives' scope of effects for the following resources is very similar to the scope of effects evaluated in the 2010 EA for the Rock Ramp and Relocate Main Channel Alternatives. As such, the previously analyzed effects are incorporated by reference and the following resources have not been re-evaluated.

- Climate
- Air Quality
- Hydrology
- Lower Yellowstone Project irrigation districts
- Environmental justice
- Indian trust assets

## 4.2. Adaptive Management

Adaptive management (AM) is a strategy for addressing a changing and uncertain environment that relies on common sense and learning. Adaptive management draws upon theories from ecology, economics, social sciences, engineering, and other disciplines as well as on concepts such as social learning, operations research, economic values, and political differences with ecosystem monitoring, modeling, and science (National Research Council, 2004). Application of AM is intended to support actions when the scientific knowledge of their effects on ecosystems is unknown or limited (Holling, 1978). This does not mean that actions are delayed or postponed until there is agreement that enough has been learned about an ecosystem. Rather, AM provides a means to implement actions, monitor, and adjust management actions when new information becomes available.

The basic theme of AM is to continually evaluate project operations and effects and develop actions that respond to observed changes. This means that project managers must revisit objectives and develop a range of choices for how they would manage a project if changes occur. Managers must also use the information gained through monitoring and evaluation and apply it to future decisions. A key to successful implementation of any AM strategy is to involve stakeholders in the learning and evaluation processes.

For the purposes of the Intake Project, if an action alternative is selected for implementation, the Corps would be responsible for a 1 year warranty period to ensure the project physically performs as designed. Reclamation would use AM to maximize project success. The AM plan would be implemented to address project uncertainties through monitoring of responses to management actions, assess progress towards project objectives, and implement potential adjustments to maximize project performance.

For further information on AM see Appendix J for the Adaptive Management Plan.

## 4.3. Geomorphology

### 4.3.1 Introduction

- How would the fish passage alternatives affect the geomorphic characteristics of the lower Yellowstone River?

### 4.3.2 Methods

To evaluate effects to channel characteristics, the existing channel slope in the Intake Project area was compared to the designed slope of the action alternatives. Additional details on baseline data and methodology are presented in the 2010 EA.

### 4.3.3 Results

#### *4.3.3.1 Short-Term and Long-Term Effects to Channel Characteristics*

**Bypass Channel Alternative**

The Bypass Channel Alternative would not change the bed slope of the main channel of the Yellowstone River. The slope of the proposed bypass channel would be approximately 0.06%, compared to a slope of approximately 0.05% in the existing high flow chute. The proposed bypass channel slope compares favorably to 10 side channels within about 50 river miles with slopes ranging from 0.01% to 0.07% (Corps, 2010).

**Rock Ramp Alternative**
The Rock Ramp Alternative would decrease the slope near the existing dam crest and boulder field from an average of 2.0% (0.02 feet/feet) down to a maximum of 0.9% (0.009 feet/feet). The final design of the rock ramp likely would have a variable slope of 0.2% - 0.9% (0.002 feet/feet **–** 0.009feet/feet), but this slope would be based on physical modeling.

#### *4.3.3.2 Short-Term and Long-Term Effects to the Channel Migration Zone*

The channel migration zone (CMZ) of the Yellowstone River includes areas prone to lateral channel movement over the next 100 years (Thatcher et al., 2008). The CMZ is an important characteristic of the Yellowstone River and is an issue raised by resource agencies, therefore an analysis of impacts to the CMZ based on available information is included in this EA.

Most of the river corridor on Joe’s Island is included in the historic migration zone. Thatcher et al. (2008) defines the historic migration zone as the combined portion of the river corridor that represents a zone of historic channel occupation over approximately the past 50 years. More information on the CMZ can be found in Chapters 3 and 4 of the Intake Final EA (2010).

Analysis of the CMZ shows how the alternatives could change the river corridor in the area directly affected by Intake Project features.

**Bypass Channel Alternative**
The Bypass Channel Alternative would affect a total of approximately 475 acres in the CMZ (both long and short term). Most of this area is classified as wetlands, and a discussion of wetland impacts is included in the wetlands section of this Supplemental EA. There would be 50 acres in the CMZ that would experience long-term effects from construction of the new channel. Figure 4.1 shows the permanent features in the CMZ. Approximately 425 acres in the CMZ would experience short-term effects from placement of temporary features such as haul roads, construction zones, and stockpiles needed to create the permanent features. Table 4.1 shows the number and types of acres in the CMZ that would be affected by features of this alternative.

In addition, the reduction in magnitude and frequency of flow in the existing high flow channel downstream from the channel diversion is not expected to have measurable impacts on the channel geomorphology. The area has remained relatively unchanged for at least 50 years.

**Rock Ramp Alternative**
This alternative would affect a total of 57 acres within the CMZ (Table 4.2). Much of this area is classified as wetlands, and a discussion of wetland impacts is included in the wetlands section in this Supplemental EA. Of these 57 acres, 32 would experience long-term effects from

construction of the new weir and rock ramp. The remaining 25 acres would experience short-term effects from placement of temporary features, such as construction zones and haul roads. Figure 4.2 shows the permanent features of the Rock Ramp Alternative in the CMZ, and Table 4.2 shows the numbers and types of acres affected by features of this alternative.

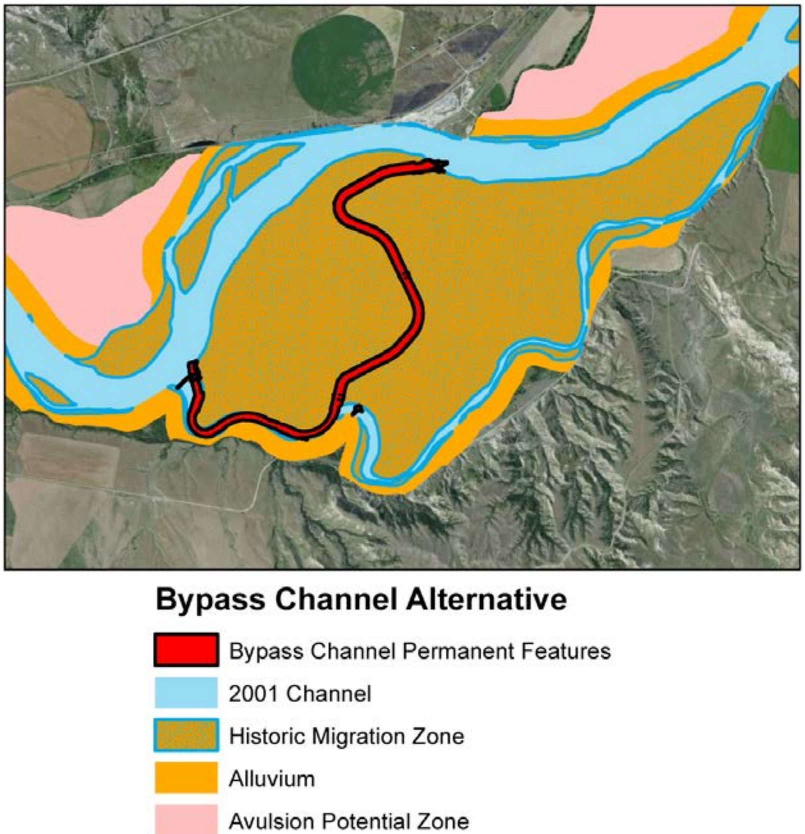


**Figure 4-1. Bypass channel alternative permanent features within the channel migration zone**

**Table 4-1. Channel migration zone acres temporarily or permanently affected by the bypass channel alternative**

| Bypass Channel Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Main Channel (acres) | Historic Migration Zone (acres) | Alluvium (acres) | Avulsion Potential Zone (acres) | Channel Migration Zone TOTAL (acres) |
| Permanent Features | New Channel & Dam | 2 | 48 | 0 | 0 | 50 |
| Tempo-rary Featur | Construction Zone | 0 | 400 | 15 | 0 | 415 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Haul Roads | 0 | 8 | 2 | 0 | 10 |
| **TOTAL Permanent** | | **2** | **48** | **0** | **0** | **50** |
| **TOTAL Temporary** | | **0** | **408** | **17** | **0** | **425** |

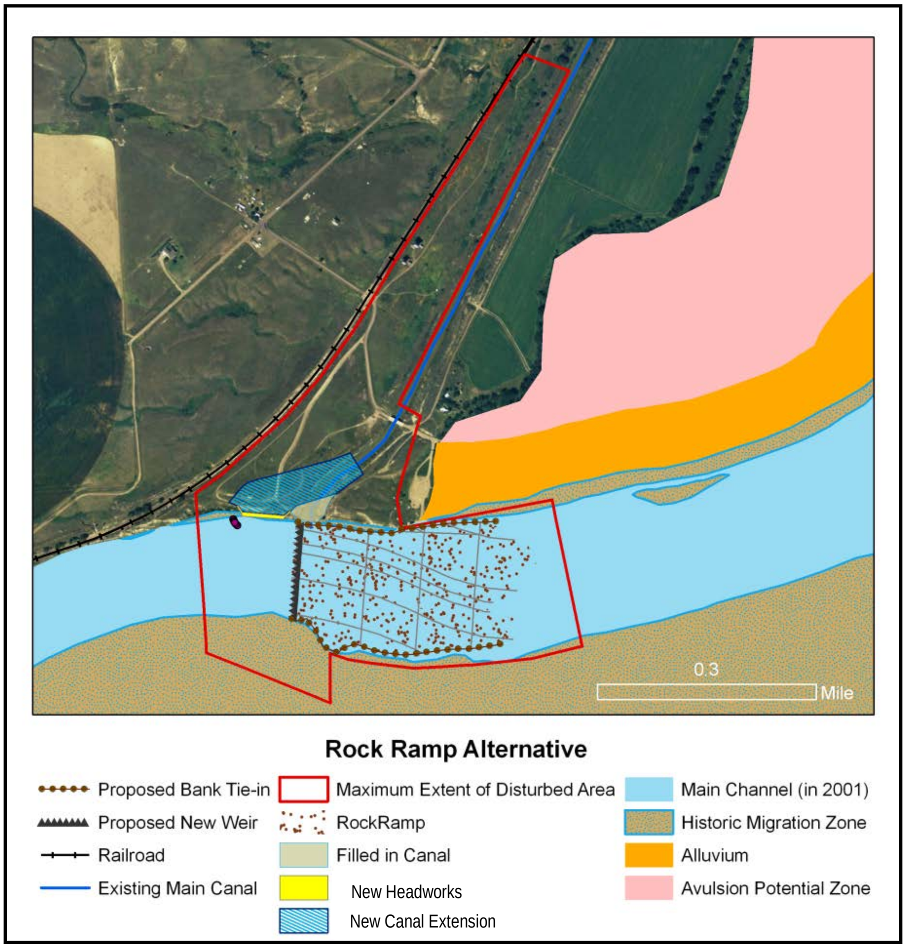


**Figure 4-2. Rock ramp alternative permanent features within the channel migration zone**

**Table 4-2. Channel migration zone acres temporarily or permanently affected by the rock ramp alternative**

| **Rock Ramp Alternative** | | | | | | |
|---|---|---|---|---|---|---|
| | | Main Channel (acres) | Historic Migration Zone (acres) | Alluvium (acres) | Avulsion Potential Zone (acres) | Channel Migration Zone TOTAL (acres) |
| **Permanent Features** | New Weir & Rock Ramp | 32 | 0 | 0 | 0 | 32 |
| **por ary Feat** | Construction Zone | 0 | 4 | 0 | 0 | 4 |

| Rock Ramp Alternative | | | | | | |
|---|---|---|---|---|---|---|
| | | Main Channel (acres) | Historic Migration Zone (acres) | Alluvium (acres) | Avulsion Potential Zone (acres) | Channel Migration Zone TOTAL (acres) |
| | Haul Roads | 1 | 18 | 2 | 0 | 21 |
| **TOTAL Permanent** | | **32** | **0** | **0** | **0** | **32** |
| **TOTAL Temporary** | | **1** | **22** | **2** | **0** | **25** |

**Bypass Channel Alternative**
The main construction-related feature of the Bypass Channel Alternative is excavation of approximately 1.2 million cubic yards of material. The bypass channel is approximately 15,500 feet in length, of which approximately the upper 1/3 is in the existing high flow channel. The remaining 2/3 crosses Joe's Island and rejoins the Yellowstone River just below the existing rock field. Depth of channel excavation ranges from about 4 feet in the upper reaches to nearly 20 feet towards the downstream end. The critical concept in upstream fish passage design is the location of the downstream fish entrance and the attraction flow (Larinier, 2001). The optimal location of the downstream fish entrance is that it is close enough to the weir that fish may locate it as they look for a barrier-free pathway once they encounter the obstruction.

Other features include rock riprap at two bends and vertical riprap control structures at the downstream end and at two locations in the channel (approximately 1/3 and 2/3 of the way up from the downstream end). The upstream entrance includes a concrete sill with riprap sills tied into the surrounding ground. The concrete and riprap structure at the upstream entrance is intended to prevent excessive flow through the bypass and to minimize the potential for the entire Yellowstone River to capture and relocate to the bypass channel. A concrete sill is proposed due to the extreme ice forces imposed on the upstream entrance of the bypass channel. The two downstream riprap sills are proposed for maintaining channel slope and allowing for early identification of channel movement. Similar to the upstream control structure, the downstream riprap sills would be over-excavated and backfilled with native river rock to give the appearance of a seamless channel invert while providing stability during extreme events. Also, a concrete sill and rip rap structure to maintain channel form, gradient, and location will be placed at the downstream fish entrance to the bypass channel.

#### *4.3.3.3 Short-Term and Long-Term Effects of Channel Modifications*

A new concrete weir is proposed just upstream from the existing rock weir with a surface elevation of 1990.5 feet (NAVD 88) to provide sufficient water surface elevations to divert the appropriate flows through the bypass channel and to maintain irrigation diversions. The top of the timber crib in the existing weir is at elevation 1988 feet (NAVD 88) with riprap material periodically placed on top by the LYIP. The crest of the new weir would be located approximately 40 ft upstream from the existing weir. The space between the existing crest and proposed crest would be partially filled with material excavated from the bypass channel with the remainder filled with riprap and seeded with native materials.

While the proposed bypass channel would divert more flow than the existing high flow channel, construction of the bypass channel is not expected to significantly alter the main channel's characteristics.  Because the proposed bypass diverts sediment suspended within the top of the water column, it would not be expected to pass larger sediments.  Analysis was completed to determine the maximum diversion without appreciably  impacting sediment transport in the main channel.  Sediment modeling using HEC-RAS indicates that diverting more than 15% of the total Yellowstone River flow increases the risk of sediment deposition in the main channel in front of the headworks.

The existing high flow channel downstream of the channel diversion would not be physically altered during construction, but flow downstream from the channel diversion would decrease in frequency and magnitude.  Currently, the high flow channel begins flowing when total Yellowstone River discharges are above approximately 30,000 cfs (between 1 and 2-year discharge).  The proposed channel diversion would pass some water through a low-level conduit at 30,000 cfs, but the discharge would be less than existing conditions.  Once the Yellowstone River is flowing at 60,000 cfs (≈5-yr discharge), the channel diversion would be overtopped, allowing greater flow into the high flow channel below the diversion.  As total Yellowstone River flows increase, discharge in the existing high flow channel below the channel diversion would approach existing flows.

Future design efforts on the channel diversion will optimize the flow split between the proposed bypass channel and the existing high flow channel downstream from the diversion to minimize adverse impacts to the high flow channel and existing native fish passage while maximizing benefits on the constructed bypass channel.

**Rock Ramp Alternative**

To construct the Rock Ramp Alternative, the existing boulder field would be moved and reworked.  The new rock ramp would extend farther downstream than the existing boulder field and be built over the existing Intake Diversion Dam structure.  A new weir would be constructed as well.  The existing boat ramp would be removed and replaced at an undetermined location near the Intake Project area.

The Rock Ramp Alternative would add a total of 11 new structures in or next to the river channel and remove, bury, or replace 4 of them for a net gain of 7 structures.  The total number of structures in the Rock Ramp Alternative is 12, because the existing headworks has been buried in place and acts as a bank stabilizing structure.

The estimated length of bank stabilizing features would increase from 1,643 linear feet to 4,542 linear feet.  The existing boulder field covers approximately 6 acres of riverbed, and the new rock ramp structure would cover approximately 32 acres.  The additional area of the new rock ramp structure would reduce slope and control water velocity to allow fish passage over the structure.

Table 4.3 summarizes the number of man-made structures in each alternative and the estimated sizes of those features.

**Table 4-3. Comparison of bank stabilization features by alternative**

| Feature | Bypass Channel | | Rock Ramp | |
|---|---|---|---|---|
| | # of Structures | Size (feet or acres) | # of Structures | Size (feet or acres) |
| Existing Headworks | 1 | 285 feet[1] | 1 | 285 feet[1] |
| New Headworks | 1 | 440 feet | 1 | 440 feet |
| Existing Dam | 1 | 664 feet[2] | 0[2] | 0[2] |
| New Control Structure/Weir | 1 | 664 feet | 1 | 664 feet |
| Riprap | 2 | 1400 feet | 1 | 3153 feet |
| Existing Boulder Field | 1 | 6 acres | 0[2] | 0[2] |
| Rock Ramp | 0 | 0 | 1 | 32 acres |
| New Side Channel | 1 | 9400 feet[3] | 0 | 0 |
| Rock Sills | 4 | 200 feet | 0 | 0 |
| | | | | |
| **Total** | **12** | | **5** | |

1 - Buried in place and remains as a bank stabilizing structure.
2 - Buried in place but does not contribute to bank stabilization.
3 - Excludes part of existing high flow channel that will be used for the bypass channel.

**Cumulative Effects**

To assess the cumulative effects of the proposed alternatives, a geographic information system (GIS) inventory of bank stabilizing structures (Natural Resources Conservation Service, 2003) was analyzed from Cartersville Dam to the confluence with the Missouri River. This was done to compare the number of features upstream to the next fish passage barrier in the context of the larger section of the lower Yellowstone River. The inventory of stabilization features in the lower Yellowstone River from Cartersville Dam to the confluence with the Missouri River indicates there are currently 131 features for a total length of 280,515 feet.

The Rock Ramp would result in a minor increase of 1.6% in the length of stabilization features on the lower Yellowstone River from Cartersville Dam to the confluence with the Missouri River. The Bypass Channel Alternative would require approximately half of the stabilization features needed for the Rock Ramp and would have less effect.

**Actions to Minimize Effects (Appendix I)**

River morphology will be monitored to assess potential changes to the stream channel resulting from construction of the selected alternative. The Environmental Review Team (ERT) will be consulted regarding specific measures to offset impacts if substantive changes are believed to have been caused by the Intake Project.

### 4.3.4 Summary

The Bypass Channel Alternative would have no short-term or long-term effect on main channel bed slope. This alternative would permanently affect 50 acres in the CMZ and add approximately 1,400 feet of bank stabilization structures in the Intake Project area. Short-term effects include temporary disturbance of 425 acres within the CMZ.

Long-term effects of the Rock Ramp Alternative consist of a reduction in the slope of the main channel in the area of the existing Intake Diversion Dam and associated features. This alternative would permanently affect 26 acres in the CMZ and increase the amount of bank stabilizing structures by 2,899 feet.

## 4.4. Surface Water Quality

### 4.4.1 Introduction

- How would fish passage alternatives affect water quality in the lower Yellowstone River?

### 4.4.2 Methods

Construction of either action alternative would disturb existing sediment, potentially releasing contaminants into the water column. Additionally, sediment could be mobilized due to altered hydraulic properties. To evaluate potential impacts associated with construction, sediment samples from sites upstream and downstream of Intake Dam were analyzed. Details of the sampling methods and results are described in the 2010 EA.

### 4.4.3 Results

#### *4.4.3.1 Short-Term and Long-Term Effects of the Alternatives*

**Bypass Channel Alternative**

Approximately 1.2 million cubic yards of soil would be excavated to construct the bypass channel using either mechanical excavation or hydraulic dredging. The material removed to construct the bypass consists of cohesive, fine-grained soils on top of coarse-grained soils in the lower part of the profile. Short term increases in turbidity are likely to result from the construction (excavation, dewatering, and transport), but best management practices, detailed by the contractor in its construction storm water management plan, will be used to control surface runoff. Most excavated materials will be placed within the waste pile located out of the floodplain (site shown in Figure 2.4). Erosion and runoff control measures will be utilized to prevent runoff from the construction site into drainages that lead to the river (see "Actions to Minimize Effects" section below). Approximately 5,000 cubic yards excavated from the bypass channel would be used to provide partial fill between the existing dam and the new weir. Work in the existing channel would temporarily increase turbidity during construction and would result in some sedimentation and siltation downstream. Construction-generated sediment deposited near the dam would likely be transported downstream during subsequent high flow events. Sediment would continue to erode and be transported from the new bypass channel until it stabilizes.

Because concentrations of nutrients and trace elements are similar in the sediment samples and the river water, no significant change in concentrations of these constituents is expected. It is unknown to what extent any sediment deposited upstream of the existing dam would be transported downstream in the new channel. However, sediment deposition upstream of Intake Dam is relatively minor and appears to be limited by frequent scouring during high flow events.

Because the Bypass Channel Alternative would not affect cumulative river flow quantity, point source discharges, or non-point source discharges after construction, all water quality effects would be temporary.

**Rock Ramp Alternative**
Construction of the rock ramp would disturb sediments in the existing river channel to a greater degree than the bypass alternative, but the amount of sediment transported downstream during construction would still be considered minor and short term.

Because concentrations of nutrients and trace elements are similar in the sediment samples and the river water, no substantial change in concentrations of these constituents is expected.

Because the Rock Ramp Alternative would not affect river flows, point source discharges, or non-point source discharges after construction, all water quality effects would be temporary.

**Cumulative Effects**
With implementation of actions to minimize effects, impacts of the action alternatives on water quality would be minor and temporary. No changes in beneficial uses or identified impairments would occur.

**Actions to Minimize Effects (Appendix I)**
- A water quality monitoring program will be established to ensure water quality standards are not violated during construction activities.
- Equipment for handling and conveying materials during construction shall be operated to prevent dumping or spilling the materials into wetlands and waterways.
- Discharges of dredged or fill material into waters of the U.S. will be carried out in compliance with provisions of Section 404 of the Clean Water Act and requirements contained in the Section 401 water quality certification.
- Erosion control measures will be employed to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness, particularly after storm events, and the most effective techniques will be identified and employed.
- Silt barriers, fabric mats, or other effective means will be placed on slopes or other eroding areas to reduce sediment runoff into stream channels and wetlands until vegetation is re-established. This will be accomplished either before or as soon as practical after disturbance activities.
- Contamination of water at construction sites from spills of fuel, lubricants, and chemicals will be minimized by following safe storage and handling procedures in accordance with state laws and regulations.
- Hazardous materials will be handled and disposed of in accordance with a hazardous waste plan.
- Contractor will be required to have an approved construction storm water management plan to control runoff.

### 4.4.4 Summary

The Bypass Channel Alternative would cause temporary increases in turbidity and sedimentation during construction, but no long-term changes in water quality are anticipated. The Rock Ramp Alternative would likewise cause temporary increases in turbidity and sedimentation during construction. No long-term changes in water quality are anticipated as a result of any of the alternatives.

## 4.5. Aquatic Communities

### 4.5.1 Introduction

- How would the alternatives affect aquatic communities in the Intake Project area?

This section addresses aquatic communities that may be affected either by construction of bypass features or by subsequent changes in habitat conditions on the lower Yellowstone River. Intake Project construction may impact aquatic communities on either a temporary or permanent basis. Temporary impacts are associated with initial construction or temporary fixtures associated with construction after which habitats are expected to revert to previous conditions. Temporary impacts also could include short-term changes in flow or water quality that may affect aquatic communities. Permanent impacts are long-term impacts associated with construction of permanent facilities such as a new concrete weir, rock ramp or bypass channel.

### 4.5.2 Methods

To analyze the impacts of the proposed alternatives in the Yellowstone River, a literature search was conducted to identify fish, mussels, and macroinvertebrates currently inhabiting areas that could be affected by the Intake Project, followed by coordination with resource agencies to confirm presence/absence of species. Consideration was also given to the types of habitats and how those habitats might be impacted. Potential impacts were identified and related to the different aquatic communities.

To help in quantifying habitat-based benefits of improved fish passage at Intake Dam, the Fish Passage Connectivity Index (FPCI) was used. The FPCI was developed to evaluate ecosystem outputs of alternative measures for fish passage improvements on the Upper Mississippi River System (UMRS) for cost effectiveness and incremental analysis. The model was initially developed for use in the plan formulation process for the Navigation and Ecosystem Sustainability Program (NESP) for the Lock and Dam 22 fish passage improvement project. The model is applicable to fish passage improvement projects at other navigation dams and to other large rivers with appropriate modifications. The *Fish Passage Benefits Analysis – Intake Diversion Dam Fish Passage Project, Lower Yellowstone River, Intake, Montana* can be found in Appendix E, Attachment 1. Results of the modeling are utilized below to describe benefits of each alternative to fish passage. Although there is considerable uncertainty in the scientific community with regard to all the parameters that may affect fish passage, the modeling is used to provide an estimate of benefits and a relative comparison between alternatives.

### 4.5.3 Results

#### *4.5.3.1 Short-Term and Long-Term Effects of the Alternatives*

There is no change in the short and long-term effects disclosed in the 2010 EA for mussels, macroinvertebrates, and invasive aquatic species. In addition, short and long-term effects of the Bypass Alternative are anticipated to be similar to the Rock Ramp Alternative for these organisms. No additional analysis of effects related to these organisms is presented.

**Fish**
Improving passage at Intake would potentially open approximately 165 miles of additional habitat in the Yellowstone River to native fish currently impeded by the diversion structure. Additionally, successful fish passage at Intake would increase ecological connectivity and help maintain genetic diversity in populations of fish that might otherwise be isolated. Either fish passage alternative would likely promote a larger, more diverse and healthy fish population as a result of improved passage.

Table 4.4 presents the results of the FPCI modeling for each of the alternatives. There are many factors that play a role in the ability of fish passage alternatives to be successful and many uncertainties with regard to fish passage design requirements. Both action alternatives, while they produce similar results in the modeling, have positives and negatives regarding the ability to improve fish passage.

**Bypass Channel Alternative**
Strong swimming fish (e.g., adult sauger) currently pass upstream at Intake Dam under some flows. The Bypass Channel Alternative would be constructed to provide a range of lower flow velocities to accommodate weaker swimming fish such as pallid sturgeon and juvenile native fish. The Bypass Channel Alternative would not only increase the range of flows in which fish can pass, but it would provide passable flows in the bypass channel across all seasons, helping to accommodate early and late spawners that migrate outside of the spring/summer high flow window. There is concern that during low runoff years, velocities at the downstream bypass channel entrance may not be sufficient to attract migrating fish.

Flows within the bypass channel would have less turbulence than the rock ramp. Sturgeon appear to have difficulty negotiating turbulence in a large scale rock ramp model (White & Mefford, 2002). However, it is uncertain exactly what kind of shear flows or eddies may form near the downstream entrance to the bypass channel. Complex flow patterns at the downstream entrance to the bypass channel could affect the ability of some fish to locate the channel entrance and affect their ability to pass.

A large eddy currently develops at the proposed downstream entrance to the bypass channel at some flows. Montana FWP has expressed concerns that the eddy may limit the effectiveness of the bypass channel for fish passage. This situation is being modeled by the Corps and Reclamation to identify means to reduce the impact of eddies and other velocity barriers. While the FPCI model does consider water velocities and swimming abilities of fish, turbulence is not evaluated as a parameter in the FPCI benefits analysis, and therefore not considered in the model benefits output.

**Table 4-4. Fish passage connectivity index model results for each alternative**

| Common Name | Acres of Habitat, Intake to Cartersville | No Action: Є = Fish Passage Connectivity | No Action: Habitat Units (Є X acres) | Bypass Channel: Є = Fish Passage Connectivity | Bypass Channel: Habitat Units (Є X acres) | Rock Ramp: Є = Fish Passage Connectivity | Rock Ramp: Habitat Units (Є X acres) |
|---|---|---|---|---|---|---|---|
| Shovelnose sturgeon | 12637 | 0.13 | 1620 | 0.50 | 6318 | 0.60 | 7582 |
| Paddlefish | 12637 | 0.19 | 2388 | 0.50 | 6318 | 1.00 | 12637 |
| Goldeye | 10141 | 0.06 | 641 | 0.70 | 7099 | 0.60 | 6085 |
| Smallmouth buffalo | 17166 | 0.10 | 1766 | 0.70 | 12016 | 0.60 | 10299 |
| Blue sucker | 12637 | 0.08 | 1004 | 0.50 | 6318 | 0.60 | 7582 |
| White sucker | 12637 | 0.00 | 15 | 0.70 | 8846 | 0.60 | 7582 |
| River carpsucker | 10141 | 0.06 | 569 | 0.70 | 7099 | 0.20 | 2028 |
| Shorthead redhorse | 12637 | 0.06 | 798 | 0.70 | 8846 | 0.60 | 7582 |
| Channel catfish | 17166 | 0.06 | 996 | 0.70 | 12016 | 0.60 | 10299 |
| Smallmouth bass | 10141 | 0.07 | 662 | 0.70 | 7099 | 0.48 | 4868 |
| Walleye | 15818 | 0.03 | 448 | 0.50 | 7909 | 1.00 | 15818 |
| Sauger | 15818 | 0.04 | 691 | 0.50 | 7909 | 0.60 | 9491 |
| Freshwater drum | 17166 | 0.06 | 1109 | 0.70 | 12016 | 0.60 | 10299 |
| **Average Habitat Units** | | | **978** | | **8447** | | **8627** |

From a hydraulic standpoint, the proposed bypass channel will be fairly consistent with natural side channels in the Yellowstone River (Appendix A2, Attachment 6) and is intended to exhibit similar habitat conditions. Based on telemetry studies in the lower Missouri River and similar research conducted in 2011 on the Yellowstone River, it appears pallid sturgeon migrate in a characteristic manner, moving upstream primarily along the inside bends of the river and entering side channels located on inside bends (BRT, 2012). This pattern of behavior is consistent with that observed in reproductive pallid sturgeon tracked in the highly-modified, channelized lower Missouri River where it appears they optimize their allocation of energy by utilizing the energetically least-demanding migratory pathways (McElroy et. al., 2012). The bypass channel is intended to function much like a natural side channel, and as such, is likely to be utilized by many species of fish, including sturgeon. The angles between side channels and the main channel are being investigated with the intent to further replicate natural conditions and minimize shear flow barriers. The degree of naturalness of the bypass feature is also a variable not included in the FPCI modeling, and therefore not reflected as part of the model output.

One of the main uncertainties regarding partial flow fish passage designs revolves around flow attraction at the entrance to the bypass channel and the forces that are key to that attraction. Two parameters closely related to fish attraction include the percentage of flow captured by the particular design and the location of the passage feature. Both of these parameters are captured in the FPCI benefits modeling (Appendix E, Attachment 1); however, what constitutes an effective attraction flow and the cues fish use to determine viable and preferred pathways is not known.

The bypass channel is currently designed to carry approximately 15% of the total flow to keep sediment balance from becoming an issue at the new headworks (Appendix A2, Attachment 6). While Larinier (2000) suggests optimal fishway designs on large river systems should capture 10% of the total flow during low flow periods, or 1.5% of high flows, it was recommended by the BRT that at least 10% of the overall flow would be a minimum requirement for passage with 30% or more being desirable based on professional judgment. Thus, a 15% flow capture design for the bypass channel is not the most favorable bypass option from a biological perspective according to the BRT, but does aid in managing sedimentation issues. As such, it is considered a compromise for addressing the uncertainties of sedimentation and fish attraction flows.

The AM plan (Appendix J) describes the monitoring plan associated with improving fish passage and potential adjustments that could be made if the bypass channel does not perform as expected. One potential adjustment includes the construction of a flow augmentation structure located near the downstream entrance the bypass channel. Such a structure would increase flow at the bypass channel downstream entrance (up to 23% of main channel flow), presumably increasing its attractiveness to migrating fish. While this flow augmentation structure is currently considered an AM feature, it may be included in the final design should a determination be made that it is needed prior to construction.

Intake Dam will be raised by approximately one foot through construction of a new weir approximately 40 feet upstream of the existing structure and will continue to be a fish passage impediment in the bypass channel alternative. The existing dam would remain in place and be incorporated into the new structure through the placement of gravel and rockfill between the two structures. The increased height is required in order to ensure sufficient flows are present in the bypass channel for passage and into the headworks for irrigation. Concerns have been expressed that raising the diversion weir crest may further aggravate passage that the dam currently is able to accommodate because of changed hydraulic conditions caused by the weir, as well as the potential for exposed metal to impact sturgeon and paddlefish with highly developed electroreception.

Concern has also been raised that velocities across the top on the new weir will be too high to allow passage for some native species. The distance across the top of the proposed weir has been reduced considerably to address this issue. Hydraulic analyses indicate that flows will not appreciably change across the revised structure compared to the current diversion structure. While the total distance from the downstream and upstream ends of the structure will increase to some extent by moving the new weir upstream, depths across the dam face do not change from the existing condition. Although the potential for fish passage across the proposed structure will likely remain unchanged compared to the existing diversion structure, overall fish passage associated with this action alternative is anticipated to improve as a result of the new bypass channel. The ability of native fish to pass the new diversion structure either across the weir, through the bypass channel, or through the existing high flow channel will be monitored and addressed through AM.

As mentioned above, metal components utilized in construction can potentially affect the passage of electroreceptive fish by generating an electrical field. Intake currently has a large amount of metal components utilized in its original construction and maintenance, including

1x4-inch metal straps spaced every 24 inches across the weir. Any new construction at Intake is being planned in a way that will either minimize the use of exposed metal, or remove it after construction is completed. As such, the action alternatives are not considered to create additional passage issues for electroreceptive fish.

The proposed alignment of the bypass channel is designed to follow the upper mile of the existing high flow channel at which point the channel would diverge and flow toward the proposed weir location on the river. At the point of departure, a channel diversion would be constructed, effectively restricting flow to the existing high flow channel to keep most of the flow in the proposed bypass channel. The channel diversion would be designed to allow flows into the existing high flow channel through multiple pipes or culverts during low to normal flows (Yellowstone River discharge of 7,000 cfs or greater). Larger events would flow through these conduits and also overtop the diversion (Yellowstone River discharges greater than 60,000 cfs, or 20% annual exceedence probability).

Currently the existing high flow channel only begins to carry water at approximately 25,000 – 30,000 cfs (equaled or exceeded approximately 50% annually). As such, the hydrologic character of the channel is likely to change somewhat because it will carry more water during low to normal flows with up to 40 cfs diverted when Yellowstone River is flowing at 7,000 cfs or more. The channel would not convey flows greater than 40 cfs (as it currently does at Yellowstone River flows of greater than 25,000 cfs) until flows exceed 60,000 cfs. The new condition will result in a less stagnant condition in the side channel, especially during lower Yellowstone River flows. Therefore, it is anticipated that the existing high flow channel may provide better habitat for fish during low flows. Existing fish passage benefits provided by the current high flow channel should be improved by the bypass channel alternative. In addition, the new bypass channel is expected to function much like a high flow channel itself having many habitat characteristics of other side channels in the lower Yellowstone River. This combination should add additional habitat complexity to the site.

There is uncertainty as to the degree native fish other than pallid sturgeon will be able to pass either the proposed weir, the proposed bypass channel, or the existing high flow channel once that diversion is constructed. The ability of native fish to access the Yellowstone River upstream of Intake will be monitored and addressed through AM.

The Bypass Channel Alternative would result in the excavation of more material during construction than either the No Action alternative or the Rock Ramp alternative. Increases in sedimentation and turbidity during construction could cause temporary adverse effects on aquatic organisms particularly if it occurred during the spawning season. However, most fish species in the lower Yellowstone River are adapted to highly turbid water, so construction-related effects on fish populations would likely be minor and temporary.

**Rock Ramp Alternative**

The rock ramp would have lower velocities and greater depth than that over the existing dam and would likely improve fish passage over current conditions. The rock ramp would function as a long riffle, allowing passage and providing foraging and spawning habitat for a variety of fish species. However, the design of the rock ramp will have a greater slope, higher velocities, and greater amounts of turbulence than the Bypass Channel Alternative, as well as other riffles/rapids found in the lower Yellowstone River (see Appendix B). The proposed ramp also falls outside of the range of proportional low velocities [< 6 feet per second (fps)] observed in natural riffles.

Strong swimming fish (e.g., adult sauger) can currently pass upstream at Intake Dam under most flows. Nonetheless, the Rock Ramp Alternative would improve passage for these species by reducing velocities and increasing the range of flows and seasonal timeframes when fish can pass. The rock ramp design is very long (1,600 feet) in order to provide for a shallower slope necessary to reduce velocities. While the rock ramp modeling shows that a majority of the ramp might accommodate velocities in a range of most species' "burst" speed, there are limited areas where the ramp would provide resting areas along its path. Thus, passage may be problematic due to the length for which a fish must sustain a burst swimming speed as it passes across the entire rock ramp.

As mentioned earlier, one area of uncertainty in designing fish passage projects is designing the fishway such that a fish will be attracted to it and utilize it. Because the rock ramp alternative is designed to provide passage across the full width of the main channel, and is designed to carry the whole flow of the main channel, there would be very little risk in a fish being able to find the fish passage feature.

This alternative would result in more in-channel placement of fill material, but have less soil excavation than the bypass alternative. Increases in sedimentation and turbidity during construction could cause a temporary adverse effect on aquatic organisms particularly if they occurred during the spawning season. However, most fish species in the lower Yellowstone River are adapted to highly turbid water, so construction-related effects on fish populations would likely be minor and temporary.

Because this alternative is constrained to the main channel of the Yellowstone River, it will have minor impacts to aquatic habitats associated with Joe's Island.

**Cumulative Effects**
Improved fish passage at Intake would benefit aquatic communities, and these benefits would be magnified if similar projects are undertaken at other upstream irrigation intakes (e.g., Cartersville diversion). Adverse impacts to aquatic communities from the action alternatives would be relatively minor and temporary. There are no known or reasonably foreseeable actions that would elevate these minor impacts to greater magnitude.

**Actions to Minimize Effects (Appendix I)**

***General***

- All work in the river will be performed in a manner to minimize increased suspended solids and turbidity, which may degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed by construction will be seeded with native vegetation to minimize erosion.

- All contractors will be required to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread on Aquatic Nuisance Species.

***Fish***

- To avoid potential impacts, coffer dam construction and in-stream heavy equipment activity will be coordinated with fishery experts from the Service, MFWP, Reclamation and the Corps to avoid and or minimize potential impacts.
- All pumps will have intakes screened with no greater than ¼-inch mesh when dewatering cofferdam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of juvenile or adult fish occupying these areas. Fish will be removed by methods approved by the Service and MFWP prior to final dewatering.
-

### 4.5.4 Summary

The Bypass Channel Alternative includes a new diversion structure in the Yellowstone River, a three-mile long bypass channel, and a culverted diversion in the high flow channel. The Rock Ramp Alternative involves the construction of a long, low-gradient ramp in the Yellowstone River. Both alternatives are intended to improve passage for pallid sturgeon and other native fish and provide access to additional aquatic habitat in the Yellowstone River; however, there is uncertainty as to how native fish will respond to the improvements and the subsequent degree to which they will pass. Reclamation will monitor the physical parameters associated with the bypass channel and/or rock ramp and whether native fish are passing upstream either over the proposed diversion structure or rock ramp, through the proposed bypass channel, or through the existing high flow channel and diversion structure. If no, or limited, passage is documented, Reclamation will propose measures to address the deficiency.

## 4.6. Federally-Listed Species and State Species of Special Concern

### 4.6.1 Introduction

➢ How would the Intake Project affect federally-listed species and state species of concern in the area of potential effects?

This project would implement an RPA issued to the Corps in the 2003 Amended Biological Opinion for the Missouri River Master Manual. Because the Service has already considered the biological effects of construction of a fish passage project at Intake during development of the RPA and determined it is an integral component to avoid jeopardy to pallid sturgeon, section 7 consultation for construction of an action alternative for this project has been completed. However, for the purposes of NEPA this EA discloses the potential effects and benefits of the project on listed and candidate species in the action area.

While Section 7 consultation for a fish passage project has been concluded, the operations of the Intake Project by Reclamation, including operation of the new headworks in conjunction with the implemented (selected) fish passage design, requires a separate but parallel Section 7 consultation. This parallel effort will likely require formal Section 7 consultation with the Service. The future BA on operations will be completed prior to the actual operation of the selected fish passage alternative. Section 7 consultation for the operation of the completed canal headworks and fish screens was completed in February 2012.

### 4.6.2 Methods

Analyses of impacts to resources (hydrology, geomorphology, surface water quality, and lands and vegetation) were used to analyze potential impacts to federally listed species and Montana species of special concern. The resource analyses took into account actions to minimize effects (see below and Appendix I). Additionally, federal and state lists and databases were searched to determine distribution and occurrence of these species within the Intake Project area (action area per ESA procedures). The federal list was confirmed in the May 12, 2009, coordination meeting with the Service. The Montana species of special concern were confirmed by the cooperating agencies after review of a preliminary draft of Chapter 3 of the 2010 EA and subsequent comments (see Chapter 5 for further information). The ESA species list was again updated by Reclamation in the 2012 consultation for operation of the headworks. No new species that may be present in the action area have been listed or proposed since the 2012 consultation.

Potential impacts to species in the Intake Project action area were assessed. Federally threatened and endangered species and species of special concern potentially in the Intake Project area are listed in Appendix F.

To further evaluate the differences in benefits between the two action alternatives, a hydraulic model was used (Corps, 2009) with the FPCI to determine benefits to fisheries (including sturgeon). Appendix A provides the details of this analysis, as well as the cost effectiveness and incremental cost analysis of the alternatives. The results of this analysis are captured above under the aquatic resources section, and are summarized below.

#### *4.6.2.1 Short-Term and Long-Term Effects of the Alternatives*

**Bypass Channel Alternative**

***Federally-Listed Species:*** There are no impacts identified for the whooping crane, interior least tern, or black-footed ferret under this alternative. Whooping cranes are uncommon migrants in the Intake area and are not anticipated to be affected by the proposed action. Best management practices include periodic review of the Service's crane siting database and consulting with the Service if whooping cranes are sited within the project area. Interior least terns nest on exposed bars and feed in shallow water near bars and the shoreline. Best management practices include weekly visual surveys conducted from May 15 to August 15 at all potential least tern nesting areas within line of site of the construction area and restricting all construction and surface disturbing activities from May 15 to August 15 within 0.25 miles or the line of site of any active interior least tern nest. These actions will minimize any construction-related impact on interior least terns. Black-footed ferrets exclusively inhabit prairie dog towns. There are no known prairie dog colonies or towns on Joe's Island or in the immediate vicinity of the project area. We have concluded that this alternative "may affect, but is not likely to adversely affect" whooping cranes and interior least terns and would have no effect on black-footed ferrets.

The Bypass Channel Alternative uses the best available scientific information to identify physical parameters important to sturgeon use of secondary and high flow channels in the Yellowstone River. Two-dimensional modeling suggests that velocity parameters identified by the Service through the BRT may not be achievable at extremely low and high flows. Modeling suggests that other important physical parameters can be achieved in the bypass channel under most flow conditions. However, uncertainty remains whether pallid sturgeon will enter and travel the entire three-mile length of the bypass channel. The Corps and Reclamation will monitor the physical parameters of the bypass channel to document whether the channel conforms to the criteria developed by the BRT. The Corps will be responsible for the first year after construction to ensure the channel performs as designed and Reclamation will continue monitoring in the following years consistent with the Adaptive Management Plan (Appendix J).

A large eddy currently develops at the proposed downstream entrance to the bypass channel at some flows. The reverse flow associated with eddies may limit the effectiveness of the bypass channel if shearing flows deter pallid sturgeon from entering the channel. This eddy produces reverse flow in the river and creates a "curtain" of shear flow near the proposed downstream entrance to the bypass channel. Pallid sturgeon have been documented to avoid areas of high turbulence and shear flow (White & Mefford, 2002). The hydraulic conditions anticipated at the entrance to the bypass channel are being modeled by the Corps and Reclamation to identify alternative channel alignments and other means to reduce eddy development and other velocity barriers.

Implementation of actions to minimize effects (Appendix I) on pallid sturgeon would minimize short-term impacts of construction-related activity. Furthermore, the overall purpose of the project is to benefit pallid sturgeon recovery by improving fish passage and minimizing entrainment. There are many factors involved in the ability of fish passage alternatives to be successful and many uncertainties with regard to fish passage design requirements. Both action alternatives, while they have similar modeling results, have positives and negatives regarding the ability of each design to provide fish passage. The benefits of the bypass channel are slightly less favorable than those for the Rock Ramp Alternative. However, upon comparison of cost per benefit output, the bypass channel compares more favorably. The overall long-term effect of the bypass channel is anticipated to be highly beneficial to pallid sturgeon and more than offset minor short-term impacts caused by construction. Any potential short-term effects would be considered insignificant and discountable.

Incidental take of pallid sturgeon during construction was considered in the original 2003 amended Missouri River Biological Opinion. Based on the analysis and environmental commitments in the 2010 ESA consultation, EA, and FONSI, as well as the analysis in the current EA, it is not anticipated that incidental take in conjunction with fish passage construction will occur. Therefore, it has been concluded that construction of this alternative "may affect, but is not likely to adversely affect" the pallid sturgeon.

Sprague's pipits require large patches of continuous grassland and areas with little shrub or tree cover. Habitat segmentation (via roads, etc) is also thought to have led to declines in their populations. Segmentation has the effect of creating smaller and smaller habitat patches while also increasing habitat edges. Increased edges create vulnerabilities to nesting sites through exposure to increased predators and brood parasitism (Jones, 2010). Because the Intake site is already somewhat segmented, adjacent to several roads, and is mostly grassland interspersed with riparian and upland forested and shrub areas, the likelihood that Sprague's pipits would be found using the site is minimal. Implementation of a migratory bird management plan would minimize potential adverse impacts to Spague's pipit and other grassland nesting birds.

While the site does have some sagebrush, many of these same habitat attributes are likely to make the site minimally suitable for greater sage grouse as well. However hens with chicks are known to feed on succulent forbs and insects where cover is sufficiently tall to conceal broods and provide shade. Depending on availability of succulent vegetation availability within upland grassland and sagebrush habitats, hens may move with their broods to moister areas that provide an abundance of forbs and insects for food, and tall grass for hiding from predators. While nesting would be unlikely in the floodplain of the Yellowstone River, greater sage grouse could potentially occur in the area, particular in the later summer months when broods may be utilizing the moister riparian bottom areas. Upon completion of project construction, much more of the Joe's Island will be isolated and would be considered a benefit if grouse do utilize the area. Grassland areas affected by spoiling of channel material (particularly at the waste pile site) contain some silver sagebrush, as does the bottomland shrub areas. While silver sagebrush habitats are common in the surrounding areas, any habitats containing sagebrush that are affected by the project will be reestablished. This will help assure that negative impacts to habitats potentially utilized by greater sage grouse are only temporary.

***State Species of Special Concern:*** Construction activities for the Bypass Channel Alternative would have a temporary effect on species of concern in the immediate vicinity of the construction area. Human activity and noise from equipment and machinery would disturb some species that are sensitive to this type of activity causing animals to move to other areas. A limited number of trees, shrubs, and vegetative cover would be eliminated at some sites during construction.

Construction activity in the river and adjacent bank would affect fish and aquatic invertebrates, but most of these species are mobile enough to move out of construction areas. Excavation of a new channel in the uplands on Joe's Island would not impact aquatic invertebrates and might provide new habitat as upland would be converted to riverine habitat. It should be noted that the new channel created by this alternative would allow passage of fish but the channel would not be allowed to migrate within the floodplain. This could limit the habitat structure of the new channel for fish and aquatic invertebrates.

The FPCI benefits analysis completed for this project accounted for several fish species of special concern. Species of special concern utilized in this analysis include the shovelnose sturgeon (as surrogate to pallid sturgeon), paddlefish, sauger, and blue sucker. Habitat loss and the presence of migratory barriers are largely related to all of these fish being listed as a species of special concern in the state of Montana, and these species provide a good indication of the benefits that result from improving fish passage at Intake. While the benefits are much higher for either action alternative when compared to no action, benefits associated with the rock ramp appear to be somewhat greater than benefits of the bypass channel. However, the cost per habitat unit of benefits is lower for the Bypass Channel Alternative.

In the 2010 EA, a table presented all the Montana State Species of Special Concern along with potential impacts to those species. These impacts have not changed since drafting the 2010 EA and can be found in Chapter 4 of that document. Reclamation will develop a migratory bird management plan to minimize potential adverse impacts on migratory birds and their breeding habitat.

**Rock Ramp Alternative**

***Federally-Listed Species:*** The impacts identified for this alternative are the same as described above for the Bypass Channel Alternative, but are less because the size of this alternative's footprint is smaller. Best management practices are also the same for this alternative. The hydraulic analysis and FPCI evaluation (Appendix E) found that the Rock Ramp Alternative scores slightly higher and more favorably for pallid sturgeon than the Bypass Channel Alternative, but the cost per habitat unit is much more. Detailed description of the potential effects to pallid sturgeon from this alternative can be found in the 2010 EA and BA. Because construction occurs in the river for this alternative, we have concluded that this alternative "may affect, but is not likely to adversely affect" the whooping crane, least tern, or pallid sturgeon.

Black-footed ferrets exclusively inhabit prairie dog towns. There are no known prairie dog colonies or towns on Joe's Island or in the immediate vicinity of the project area, and we have concluded that this alternative would have no effect on black-footed ferrets.

Under the Rock Ramp Alternative, much less habitat area potentially considered suitable habitat for the Sprague's pipit or greater sage grouse would be impacted, as the construction of the project would be mainly confined to the river channel area. Access points and stockpile areas would be the only areas affected during construction. Implementation of a migratory bird management plan would minimize potential adverse to Spague's pipit and other grassland nesting birds.

Greater sage grouse are not common in the project area, however Joe's Island provides some areas of suitable habitat. Effects to Joe's Island would be temporary for this alternative and those areas disturbed would be restored. Any potential adverse effects to greater sage grouse would be temporary and minor.

***State Species of Special Concern:*** Impacts to land areas adjacent to the river during fish passage construction would be minimal, thus impacts to species of concern are anticipated to be minimal.

Rock ramp placement could impact fish and aquatic invertebrates identified as species of special concern. Construction activity in the river and adjacent bank would affect fish and aquatic invertebrates, but most of these species are mobile enough to move out of construction areas. Actions to avoid and minimize these adverse impacts can be found in Appendix I. Even with actions to minimize effects in place there may be short-term minor effects to aquatic invertebrates in the immediate vicinity of construction activities. Overall, with actions to minimize effects in place, the long-term impact of construction activities on aquatic invertebrate assemblages would be minor. Because large, stable substrates such as boulders and cobbles support larger, more productive invertebrate populations than do unstable gravel and sand substrates, creating a rock ramp may result in minor improvements in the diversity of the aquatic invertebrate community.

Actions to minimize effects (Appendix I) would be incorporated into all the action alternatives to avoid potential adverse effects. Therefore, with these commitments, any potential adverse impacts would not result in a loss of individuals and are extremely unlikely to occur. Only minor impacts to Montana state species of special concern are anticipated.

**Cumulative Effects**

Impacts to federally-listed species and state species of special concern from the action alternatives would be relatively minor and temporary. Improved fish passage would benefit federally-listed fish species and state fish species of special concern, and these benefits would be magnified if similar projects are undertaken at other upstream irrigation intakes (e.g., Cartersville diversion). There are no known or reasonably foreseeable actions that would elevate these minor impacts to greater magnitude.

**Actions to Minimize Effects (Appendix I)**

***Whooping Crane***

- Reclamation will monitor the Service's whooping crane sighting reports to ensure that whooping cranes are not in the Intake Project area during construction. If any are sighted within the Intake Project area, Reclamation will consult with the Service regarding appropriate actions.

***Interior Least Tern***

- Visual surveys will be conducted weekly from May 15 to August 15 at all potential least tern nesting areas (sparsely vegetated sandbars) within line of site of the construction area.
- All surface-disturbing and construction activities will be restricted from May 15 to August 15 within 0.25 miles or the line of site of any active interior least tern nest.

***Pallid Sturgeon***

- A physical model will be constructed to provide additional velocity and turbulence data needed for final design.
- Reclamation and the Corps will consult with the BRT during the design of the selected alternative, including but not limited to reviewing results and making recommendations on the physical model, hydraulic modeling, and final alternative design.
- The construction activities will be monitored by a qualified fisheries biologist to avoid direct impacts to adult or juvenile pallid sturgeon. In-stream construction activities will cease if the fisheries monitor determines there is potential for direct harm or harassment of pallid sturgeon, until the potential for direct harm or harassment has passed. This will mainly be accomplished by coordination with MFWP regarding its observation of

movements of radio-tagged pallid sturgeon and other monitored native fish during the construction season.
- Any in-stream construction activity will be conducted during periods most likely to minimize the potential impact to the pallid sturgeon. The months to avoid and/or minimize impacts to pallid sturgeon are June and July.

***Species of Special Concern***

- Before every construction season, the ERT will meet with MFWP to determine procedures to minimize impacts to species of special concern. Surveys for species likely to occur in the Intake Project area may be required as some of these species could be potentially harmed by construction activities. Survey requirements will be coordinated with Montana Natural Heritage Program and MFWP prior to any construction activities. These species could require surveys: bald eagle, grasshopper sparrow, red-headed woodpecker, greater sage grouse, Sprague's pipit, Townsend's big-eared bat, nine-anther clover, pale-spiked lobelia, and silky-prairie clover.

### 4.6.3 Summary

It was determined that the Bypass Channel Alternative "may affect, but is not likely to adversely affect" pallid sturgeon, whooping cranes, and interior least terns and would have no effect on black-footed ferrets. Potential impacts to Sprague's pipit and greater sage grouse are anticipated to be temporary and minor. Likewise, it was determined that potential impacts to state-listed species are anticipated to be temporary and minor.

It was determined that the Rock Ramp Alternative "may affect, but is not likely to adversely affect" pallid sturgeon, whooping cranes, and interior least terns and would have no effect on black-footed ferrets. Potential impacts to Sprague's pipit and greater sage grouse are anticipated to be temporary and minor. Likewise, it was determined that potential impacts to state-listed species are anticipated to be temporary and minor.

## 4.7. Recreation

### 4.7.1 Introduction

- ➢ How would the Intake Project affect recreational opportunities, including camping, hunting, fishing, boating, concessions, swimming, picnicking, and day use at the Intake fishing access sites (FAS) and Joe's Island?

- ➢ How would the Intake Project affect the recreation infrastructure, including the campground, picnic/day use area and the boat ramp at Intake FAS and Joe's Island?

This section addresses recreational opportunities and associated recreation infrastructure that may be affected during and after Intake Project construction.
Construction activities may impact the quality of the recreational experience and or the physical environment on a temporary basis. These impacts are expected to be short-term, depending upon the alternative selected for implementation and the Intake Project construction schedule.

Construction would take approximately 2 ½ years for the Rock Ramp Alternative and 3 years for the Bypass Channel Alternative. Fishing and boating would not be restricted in the newly constructed bypass channel. Wakes from boating may cause minor erosion in the bypass channel, however it is expected to be minimal and not appreciably add to O&M costs. Potential wake damage to the bypass channel will be monitored through the AM process.

Some recreational opportunities and/or infrastructure may be lost for future use or enjoyment, although actions to minimize effects would offset these impacts (see Actions to Minimize Effects subsection and Appendix I).

### 4.7.2 Methods

The analysis took into consideration impacts to the physical environment as well as certain intrinsic values such as the quality of the view shed, sense of quiet and solitude, and access to water.

### 4.7.3 Results

#### *4.7.3.1 Short-Term and Long-Term Effects of the Alternatives*

**Camping and Picnic/Day Use**

***Bypass Channel and Rock Ramp Alternatives:*** Neither alternative would physically impact the campground or picnic/day use area. Both alternatives would have some short-term impacts to recreational opportunities at the Intake FAS. During Intake Project construction noise, dust, and construction equipment could impact the sense of quiet and solitude traditionally experienced in these areas. Ease of access to the campground and picnic/day use area might be reduced during periods of heavy construction adjacent to the recreation areas or along the entrance road. These impacts could discourage recreational use of the campground or picnic/day use area. At times, due to construction need or for public health and safety, the recreational areas might be closed for limited periods of time.

The Rock Ramp Alternative would require closure of the existing boat ramp which could temporarily reduce recreational use of the campground or picnic/day use area. A new boat ramp would be constructed concurrent with construction of the ramp alternative, therefore long-term impacts are not expected (see “Actions to Minimize Effects” subsection and Appendix I).

Once the bypass channel is constructed, the short-term construction impacts to the campground and picnic/day use area noted above should be alleviated.

Once the Rock Ramp Alternative is constructed, the short-term construction impacts to the campground and picnic/day use area noted above should be alleviated. The river would flow in the same channel and the visual and audio aesthetics of the river should remain the same. There should be no long-term impacts to the campground or picnic/day use areas.

Both alternatives would impact the camping and picnicking/day use opportunities on Joe's Island during fish passage construction. There are no developed campgrounds or day use facilities on Joe's Island, but the area is used for primitive camping and picnicking. Short-term construction impacts due to either alternative may result in use of Joe's Island being restricted or temporarily prohibited. This could result in fewer visitations to the area.

The Bypass Channel Alternative would have a long-term impact to recreation on Joe's Island, as access to the dam from the south would be restricted due to the newly constructed bypass channel. This would result in reduced visitation to the area. There should be no long-term impacts to recreation at Joe's Island due to the Rock Ramp Alternative.

If either action alternative is constructed, roads that were constructed for fish passage construction purposes, if left in place, would improve access to Joe's Island.

**Hunting**

***Bypass Channel and Rock Ramp Alternatives:*** Hunting is prohibited and would remain so at Intake FAS, during and after construction of either action alternative. During fish passage construction, hunters wishing to access the river by boat might experience short-term impacts when the boat ramp at the Intake FAS is temporarily closed, or if foot access is limited through the construction zone. This could result in fewer visits to the river by hunters; however, hunting access to the river is nominal during designated hunting seasons. Foot access restrictions to the river should be alleviated once the Intake Project is completed.

The Bypass Channel Alternative would not require closure of the boat ramp at the Intake FAS, and therefore would not impact visitation to the FAS.

Hunting on Joe's Island and access to downstream lands could be impacted on a short-term basis during construction of either alternative if the island is closed for safety purposes. Once the Intake Project is completed, it is likely that hunting restrictions would be lifted.

Once the Bypass Channel Alternative is constructed, Joe's Island would become bisected, and access across the bypass channel would be limited to boat traffic. This would be a long-term but minimal impact; hunting on Joe's Island only provides limited opportunities, and there are other hunting opportunities on block management lands and other public lands along the river.

If the Rock Ramp Alternative is constructed, hunting on Joe's Island should not be substantially changed.

**Fishing**

***Bypass Channel and Rock Ramp Alternatives:*** During Intake Project construction, anglers using either side of the river (Intake FAS or Joe's Island) might experience short-term impacts when access to the river is temporarily restricted within the construction zone. Construction activities in the river would also restrict fishing opportunities temporarily. Fishing outside the construction zone would still be available. However, for the bypass channel, it is likely that fishing access to the face of the dam would permanently change due to the mouth of the bypass channel meeting the river right below the dam. This would not preclude fishing opportunities at the site, but would likely impact how closely bank fisherman could access the river near the dam face.

During Intake Project construction, snagging for paddlefish could be impacted. Intake Project construction activities may alter paddlefish behavior at the dam site discouraging paddlefish from concentrating below the dam. This may reduce the number of paddlefish snagged at the FAS. However, this could increase overall snagging opportunities in the Yellowstone River if more paddlefish migrate up river. Historically, the paddlefish season at Intake is closed when a designated number of paddlefish are snagged. This often occurs before the season's established closing date. Without the high numbers of paddlefish snagged at Intake, the yearly quota might not be filled as quickly, and the season might stay open longer affording anglers more days to snag paddlefish until the quota is either met or the season officially ends.

Once either action alternative is completed, paddlefish would be less inclined to congregate at the Intake FAS. This should reduce snagging opportunities at the FAS but should also increase snagging opportunities further up river. As discussed in the "Aquatic Communities" section, paddlefish may benefit from additional spawning areas up river, which could improve reproduction and increase populations.

As a byproduct of the recreational paddlefish fishery on the lower Yellowstone River, the Glendive Chamber of Commerce and Agriculture (Chamber of Commerce) administers the Yellowstone Caviar program. Before and after Intake Project construction, anglers would be able to donate roe from paddlefish snagged between Glendive and the Montana/North Dakota state line to the Chamber of Commerce, and the Chamber of Commerce would be able to accept and process the donated paddlefish roe into caviar. Intake Project construction should not reduce the number of paddlefish in the Yellowstone River or the quota for the number of paddlefish to be taken. However, during and after Intake Project construction the Yellowstone Caviar program could be impacted by a number of factors. Most of the donated roe comes from paddlefish that are currently snagged below the Intake Dam. Impacts from restricted angler access to the river or reduced numbers of paddlefish snagged at the FAS could result in less paddlefish roe donated to the program, unless the Chamber of Commerce maximizes its authorized opportunities to collect paddlefish snagged between Glendive and the North Dakota-Montana state line. Reduced donations would reduce income for the Chamber of Commerce.

Permanently closing the boat ramp under the Rock Ramp Alternative would result in long-term impacts to anglers wishing to access the river by launching boats at the Intake FAS. This could result in reduced visitation to the FAS, however the project proposes to construct a new boat ramp at or near the Intake FAS.

**Boating**

***Bypass Channel and Rock Ramp Alternatives:*** Once construction activities begin, the boat ramp at Intake would be closed periodically and be closed completely under the Rock Ramp Alternative. Thus, the Rock Ramp Alternative would impact recreationists wishing to launch boats at Intake FAS for boating, fishing, or hunting activities on the river.

Boaters would have to travel greater distances to access a concrete boat ramp. The "water taxi" that operates during the paddlefish season would launch and be retrieved further downstream. There are two concrete boat ramps at the Elk Island FAS 20 miles downstream.

As noted above in the Hunting and Fishing sub-sections, any action that reduces access to the river could impact hunting and fishing activities at and around the FAS. A 20-mile upstream boat trip from Elk Island would be a difficult trip for most boaters. Reducing boat access to the river for fishing may also impact the Yellowstone Caviar program. Anglers cannot fish or snag for paddlefish or any other species from a boat within ¼ mile downstream of Intake Dam. However, this existing restriction does not prevent boaters from launching at Intake FAS and boating below the closed area to snag paddlefish.

The lack of a concrete boat ramp may result in fewer yearly visitors to the FAS until a new boat ramp is constructed at or near the Intake FAS (see Appendix I).

The Rock Ramp Alternative would change the grade of the dam at Intake FAS. A gentler slope with a higher river level over the dam could allow for greater boat traffic up river and down river of the FAS.

Under the Bypass Channel Alternative the boat ramp will remain unaffected and this alternative could result in use of the bypass channel that may provide easier access upstream than over the rock ramp.

**Concession Operation and Sub-Contractors**

***Bypass Channel and Rock Ramp Alternatives:*** The concession and sub-contractors only operate during the paddlefish season. Both alternatives would have virtually the same short-term and long-term impacts to the concession operation and sub-contractors operating at the Intake FAS. Intake Project construction would not have a direct physical impact to the concession operation and sub-contractors. Those opportunities would remain.

During the paddlefish season, Intake Project construction noise, dust, and construction equipment could impact the sense of quiet and solitude traditionally experienced in these areas. Ease of access to the campground, picnic/day use area, and boat ramp might be reduced during periods of heavy construction activities adjacent to these areas or along the entrance road. These impacts could discourage use of the recreation areas, thereby potentially reducing income for the concessionaire. Any reduction in paddlefish snagging opportunities at the Intake FAS might impact the sub-contractors operating at the FAS. If the sub-contractors are paid by the number of paddlefish processed, a longer season would mean they would have to work more days; or, if the sub-contractors are paid by the hour or day, it would likely cost the Chamber of Commerce additional money.

### Swimming and Ice Fishing

***Bypass Channel and Rock Ramp Alternatives:*** Both alternatives would have virtually the same short-term impacts to swimming and ice fishing opportunities. Short-term impacts would include no river access within the construction zone; however, swimming is already discouraged downstream of the dam because of turbulence and other safety issues. These opportunities would still exist outside the construction zone and would be available upon Intake Project completion.

### Cumulative Effects

With implementation of actions to minimize effects, the action alternatives would have minimal impacts to the recreation opportunities and infrastructure at the Intake FAS.

### Actions to Minimize Effects (Appendix I)

- In order to minimize impacts to recreationists, the construction contractor will implement dust abatement activities on all dirt or gravel roads within or leading to the construction zone on both sides of the river.
- To allow access to recreation areas, the construction contractor will grade, on an as needed basis, all dirt or gravel roads within or leading to the construction zone, on both sides of the river, except in areas with historic properties.
- The construction contractor will use "flaggers" during periods of time when large volumes of vehicles cross the entrance road to the campground and picnic/day use area.
- The construction contractor, Reclamation, and the MFWP will meet to evaluate and coordinate closures at the FAS and Joe's Island to recreational use, including closure of construction zones to swimming, fishing, boating, hiking, camping, hunting, etc. within or on both sides of the river.
- During construction activities on the north side of the river, the construction contractor, Reclamation, and the FWP will identify a "portage" route around or through the construction zone to allow boaters to hand-carry or drag their boats past the construction zone.
- The construction contractor will clearly post and sign any areas within any designated construction zones. Signs will include warnings limiting or prohibiting certain recreational uses within the zone, such as swimming, fishing, boating, hiking, camping, etc. Signs will be posted upstream and downstream of the Intake Diversion Dam to warn boaters of construction activity.
- The MFWP will designate access corridors through the existing Intake FAS campground and picnic/day use area that could be used to access the river by foot or to launch boats under "primitive" conditions.

For the Rock Ramp Alternative, Reclamation and the MFWP will evaluate and the Corps will construct either:

- a new boat ramp at the existing Intake FAS, or
- a new boat ramp immediately adjacent to the existing Intake FAS, or

- a new boat ramp at a site near the existing Intake FAS on the west side of the Yellowstone River and accessible by Highway 16.

Reclamation and the MFWP will develop a public notification plan to include:

- signs on the road leading to the FAS or Joe's Island advising the public of closures or restrictions, and
- signs indicating the location of other recreation sites including campgrounds, picnic/day use areas and boat ramps.

### 4.7.4 Summary

In the short-term, the Rock Ramp Alternative would have the greatest impacts to the campground, day use area, and boat ramp, as those features are adjacent to the rock ramp construction area, however, both the Rock Ramp and Bypass Channel Alternatives will have some impacts to recreational opportunities such as camping, picnicking, boating, and fishing due to temporary closures, noise, dust, and restricted access to the river at certain times during construction.

In the long-term, the Rock Ramp Alternative would require closure and relocation of the boat ramp. Most fishing and boating opportunities on the river should improve after construction of either alternative. The Bypass Channel Alternative would limit access to areas adjacent to and upstream from the dam on Joe's Island having some impacts to recreation, but these impacts would be limited. Paddlefish snagging opportunities, which would continue, might be less plentiful at the Intake FAS and Joe's Island since paddlefish would likely not congregate to the same degree below the new rock ramp or may bypass the location through the Bypass Channel. However, paddlefish snagging opportunities should improve upstream.

## 4.8. Social and Economic Conditions

### 4.8.1 Introduction

➢ How would the alternatives affect the regional economy of the region?

This section addresses how the proposed alternatives may affect the regional economy. These impacts could occur as a result of operational changes that could affect the four irrigation districts in the Yellowstone project and activity in the region in three ways:

- short-term construction impacts,
- increase in long-term O&M costs, and
- short-term changes in recreation visitation and related expenditures due to construction.

It is assumed for the purposes of this analysis that cropping patterns, yields, and irrigation deliveries would be the same under the No Action (Continue Present Operation), Bypass Channel, and Rock Ramp Alternatives. Therefore, the economic impacts associated with irrigated production would all be the result of changes in water supply costs for each alternative. Recreation impacts would be related to decreases in the number of recreationists using Intake FAS during construction (see "Recreation" section).

### 4.8.2 Methods

The regional economic impacts from implementation of the Bypass Channel Alternative and the Rock Ramp Alternative were compared to continuation of current cost rates in order to evaluate the significance of each action alternative to the regional economy. The regional impacts from construction and O&M expenditures are analyzed using the IMPLAN (IMpact analysis for PLANing) model. IMPLAN version 3.0 is used to estimate regional impacts. The most recent available 2010 model year data are used with 2012 as the base year of analysis.

The IMPLAN model is based on national estimates of flows of commodities used by industries and commodities produced by industries. The flow of commodities to industry from producers and consumers, as well as consumption of the factors of production from outside the region, is represented within IMPLAN. These also account for the percentage of expenditures in each category within the region and expenditures that would flow outside the region.

In order to estimate the regional economic impacts associated with an alternative, estimates of changes in expenditures for goods and services were input into the IMPLAN model. The primary sectors used to categorized expenditures are sector 36, construction of other new nonresidential structures and sector 39, maintenance and repair construction of nonresidential structures. Estimating the impacts of construction and operation and maintenance activities requires estimates of these expenditures by expenditure category. The impacts associated with each of the alternatives are measured in terms of changes in industry output, employee compensation, and employment. Industry output is a measure of the value of industry's total production. Industry output is directly comparable to Gross Regional Product. Employee compensation represents wages and benefits paid to employees.

The impacts associated with payment of O&M costs associated with the Bypass Channel and Rock Ramp Alternatives were evaluated using farm budgets, which represent net revenues from irrigated agriculture. Farm budgets were developed using cropping patterns, input costs, crop yields and prices. A simplified approach based on the concept of farm payment capacity was used in this analysis to represent the net farm revenues available from irrigated acreage to pay increased operation, maintenance, replacement, and monitoring costs. Payment of increased O&M costs would lead to reduced disposable farm income.

### 4.8.3 Results

#### *4.8.3.1 Short-Term and Long-Term Effects of the Alternatives*

**Rock Ramp and Bypass Channel Alternatives**

***Regional Economic Impacts:*** Both of the action alternatives would generate positive impacts to the regional economy. Any action that increases levels of spending tends to lead to increased value of output, employment, and income. The value of output represents the market value (as measured by price) of goods and services produced and sold in the region. Increased spending would increase economic activity, if the funds come from sources outside the study area or if spending comes from local sources that would otherwise not be spent in the region.

The short-term regional impacts are based on an estimated construction cost of $80.0 million for the Rock Ramp Alternative and $58.9 million for the Bypass Channel Alternative (see Chapter 2). These one-time maximum short-term impacts are shown in Table 4.5. These beneficial impacts represent additional regional economic activity from an action alternative that is constructed with federal funding over the construction period.

**Table 4-5. One-time regional beneficial economic impacts from construction**

| Alternative | Construction cost (millions) | Value of output (millions) | Employee compensation (millions) | Employment |
|---|---|---|---|---|
| Rock Ramp | $80.0 | $102.2 | $39.2 | 750 |
| Bypass Channel | $58.9 | $73.0 | $28.0 | 535 |

The IMPLAN model provides estimates of economic activity in the region of analysis, which can be used as a basis for evaluating the significance of regional impacts. The IMPLAN data indicate the gross regional product (the total value of goods and services produced in a region) for the eight-county study region was approximately $3.72 billion in 2010. Total personal income was about $2.9 billion for the region and total employment was about 48,000 in 2010. The regional impacts from construction of the alternatives can be compared to the 2010 estimates for the area to get a sense of the level of regional economic impacts from construction.

Table 4.6 shows the potential one-time impact of construction of the two action alternatives relative to gross regional product, income, and employment in the regional economy. The impacts are shown as percentages of totals in one year. Construction would have a positive impact in the very short-term, but the impact would be fairly small relative to the total regional economy.

**Table 4-6. One-time regional economic impacts from construction as a percentage of gross regional product, income, and employment**

| Alternative | Estimated impacts as a percentage of 2010 gross regional product | Estimated impacts as a percentage of regional 2010 income | Estimated impacts as a percentage of regional 2010 employment |
|---|---|---|---|
| Rock Ramp | 2.75% | 1.35% | 1.56% |
| Bypass Channel | 1.96% | 0.97% | 1.12% |

Regional economic impacts may also occur as a result of O&M expenditures associated with the Rock Ramp and Bypass Channel Alternatives as well as the No Action Alternative. No Action O&M costs have changed since the 2010 EA since part of the project has been implemented and are included as a baseline from which the other alternatives can be compared. Table 4.7 shows the O&M costs and regional impacts associated with each alternative. The impacts in Table 4.7 represent a very small percentage of the total value of output and employment in the economic region and represent the case where all O&M expenditures are additional expenditures within the region. It should be recognized that increased O&M expenditures could correspond with decreased spending on other goods and services, in which case the regional impacts would be less than indicated in table 4.7.

**Table 4-7. Regional economic impacts associated with annual O&M costs for each alternative**

| Alternative | Annual O&M cost | Value of output | Employee compensation | Employment |
|---|---|---|---|---|
| Rock Ramp | $291,600 | $2397,700 | $167,000 | 3.1 |
| Bypass Channel | $231,300 | $315,400 | $132,400 | 2.3 |
| No Action | $252,400 | $344,200 | $144,500 | 2.5 |

If it is assumed that increased O&M expenditures lead to a proportional decrease in general consumer spending (such as reduced spending on food, general merchandize shopping, etc.) then the O&M expenditures associated with each of the alternatives would generate minor regional impacts. In other words, if the money spent for O&M ultimately leads to a decrease in spending that is currently occurring, then O&M expenditures would have a minor impact on the regional economy. Table 4.8 shows the impact of O&M costs for the Rock Ramp and Bypass Channel Alternatives assuming a proportionate decrease in other types of spending.

**Table 4-8. Regional economic impacts associated with annual O&M costs for each alternative**

| Alternative | Value of output | Employee compensation | Employment |
|---|---|---|---|
| Rock Ramp | $232,800 | $104,000 | 0.3 |
| Bypass Channel | $1184,700 | $82,500 | 0.2 |
| No Action | $201,300 | $90,000 | 0.2 |

**Note: This table assumes O&M costs represent reduced expenditures elsewhere in the regional economy.**

***Effects of O&M Payments on Irrigation Districts:*** The increase in O&M costs associated with the Rock Ramp and Bypass Channel Alternatives would have a negative financial impact on the four irrigation districts. Impacts from changes in O&M payments were estimated previously at the regional level. However, distributional effects are not accounted for in the regional impact analysis. The impacts of increased O&M costs on the irrigation districts are evaluated by comparing the O&M costs per acre for each alternative with per acre net farm income.

If the current estimated annual No Action O&M costs of $252,400 are applied to approximately 58,400 acres reported in the Lower Yellowstone Irrigation Project crop reports, the cost would be $4.32 annually per irrigated acre. Applying O&M costs of $291,600 annually for the Rock Ramp Alternative results in a cost of $5.00 per irrigated acre. O&M costs of $231,300 annually for the Bypass Channel Alternative result in annual O&M costs of $3.96 per irrigated acre.

In order to evaluate the significance of the O&M expenditure impacts, a payment capacity type of approach is used to estimate the impact of additional O&M costs on net farm income. Payment capacity represents the residual net farm income available to irrigators to pay the costs associated with supplying irrigation water. A payment capacity study is the first step in the completion of an ability to pay analysis. A full scale payment capacity analysis was not completed as part of this EA because the primary purpose of this evaluation is to determine the significance of the economic impacts associated with the alternatives, rather than a precise estimate of the resources available for repayment. However, the analysis must be detailed enough to be able to determine the magnitude of impacts. It should be noted that since O&M costs associated with the Bypass Channel Alternative are less than for No Action, the Bypass Channel O&M impacts are beneficial relative to No Action.

A payment capacity study is based on the use of representative farm characteristics, representative crop yields, and representative input and crop prices. A 5-year time horizon is typically used for crop yields and prices. Representative farm characteristics refer to the fact that not all crops grown in an area and not all farm management practices must be included in a payment capacity analysis. However, the farm budget used in a payment capacity analysis must be reasonable for the region of analysis. The purpose of this analysis is to evaluate the impact of O&M costs associated with the action alternatives on net farm revenue.

*Representative cropping patterns, crop prices, and yields.* Representative irrigated cropping patterns for the four irrigation districts are based on the crop acreages reported by the Lower Yellowstone Irrigation Project Board of Control for 2007 and historical county level data obtained from U.S. Department of Agriculture National Agricultural Statistics Service. More recent district level cropping pattern data were not provided. Therefore, county level data for the eight counties included in the impact study area were used to determine if there appeared to be any significant trends in crops grown in the area. Irrigated crop acreages for 2007 for the study area are shown in Table 4.9, and the irrigated county crop acreages for 2003 to 2011 are presented in Table 4.10. Lower Yellowstone Districts #1 and #2 are evaluated as one unit because the Lower Yellowstone Irrigation Project Board of Control operates these districts as one with a common Montana water right. The percentages shown in Table 4.11 are representative of the crops actually produced in the area but do not exactly match the percentage of all crops grown in the districts.

**Table 4-9. 2007 irrigated estimated crop acreage by irrigation district**

| District | Sugar beets | Hay | Wheat | Barley | Corn |
|---|---|---|---|---|---|
| Lower Yellowstone Districts #1 & #2 | 24,944 | 6,493 | 8,793 | 11,024 | 3,987 |
| Intake Irrigation District | 392 | 156 | - | 192 | 146 |
| Savage Irrigation District | 820 | 215 | 162 | 707 | 263 |

**Table 4-10. Irrigated crop acreage in eight-county study area from 2003 to 2011**

| Crop | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Sugar beets | 39,670 | 39,790 | 40,320 | 37,540 | 32,640 | NA | 21,000 | 30,000 | 29,900 |
| Corn | 18,300 | 12,400 | 12,400 | 15,000 | 26,200 | 21,800 | 15,400 | 14,200 | 10,500 |
| Alfalfa* | 30,000 | 31,500 | 24,500 | 20,000 | 28,000 | 12,000 | 20,172 | 22,469 | 16,099 |
| Wheat* | 28,100 | 24,700 | 20,900 | 18,400 | 22,800 | 28,500 | NA | NA | NA |

* Figures represent only Montana counties because North Dakota data were not available.

The county average acreage data indicate that sugar beets continue to be a dominant crop grown in the area. Corn and alfalfa appear to be decreasing as a percentage of total crops while wheat remained as a relatively high percentage. Irrigated barley acreage data were not available at the county level.

**Table 4-11. Irrigated cropping percentage based on 2007 average crop acreage and county-level crop acreage trends**

| Irrigation District | Sugar beets | Hay | Wheat | Barley | Corn |
|---|---|---|---|---|---|
| Lower Yellowstone District #1 and #2 | 45% | 10% | 20% | 15% | 10% |

| | | | | | |
|---|---|---|---|---|---|
| Intake Irrigation District | 40% | 10% | 20% | 10% | 20% |
| Savage Irrigation District | 35% | 15% | 15% | 20% | 15% |

Crop prices and yields are needed in order to estimate representative farm revenues. Crop prices for the most recent five years for which data are available were obtained at the state level for both Montana and North Dakota from the United States Department of Agriculture, National Agricultural Statistics Service. These prices are shown in Table 4.12.

The two-state average price was used to estimate gross farm revenues from irrigated production for each crop except corn. The two-state average was considered more representative of prices for the study area that includes both states. Montana prices were used for corn, because essentially all corn production in the area is in the Montana districts.

**Table 4-12. State-level crop prices used to evaluate net farm income**

| Crop | 2007 | 2008 | 2009 | 2010 | 2011 | 2007 to 2011 Average |
|---|---|---|---|---|---|---|
| **Montana** | | | | | | |
| Barley (bushel) | $4.14 | $5.78 | $4.86 | $4.08 | $5.25 | $4.82 |
| Corn (bushel) | $4.76 | $3.80 | $4.23 | $6.00 | $6.40 | $5.04 |
| All Hay (ton) | $78.50 | $116.00 | $95.50 | $80.00 | $97.00 | $93.40 |
| Sugar beets (ton) | $39.10 | $50.80 | $53.40 | $64.00 | NA | $51.83 |
| Sprung Wheat (bushel) | $7.60 | $7.36 | $5.72 | $6.87 | $8.40 | $7.19 |
| | | | | | | |
| **North Dakota** | | | | | | |
| Barley (bushel) | $3.91 | $5.18 | $3.85 | $3.74 | $5.55 | $4.45 |
| Corn (bushel) | $4.06 | $3.74 | $3.18 | $5.01 | $5.75 | $4.35 |
| All Hay (ton) | $57.00 | $79.50 | $54.50 | $58.00 | $66.00 | $63.00 |
| Sugar beets (ton) | $46.30 | $51.00 | $51.90 | $69.90 | NA | $54.78 |
| Wheat (bushel) | $7.74 | $7.31 | $4.90 | $6.78 | $8.20 | $6.99 |
| | | | | | | |
| **Two state average** | | | | | | |
| Barley (bushel) | $4.03 | $5.48 | $4.36 | $3.91 | $5.40 | $4.64 |
| Corn (bushel) | $4.41 | $3.77 | $3.71 | $5.51 | $6.08 | $4.69 |
| All Hay (ton) | $67.75 | $97.75 | $75.00 | $69.00 | $81.50 | $78.20 |
| Sugar beets (ton) | $42.70 | $50.90 | $52.65 | $66.95 | NA | $53.30 |
| Wheat (bushel) | $7.44 | $7.33 | $5.31 | $6.83 | $8.30 | $7.04 |

Richland County yields were used to estimate agricultural production revenues due to limited irrigated acreage yield data available for McKenzie and Dawson Counties in the National Agricultural Statistics Service database. The price and yield data were used to estimate gross farm revenues for each of the four Lower Yellowstone Project irrigation districts. Crop yields are shown in Table 4.13.

**Table 4-13. Crop yields used to estimate irrigated agricultural revenues**

| Year | Alfalfa (tons) | Barley (bushels) | Sugar beets (tons) | Wheat (bushels) | Corn (bushels) |
|---|---|---|---|---|---|
| 2004 | 4.5 | 102 | 19.5 | 73.3 | 118.0 |
| 2005 | 4.7 | 93 | 21.2 | 67.5 | 115.0 |
| 2006 | 4.7 | 93 | 25.0 | 71.4 | 154.0 |
| 2007 | 4.7 | 92 | 24.0 | 58.9 | 136.0 |
| 2008 | NA | 84 | 24.3* | 58.0 | 143.0 |

| | | | | | |
|---|---|---|---|---|---|
| 2009 | NA | NA | 26.7 | 63.9 | 153.0 |
| 2010 | NA | NA | 27.9 | 73.1 | 139.2 |
| 2011 | NA | NA | 25.2 | NA | 139.3 |
| **Most recent 5-year average** | **4.56** | **92.8** | **25.6** | **65.1** | **142.1** |

* Based on data from McKenzie County and Williams County, North Dakota. Montana sugar beet yield data are not available for 2008.

***Representative Crop Production Costs:*** Representative irrigated agricultural production costs were estimated for alfalfa, barley, and wheat using North Dakota State University Extension Service farm management planning guides for western North Dakota. These planning guides represented center pivot irrigation practices, while the dominant irrigation practice in the study area is flood irrigation. Therefore, adjustments were needed to represent flood irrigation costs. Northern Colorado flood irrigation budgets were used as a basis for estimating irrigation labor hours for the study area. The average wage for irrigation labor was based on data from the May 2011 Bureau of Labor Statistics State Occupational Employment and Wage Estimates for agricultural labor related to crop production in Montana and North Dakota. The average wage was $11.93 for Montana and $11.52 for North Dakota, resulting in a simple average of $11.73 per hour for both states.

Sugar beet production costs were based primarily on information from the North Dakota State University Department of Agribusiness and Applied Economics report "Economic Contribution of the Sugar beet Industry in Minnesota, North Dakota, and Eastern Montana." The representative costs per acre are shown in Table 4.14. It should be noted that the costs presented in Table 4.14 do not include district irrigation assessments. Current and future District irrigation assessments are estimated to be $30 per irrigated acre, which was the rate as of 2009 for all four irrigation districts.

**Table 4-14. Costs used to evaluate irrigated agricultural production based on 2011 estimates**

| Cost category | Seeded Alfalfa | Established Alfalfa | Barley | Sugar Beets[1] | Wheat | Corn |
|---|---|---|---|---|---|---|
| **Variable Costs** | | | | | | |
| -Seed | $60.00 | $0.00 | $18.75 | $73.20 | $22.00 | $89.60 |
| -Chemicals | $19.70 | $0.00 | $13.50 | $168.60 | $34.75 | $21.45 |
| -Fertilizer | $43.67 | $79.97 | $95.41 | $121.50 | $138.20 | $143.35 |
| -Crop Insurance | $0.00 | $0.00 | $16.30 | $0.00 | $30.00 | $36.00 |
| -Fuel & Lubrication | $20.74 | $26.76 | $13.82 | $84.80 | $12.81 | $19.18 |
| -Repairs | $13.13 | $14.34 | $10.19 | $53.50 | $11.18 | $15.45 |
| -Labor, incl. irrigation labor | $23.46 | $23.46 | $12.90 | $171.10 | $12.90 | $36.03 |
| -Miscellaneous | $10.34 | $11.83 | $7.16 | $55.20 | $9.59 | $38.14 |
| **Sum of variable costs** | **$191.04** | **$156.36** | **$188.03** | **$727.90** | **$271.43** | **$399.20** |
| **Fixed Costs** | | | | | | |
| -Overhead/Land Charge | $45.00 | $45.00 | $45.00 | $63.10 | $45.00 | $45.00 |
| -Machinery Depreciation | $86.13 | $98.13 | $62.33 | $100.70 | $58.16 | $74.69 |
| -Machinery Investment/Misc. | $62.92 | $70.04 | $44.64 | $135.20 | $45.84 | $51.83 |
| **Sum of fixed costs** | **$194.05** | **$213.17** | **$151.97** | **$299.00** | **$149.00** | **$171.52** |
| **Sum of variable and fixed costs** | **$385.09** | **$369.53** | **$340.00** | **$1,026.90** | **$420.43** | **$570.72** |

[1] 2011 budget information was not available for sugar beets. In order to represent 2011 costs, 2007 data were used for sugar beets and updated to 2011 prices using the USDA prices paid indexes. Source: North Dakota State University Extension Service, Projected Budgets for Irrigated Crops, Western North Dakota – February 2011.

Gross crop revenue, variable and fixed costs of production, irrigation district assessments and the distribution of crops can be used to estimate net revenue from irrigated crop production. The production cost for alfalfa is based on a five-year rotation, seeding alfalfa every fifth year. The results are in Table 4.15.

**Table 4-15. Net revenue per acre for lower Yellowstone irrigation districts**

| | Gross Revenue | Total Cost | District O&M cost | Net Revenue | Crop Distribution | Weighted Net Revenue |
|---|---|---|---|---|---|---|
| **District #1 & #2** | | | | | | |
| Sugar beets | $1,364.50 | $1,026.90 | $30.00 | $307.60 | 0.45 | $138.42 |
| Hay | $356.59 | $372.64 | $30.00 | $-46.05 | 0.10 | -$4.61 |
| Wheat | $458.30 | $420.43 | $30.00 | $7.87 | 0.20 | $1.57 |
| Barley | $430.59 | $340.00 | $30.00 | $60.59 | 0.15 | $9.09 |
| Corn | $666.45 | $570.72 | $30.00 | $65.73 | 0.10 | $6.57 |
| ***4.8.3.2 Average*** | | | | | | ***$151.04*** |
| | | | | | | |
| **Intake ID** | | | | | | |
| Sugar beets | $1,364.50 | $1,026.90 | $30.00 | $307.60 | 0.40 | $123.04 |
| Hay | $356.59 | $372.64 | $30.00 | $-46.05 | 0.10 | -$4.61 |
| Wheat | $458.30 | $420.43 | $30.00 | $7.87 | 0.20 | $1.57 |
| Barley | $430.59 | $340.00 | $30.00 | $60.59 | 0.10 | $6.06 |
| Corn | $666.45 | $570.72 | $30.00 | $65.73 | 0.20 | $13.15 |
| ***Average*** | | | | | | ***$139.21*** |
| | | | | | | |
| **Savage ID** | | | | | | |
| Sugar beets | $1,364.50 | $1,026.90 | $30.00 | $307.60 | 0.35 | $107.66 |
| Hay | $356.59 | $372.64 | $30.00 | $-46.05 | 0.15 | -$6.91 |
| Wheat | $458.30 | $420.43 | $30.00 | $7.87 | 0.15 | $1.18 |
| Barley | $430.59 | $340.00 | $30.00 | $60.59 | 0.20 | $12.12 |
| Corn | $666.45 | $570.72 | $30.00 | $65.73 | 0.15 | $9.86 |
| ***Average*** | | | | | | ***$123.91*** |

Multiplying the acreage for each district by the weighted net revenue per acre and summing the result leads to an estimated net revenue of $8.75 million annually or about $149.85 per acre. The average net revenue per acre for all four districts is considered representative for the entire Lower Yellowstone project. The payment capacity guidelines allow for a reasonable family farm income, which would include any dryland based farm revenues that would be part of the farm operation. The predominant dryland agricultural activity in the area is pastureland. The National Agricultural Statistics Service publication "North Dakota 2012 County Rents & Values" (March 2012) indicates the average 5-year 2007 to 2011 pasture rental rate was $9.20 per acre for McKenzie County and $8.70 per acre for Williams County. Rental rate data were not available for individual Montana counties. A pasture rental rate of $8.95 per acre was used to estimate dryland revenues. Assuming a farm operation would include 320 irrigated acres, 160 acres of rented pasture, and 20 acres for farmstead/waste, net revenues for a farm operation would be about $46,400 per farm operation.

Assuming additional O&M costs are passed on to irrigated crop production, No Action O&M costs would add about $1,400 in costs to each farm operation relative to current costs, the Rock Ramp Alternative would add about $1,600 in total costs prior to operation of the new headworks relative to current costs, and the Bypass Channel Alternative would add $1,270 in total costs prior to operation of the new headworks relative to current costs for each farm operation. Net farm revenues appear to be sufficient to pay the O&M costs associated with each alternative, but they would reduce net farm income by 2.74% to 3.45% depending on the alternative. Relative to No Action, the Bypass Channel Alternative actually reduces the adverse effects of O&M costs on net farm income. Annual net farm income is approximately $130 higher with the Bypass Channel Alternative relative to No Action while the Rock Ramp Alternative results in a reduction in net farm income of $200 annually. It should be noted that this analysis is based on an analysis of a representative operation, but that there may be individual operations with net revenues that are lower or higher than estimated above.

**Cumulative Effects**

Based on Reclamation's experience with Section 7 consultation and ESA compliance on other projects and facilities, the Service would likely require that improved fish passage be in place by a certain date. Failure to achieve compliance with ESA under No Action could result in curtailment of project water deliveries over the long term and adverse economic consequences. The Bypass Channel and Rock Ramp Alternatives would increase O&M costs, which would reduce the financial viability of the irrigation districts. Increased economic activity associated with construction and O&M activities would lead to potentially positive overall regional economic impacts and continued delivery of a reliable water supply.

### 4.8.4 Summary

Based on the expected continuation of current agricultural production or trends in production and recreation activities, as described in the Lower Yellowstone Irrigation District and Recreation sections, there are no significant regional economic impacts associated with changes in output in these two sectors. There would be short-term positive regional economic impacts (increased output, employee compensation, and employment) associated with initial construction of the proposed action alternatives. These short-term positive impacts could be relatively large in absolute terms if project costs inject federal funds into the region, but are small relative to the overall level of activity in the regional economy. Some positive regional impacts would also be expected in the long run at a much lower level due to O&M costs associated with each alternative, including the No Action Alternative. However, these short-term O&M impacts are likely to be insignificant compared to the size of the regional economy. Increased O&M costs associated with the Rock Ramp Alternative may reduce net farm income by 0.44% relative to No Action while net farm revenues may actually be 0.29% higher with the Bypass Channel Alternative compared to No Action. Farm revenues appear to be sufficient to pay the increased O&M costs associated with the Rock Ramp Alternative.

## 4.9. Lands and Vegetation

### 4.9.1 Introduction

- ➢ How would the fish passage alternatives affect lands and vegetation including wetlands, grasslands, woodlands, riparian areas and noxious weeds in the area of potential effects?

This section addresses lands and vegetation that may be affected by construction of fish passage features. Lands and vegetation include wetlands, grasslands, woodlands, riparian areas, and noxious weeds.

Construction may impact lands and vegetation on either a temporary or permanent basis. Temporary impacts generally are short term and associated with project construction. Following contouring and revegetation, the land is expected to revert to previous uses. Permanent impacts are long-term impacts typically associated with construction of permanent facilities. Permanent impacts could result in irretrievable commitment of resources. Some of the natural resources discussed above would be lost due to conversion to permanent facilities. Another way natural resources may be impacted is by fish passage features that could potentially influence hydrology in the Yellowstone River. For example, a change in river flows could lead to bank erosion and loss of land.

### 4.9.2 Methods

To analyze the impacts of the proposed Intake Project, land use databases developed by various state and federal agencies were used to inventory land cover types within the area of potential effects using GIS. The methods used to compile the inventory are explained in Chapter 3 of the 2010 EA.

### 4.9.3 Results

#### *4.9.3.1 Short-Term and Long-Term Effects of the Alternatives*

**Wetlands**

***Bypass Channel Alternative:*** A total of 20.5 acres of palustrine and riverine wetlands are located within the construction area footprint and may be impacted during construction. Wetlands (Appendix K) would be avoided to the maximum extent possible. A majority of the impacts to wetlands would be temporary, and all permanent impacts would be mitigated on-site concurrent with project construction.

Temporary impacts to wetlands would result from the placement of box culverts on two haul roads on Joe's Island, which would fill less than one acre of emergent wetlands and backwater channel. Following construction, haul roads and culverts would be removed and the area restored to pre-disturbed conditions.

This alternative is anticipated to permanently impact 13 acres of riverine habitat in the Yellowstone River and the high flow channel and about one-half acre of emergent wetland associated with the high flow channel. Permanent impacts to wetlands adjacent to the Yellowstone River and side channel would be limited to the construction of the weir upstream of the existing dam and excavation of the bypass channel. Weir construction would result in approximately one acre of fill being placed in the river directly upstream of the existing dam. It is anticipated that the low quality riverine habitat present at the existing dam area prior to the disturbance would redevelop following construction and would provide similar ecological benefits. The bypass channel construction would affect 11 acres of high flow channel habitat where the upper end of the bypass follows the existing high flow channel and one additional acre of high flow channel habitat where the channel diversion is constructed. In addition, less than one-half acre of emergent wetland associated with the high flow channel would likely be impacted. Due to fluctuating seasonal flows in the high flow channel, the emergent wetlands vary in size annually; therefore, the anticipated impact acreage is provided as an average.

Excavation of the bypass channel would create approximately 60 acres of new side channel habitat similar to other side channels on the Yellowstone River. The gently sloping banks of the bypass channel may encourage wetland vegetation to grow and may exceed any permanent wetland impacts associated with channel construction.

Based on the analysis above, impacts to wetland resources would be considered negligible as a result of implementing the Bypass Channel Alternative. As the project progresses and details are refined, opportunities to avoid and/or minimize impacts to wetland and riparian resources will continue to be evaluated and pursued. Unavoidable wetland impacts will be mitigated on-site to the extent practicable.

***Rock Ramp Alternative:*** Approximately 55 acres of riverine habitat are located within the construction area footprint and could be impacted. Of these 55 acres, about 2 acres of riverine habitat are already impacted by the existing dam structure and rock that has been added to the top of the dam and subsequently displaced downstream. Replacing the diversion dam with a new concrete weir would not increase impacts, as compared to No Action Alternative (Continue Present Operation).

The addition of rock to build the ramp would impact about 32 acres of riverine habitat including the river bottom. After completion of the rock ramp, the riverine habitat would be converted to constructed river bottom habitat. The remaining 23 acres of riverine habitat in the construction area could be temporarily impacted during project construction activities (e.g. equipment movement). All temporary wetland impacts would be addressed by actions to minimize effects and mitigation implemented where necessary (Appendix I). Overall, with avoidance and mitigation measures, wetland impacts are considered to be minor.

**Riparian Areas**

***Bypass Channel Alternative:*** This alternative would have the greatest potential impact to riparian habitat. A total of 70 acres of riparian habitat are located within the construction area footprint. Ten acres of existing riparian habitat will be impacted during excavation of the new channel. The construction of temporary access roads and other construction activities would impact approximately 3 acres of riparian shrub and forested riparian habitats. These impacts are considered temporary and would be restored upon completion of construction. The remaining riparian habitat within the construction area would be protected by actions to minimize effects

(Appendix I). All temporary and permanent impacts to riparian habitat are considered moderate and would be offset by avoidance and mitigation commitments.

***Rock Ramp Alternative:*** Of the two action alternatives, this alternative would have the least impact to riparian habitat. Approximately 5 acres of riparian habitat are located within the construction footprint and could be impacted. All of these 5 acres would be temporarily impacted during project construction and staging activities. Temporary impacts would be addressed by actions to minimize effects (Appendix I). Overall, with implementation of avoidance and mitigation measures, riparian habitat impacts are considered to be minor.

**Woodlands**

***Bypass Channel Alternative:*** This alternative would have the greatest impact to woodlands, shrublands, and evergreen/deciduous forested areas. This acreage does not include riparian habitat mentioned above. A total of 184 acres are located within the construction footprint. Permanent impacts of 26 acres would occur during bypass channel construction. The construction of temporary access roads and other construction activities would impact approximately 6 acres of woodlands. These impacts are expected to be temporary and restored upon completion of construction. Impacts to these woodland areas would be offset through avoidance, actions to minimize effects listed in Appendix I, and other mitigation measures. With avoidance and mitigation commitments in place, woodland impacts are considered to be minor.

***Rock Ramp Alternative:*** This alternative would have the least potential to impact woodlands. Approximately 12 acres of woodlands are located within the construction footprint and could be impacted during project construction and staging activities. Impacts to these woodland areas would be offset through avoidance, actions to minimize effects outlined in Appendix I, and other mitigation measures. With these commitments in place, woodland impacts are considered to be minor.

**Grasslands**

***Bypass Channel Alternative:*** This alternative would have the greatest impact to grasslands. A total of 321 acres of grasslands are located within the analysis area. Permanent impacts would include excavation of the new channel, which would result in the conversion of approximately 20 acres of grasslands. The placement of excavated material into the waste pile site would impact approximately 60 acres. In addition, other miscellaneous construction activities would temporarily impact minor amounts of grassland. Impacts to these grassland areas would be offset through actions to minimize effects listed in Appendix I and other mitigation measures. With these commitments in place, grassland impacts are considered to be minor.

***Rock Ramp Alternative:*** This alternative would have fewer impacts to grasslands than the other alternative. Approximately 21 acres of grasslands are located within the construction footprint and would be impacted. All of these 21 acres would be temporarily impacted during project construction and staging activities. Impacts to these grasslands would be offset through the actions to minimize effects listed in Appendix I and restoration measures. With these commitments in place, grassland impacts would be minor.

**Noxious Weeds**

***Bypass Channel Alternative:*** This alternative has the largest construction footprint, and there is a greater opportunity for this alternative to affect the spread of noxious weeds. Joe's Island has a large infestation of leafy spurge that could spread by construction activities. However, actions outline in Appendix I are anticipated to minimize the spread of noxious weeds.

***Rock Ramp Alternative:*** This alternative has a relatively small overall footprint compared to the Bypass Channel Alternative. Ground disturbance associated with construction activities could provide a pathway for dispersal and establishment of invasive plants including salt cedar, although the risk would be lower than the Bypass Channel Alternative. Actions outlined in Appendix I are anticipated to minimize the spread of noxious weeds during and after construction.

**Cumulative Effects**

With implementation of actions to minimize effects (Appendix I) and other mitigation and restoration measures, the action alternatives would minimally impact lands and vegetation. Additionally, there are no known present or future projects that would make these resources especially vulnerable to incremental effects beyond current agricultural practices. Therefore, cumulative impacts to these resources in the Yellowstone River Basin would be minimal.

**Actions to Minimize Effects**

***General***

- An ERT consisting of biologists from Reclamation, the Corps, Service, and MFWP will play a role in oversight of actions to minimize effects for land and vegetation.
- Before every construction season, Reclamation and the Corps will meet with the Service and the appropriate state wildlife agencies to determine procedures to minimize impacts to lands and vegetation. A reconnaissance survey of construction easements will be conducted to identify and verify wetlands, grasslands, woodlands, and riparian areas subject to disturbance and/or destruction in the Intake Project area during construction activities. The ERT will be consulted, as necessary, to determine appropriate avoidance and/or protection measures. If adverse impacts cannot be avoided, appropriate procedures and requirements for minimizing or mitigating effects will be discussed with the ERT.
- Disturbance of vegetation will be minimized through construction site management (e.g., using previously disturbed areas and existing easements when feasible and designating limited equipment/materials storage yards and staging areas.) It will be limited to that which is absolutely necessary for construction of the Intake Project.
- All contactors will be required to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread on Aquatic Nuisance Species.
- All areas disturbed or newly created by the construction activity will be seeded with grasses and other vegetation indigenous to the area for protection against subsequent erosion and noxious weed establishment.
- All equipment tracks and tires working on Joe's Island or other noxious weed infested areas will be cleaned daily to reduce potential of transportation to an uninfested site.

- An integrated weed plan will be developed and approved by the ERT. It will identify best management practices to control the spread or introduction of any noxious weeds or plants. The weed plan will be implemented during and subsequent to construction.
- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness and only effective techniques will be used.
- No permanent or temporary structures will be located in any floodplain, riparian area, wetland or stream that would interfere with floodwater movement, except for those described in Chapter 2 of the Intake Final EA.

***Wetlands***

- Prior to beginning construction through Conservation Reserve Program lands or program wetlands, the Natural Resources Conservation Service, Consolidated Farm Services Agency, and respective landowners will be consulted to ensure that landowner eligibility in farm subsidy programs (if applicable) will not be jeopardized and that Sodbuster or Swampbuster requirements will not be violated by construction.
- Waste material, topsoil, equipment, debris, excavated material, or other construction related materials will not be disposed of within 50 feet of any wetland, drainage channel, irrigation ditch, stream, or other aquatic systems.
- Where impacts cannot be avoided, and restoration of affected wetland habitats is necessary, wetland soils will be stockpiled for use when constructing new areas.
- Discharges of fill material associated with unavoidable impacts to wetlands or intermittent streams will be carried out in compliance with provisions of Sections 401 and 404 of the Clean Water Act and the nationwide and/or Intake Project-specific permit requirements of the Corps.
- Rock quarry materials will come from sites with no potential to impact wetlands or other protected resources.
- The ERT will play a role in oversight of actions to ensure compliance with Sections 401 and 404 of the Clean Water Act and will recommend actions to minimize effects to wetlands.

***Grasslands***

- Grasslands temporarily affected during construction will be restored with similar native species. Where existing native grasslands cannot be re-seeded in their current locations, procedures for appropriate restoration will be reviewed by the ERT.
- Disturbed native grassland will be reseeded with native species with the seed mix being determined by the ERT. Planted grasslands will be reseeded with a seed mixture appropriate for the site and watered, if necessary, until establishment. Reseeding may require mulching in order to be successful.
- Seed would be certified as cheatgrass and weed free and "blue tag;" this is especially important in areas where weedy or invasive species are already present. There are no seed lots that are free of all weeds; however, requests can be made to specify the type of weed that you would like excluded. The seed company will provide a letter of certification for the seed that would list any noxious weeds or other weed seeds in the lot of seed being provided. This information comes directly from the seed test analysis provided by certified seed testing labs. The seed used on the site can be guaranteed to be

cheatgrass free. It is recommended that the seed be tested independently, if necessary, to verify that there are no cheatgrass or noxious weed seeds present.

- Two methods of seeding should be utilized for reclamation areas. Seeds will either be drilled or broadcast based on the species being planted. Drill seeding is recommended for most grasses and large-seeded shrubs and forbs that need to be planted at least ¼ inch deep. Drill seeding is preferred for soil to seed contact, positive depth control, proper seeding rate (once calibrated), and minimum amount of seed usage. Broadcast seeding is recommended for very small and fluffy seeds that need to be planted 1/16 to 1/8 inches deep. Modern range drills may be capable of drill and broadcast seeding.
- Areas requiring re-vegetation will be seeded and mulched during the first appropriate season after redistribution of topsoil. If reseeding cannot be accomplished within 10 days of topsoil replacement, erosion control measures will be implemented to limit soil loss. Local native grass species would be used (mixture to be reviewed by the ERT).
- Seeding should take place the first appropriate season following topsoil replacement. Seeding between October 15 and April 15 is the most effective throughout Montana because late winter/early spring is the most reliable period for moist soil conditions. In general, fall seeding (between October 15 and when the frost line is deeper than four to six inches) in eastern Montana has been more successful than spring seeding. Some seed may require cold stratification to germinate. However, spring seeding may be considered if timing of construction warrants.
- To reduce erosion, water bars will be installed at specified intervals, depending upon soil type, grade, and terrain on disturbed slopes with grades of 6% or greater.
- Vegetation and soil removal will be accomplished in a manner that will prevent erosion and sedimentation.
- Noxious weeds will be controlled, as specified under state law, within the construction footprint during and following construction. Herbicides will be applied in accordance with labeled instructions and state, federal, and local regulations.
- Grass seeding will be monitored for at least three years. Where grasses do not become adequately established, areas will be reseeded with appropriate species.

***Woodlands and Riparian Areas***

- No disposal of waste material, topsoil, equipment, debris, excavated material, or other construction related materials will be done within 50 feet of any riparian area.
- Woodland and riparian areas will be avoided where practical when constructing permanent facilities.
- Woodland and riparian areas impacted by the Intake Project will be restored 2:1 with native species. Where existing woodland and riparian areas cannot be restored in original locations, then adjacent or nearby areas will be considered by the ERT.
- Native trees and shrubs will be restored with similar native species at a ratio of two trees or shrubs planted for each tree or shrub removed. Long-term success of plantings will be reviewed and approved by the ERT.
- Weed growth in tree planting areas will be controlled and tree plantings will be monitored for at least three years. Where plantings are not successful, they will be replanted with appropriate species.
- Where practicable, replanted riparian areas will be watered to ensure survival of planted vegetation. Long-term success of plantings will be reviewed and approved by the ERT.

### 4.9.4 Summary

The construction footprint for the Bypass Channel Alternative is larger thus impacts are greater. Actions to minimize effects (Appendix I) put in place and other restoration or mitigation measures would minimize or offset any potential impacts

## 4.10. Wildlife

### 4.10.1 Introduction

- How could the Intake Project affect wildlife including mammals, migratory birds, amphibians, and reptiles currently living in the Intake Project Area?

This section addresses the effects of alternatives on wildlife other than special status species (federally-listed species and state species of special concern). Most effects on wildlife can be identified by considering the effects on lands and vegetation.

Many species use trees and shrubs in woodlands as nest sites, roosts, or as cover (e.g. raptors and squirrels), and others consume parts of trees and shrubs as food. Other species, such as waterfowl, nest in emergent marshes and upland grasslands and other suitable sites. Riparian vegetation and grasslands provide food and shelter for some mammals and nesting birds. Amphibians and reptiles use terrestrial and aquatic habitats in and adjacent to the Yellowstone River.

### 4.10.2 Methods

The analysis of impacts on wildlife species considered changes in wildlife habitat represented by wetlands, woodlands, riparian areas, and grasslands. Impacts to wildlife include short-term disturbance and long-term loss of habitat from construction of project features.

Potential impacts to wildlife habitat, represented by wetlands, woodlands, riparian areas, and grasslands, are discussed in the Lands and Vegetation section above. Most wildlife populations are resilient and able to adapt to cycles of habitat abundance. Impacts to mammals, migratory birds, amphibians, and reptiles are discussed. However, a few species with small populations could experience impacts from temporary disturbances and loss of habitat. These species are evaluated in the Federally-Listed Species and State Species of Special Concern section above.

### 4.10.3 Results

#### *4.10.3.1 Short-Term and Long-Term Effects of Alternatives*

**Bypass Channel Alternative**

***Mammals:*** Much of the area proposed for construction (including staging and stockpile areas) of the weir and bypass channel is relatively undisturbed. Vehicle access to Joe’s Island is limited to a 20-mile gravel road. Current activities on the island include hunting, camping, and fishing.

Construction activities would have temporary (e.g., noise) and permanent (habitat conversion) effects on wildlife species and their habitats in the immediate vicinity of the construction area. Human activity and equipment noise would disturb some species sensitive to this activity. Those animals would be expected to move to other areas during construction.

The excavated bypass channel would cover approximately 73 acres and would affect wetlands, riparian areas, woodlands, and grasslands. However, construction of the bypass would isolate a portion of Joe's Island leading to less disturbance in the future. Actions to minimize effects (Appendix I) would be expected to offset most temporary or permanent impacts. Affected animals would be expected to return to restored habitats or areas minimally disturbed by construction. Impacts on mammals are expected to be minor after implementation of actions to minimize effects and restore disturbed habitats (Appendix I).

In addition to the channel construction, other areas that would be impacted from construction include the waste pile site and haul roads. These areas would be impacted during construction, but returned to conditions supporting existing habitat values. By following actions to minimize effects (Appendix I), methods to avoid resource impacts (Appendix I), and habitat restoration measures, long-term impacts are expected to be minor.

***Birds:*** The excavated channel would convert approximately 73 acres of primarily riparian woodlands and grasslands on Joe's Island to riverine aquatic habitat. Most of the woodlands are relatively sparse with an open canopy and mixed herbaceous and shrub understory. The areas identified for stockpiling construction materials and placement of excavated material is primarily grassland habitat. While nesting birds may utilize these habitats, efforts will be made to avoid impacts by developing a migratory bird management plan to avoid and minimize impacts to nesting or migrating birds. The migratory bird management plan would include modifying habitat outside of the nesting season to discourage nesting activity, adjusting timing of construction, avoiding certain habitats at certain times of year, and/or bird surveys to identify where it is safe to proceed with construction without impacting nesting birds. Appendix I describes some methods to avoid resource impacts in greater detail. Reclamation and the Corps will work with the Service and MFWP to develop the migratory bird management plan following selection of an alternative.

Although construction of the bypass channel will have a direct effect on existing habitats, the bypass channel would isolate a portion of Joe's Island leading to less disturbance in the future. Given the actions to minimize effects and the relative abundance of riparian forest habitat along the lower Yellowstone River, adverse effects on breeding and migratory birds is expected to be minor. There would, however, be a lag time between planting of trees and shrubs and establishment of mature habitat where reestablishment is necessary. With similar habitat adjacent to the proposed project area, this impact would be minor.

***Amphibians and Reptiles:*** The Bypass Channel Alternative construction activities would have a temporary effect on amphibians and reptile species located in the immediate vicinity of the construction area. However, slightly beneficial impacts to amphibians and reptiles will likely be realized as a result of increasing the amount of aquatic and wetland habitats available to them. This would include the creation of the new bypass channel as well as provide for the existing high flow channel to receive more water during low flows through the channel diversion. Currently the existing high flow channel only carries water during high flow events and can be dry in late summer, winter and early spring. In addition to the anticipated benefits, actions to minimize effects (Appendix I) would be implemented to offset any temporary or permanent impacts. Overall impacts to amphibian and reptiles are expected to be minor.

**Rock Ramp Alternative**

***Mammals:*** Rock Ramp construction activities would have a temporary effect on wildlife species located in the immediate vicinity of the construction area. Human activity and equipment noise would disturb some species sensitive to this type of activity. Compared to the Bypass Channel Alternative, the impacts to trees, shrubs, and other vegetative cover are smaller. This is because most of the work is confined to the main channel of the river in the vicinity of the existing dam. Actions to minimize effects (Appendix I) including those listed under the natural resources section would be expected to offset any temporary or permanent impacts. Overall impacts on mammals would be negligible.

***Birds:*** The rock ramp would be constructed in the main channel of the river and would have little or no effect on avian breeding or migratory habitat. Examination of aerial photographs did not reveal the presence of any sandbars within the footprint of the proposed rock ramp that would typically be exposed during the breeding season.

Construction activity would displace birds that are sensitive to disturbance. Staging and stockpile areas would be revegetated after construction, reestablishing any bird habitats on these areas that were lost during construction. Adverse effects on trees, shrubs, and native grasslands would be minimal. Overall impacts to birds would be expected to be minor.

***Amphibians and Reptiles:*** Rock Ramp construction activities would have a temporary effect on amphibians and reptile species located in the immediate vicinity of the construction area, similar to the impacts described for the other action alternative. Actions to minimize effects (Appendix I) would be implemented to offset any temporary or permanent impacts. Overall impacts to amphibian and reptiles would be minor.

**Cumulative Effects**

Most impacts to wildlife from the action alternatives would be relatively minor and temporary. There are no known or reasonably foreseeable actions in the lower Yellowstone River corridor that would elevate these minor impacts to greater magnitudes.

**Actions to Minimize Effects (Appendix I)**

***Mammals and Migratory Birds***

- Before each construction season, the ERT will meet with MFWP to determine procedures for avoiding and minimizing impacts to nesting or migrating birds.
- Areas potentially hazardous to wildlife will be adequately protected (e.g., fenced, netted) to prevent access to wildlife.

- To protect wildlife and their habitats, Intake Project-related travel will be restricted to existing roads and Intake Project easements. No off-road travel will be allowed, except when approved through the ERT.
- Wildlife-proof fencing will be used on reclaimed areas, if it is determined that wildlife species and/or livestock are impeding successful vegetation establishment.

***Amphibian and Reptiles***

- All riverbank disturbance areas will be inventoried for potential turtle nesting habitat. If turtle nesting habitat or evidence of turtle nesting is found in construction areas, construction in these areas will be restricted during June and July, or mitigation measures approved by the ERT will be implemented.

## 4.11. Summary

With actions to minimize effects and restore affected habitats, impacts to mammals, amphibians, reptiles and migratory birds would be minor and temporary for both alternatives. Based upon the total construction footprint that includes construction and additional work areas, the Bypass Channel Alternative would have the largest potentially affected area ( 626 acres). The Rock Ramp Alternative would have a potentially affected area of 28 acres.

## 4.12. Historic Properties

### 4.12.1 Introduction

- ➢ Would the fish passage alternatives affect historic properties (significant cultural resources)?

Section 106 of the NHPA requires that federal agencies consider the effects of federal undertakings on historic properties. Historic properties are significant cultural resources; including sites, buildings, structures, objects, or districts, or properties of traditional religious and cultural importance to Native Americans; that are either included in or have been determined eligible for inclusion in the National Register of Historic Places. Only historic properties are protected by the NHPA and are evaluated in this section.
To evaluate the effects of a proposed undertaking on historic properties, federal agencies are required to consult with the appropriate SHPO, any tribe, or Tribal Historic Preservation Officer with a historic interest in the Intake Project's undertaking area of potential effects, and the interested public. Environmental documents prepared in compliance with NEPA can be used to examine and address these effects and as the basis for consultation.

### 4.12.2 Methods

Until consultation is concluded, the actual effects of the proposed Intake Project under Section 106 of the NHPA are undetermined. At this point consultation is in progress, so the discussion in this section is based upon the best available information that compares alternatives to each other.

As explained in the Historic Properties Section of Chapter 3, 19 cultural resources have been recorded within or near the area of potential effects of the proposed Intake Project, but only seven have been determined to be historic properties protected under NHPA. The effects of the proposed federal undertaking on those seven historic properties are discussed in this section.

To estimate direct effects, locations of the historic properties recorded by Kordecki et al. (1999) were plotted on a GIS layer, which was overlain with impact corridors for all three alternatives. In addition, direct impact areas outside of the Kordecki et al. (1999) survey but inside the area of potential effects were intensively inventoried and previously recorded sites were revisited and site forms updated (Snortland, 2009). Table 4.17 lists the historic properties located within the area of potential effects of each of the alternatives.

As the area of potential effect (APE) of the project has been expanded in the southwest portion of the project area (waste pile site), additional site evaluations will be needed Site 24DW429, a prehistoric lithic scatter, will need to be evaluated and its eligibility determined.

In addition, sites, 24DW432, 24DW435 and 24DW438, are all lithic scatters which do not meet the criteria of eligibility under NHPA. If these sites are determined to be within the APE, SHPO concurrence with these recommended determinations will be requested before consultation is complete.

### 4.12.3 Results

#### *4.12.3.1 Short-Term and Long-Term Effects of the Alternatives*

Before an action alternative is constructed, Reclamation would complete consultation with the Montana State Historic Preservation Officer and other interested parties, as appropriate, to assess the effects of the proposed Intake Project on the identified historic properties and resolve potential adverse effects under Section 106 of the National Historic Preservation Act. Analysis indicates that both alternatives would likely have an adverse effect(s) to historic properties. Indian tribes which may have an interest in particular sites will be included in consultations regarding evaluations, determinations of effect and any resolutions of adverse effect pertaining to those sites.

Avoidance is the preferred method of mitigating any adverse effects, as it would preserve the historic properties. However, should avoidance not be possible, actions to minimize effects would be developed in consultation with the Montana State Historic Preservation Officer, as appropriate. All of the properties that would be affected by action alternatives are historic structures or buildings associated with the Lower Yellowstone Irrigation Project.

***Bypass Channel Alternative:*** This alternative would probably result in adverse effects to site 24DW443, Intake Diversion Dam and associated dike cableway tower, engineer’s house and power plant. The construction of the new weir may be considered an adverse effect on the existing diversion dam and construction of the bypass channel may require removal of the south cableway tower and associated buildings and removal of some or all of the dike. Mitigation for adverse effects to this site resulting from the rock ramp alternative has been agreed upon in a

Memorandum of Agreement (MOA) among Reclamation, the Corps, SHPO and the District. Portions of this mitigation (documentation of the buildings and structures) have been completed. The parties to the MOA will determine in consultation whether any additional or different mitigation is warranted given the slightly different effects resulting from the bypass channel alternative.

Site 24DW430, a prehistoric archaeological site, lies within the proposed spoil disposal area south of Joe's Island. Placing spoil on top of the site may be considered an adverse effect. Widening or improving the access road to Joe's Island which passes through the site may also result in an adverse effect. The eastern edge of the spoil pile will be moved at least 100 meters west of the access road to avoid effects to 24DW430.

***Rock Ramp Alternative:*** The main canal (24DW287) would be minimally affected by filling in a relatively small portion of the 71.6 mile-long canal. The historic headworks would be preserved in place beside the new headworks.

The Intake Diversion Dam (24DW443) and an associated dike and three buildings on Joe's Island would also be impacted. Except for minimal modification, the dam would be preserved in place and buried underneath the new rock ramp. Part of an historic dike would be damaged in the construction staging area on Joe's Island. The three buildings associated with the dam could be moved out of the staging area to protect them, but this would be an adverse effect under the NHPA.

The Headworks Camp and Gate Tender Residence (24DW447) (Figure 4-3) are in an area that would be excavated to extend the main canal upstream and build the new headworks. The house, garage, and outhouse could be relocated to nearby property and preserved. Historic archaeological features in the Headworks Camp would be destroyed by excavation of the main canal through the site and construction of the new headworks, although archaeological mitigation could preserve data and artifacts. Other actions to minimize effects are also possible.

**Figure 4-3. Headworks gate tender's residence**

Impacts to the Old Cameron and Bailey Sub-Camp (24DW298) could be avoided by fencing the historic property and monitoring construction activities in the area. The two prehistoric archaeological sites can be avoided during construction activities.

**Cumulative Effects**
No other projects within the area of potential effects have been identified that would affect historic properties.

**Actions to Minimize Effects**
Reclamation is presently consulting with the Montana State Historic Preservation Officer and other interested parties, as appropriate, regarding an MOA and data recovery plan. The Advisory Council on Historic Preservation is being notified of an adverse effects determination under the NHPA.

Reclamation proposes to implement the following actions to offset any adverse effects to historic properties:

- Engineering drawings and photographs of affected buildings and structures, if available, will be filed with the State Historic Preservation Office and the National Archives.
- If engineering drawings and photographs are not available, the buildings and structures will be recorded in accordance with the Historic American Buildings Survey and the Historic American Engineering Record, as appropriate.
- If practicable, historic buildings or structures that must be moved for construction will be returned to their original locations after construction of the Intake Project is completed. If that is not feasible, Reclamation will seek a party willing and able to adopt the historic structure or building with appropriate preservation covenants.
- Reclamation will develop and implement a data recovery plan in consultation with the Montana State Historic Preservation Officer, Advisory Council on Historic Preservation, and other interested parties, as appropriate, for mitigation of the Headworks Camp (24DW447).
- One or more signs will be installed at or near the Intake FAS to summarize the history of the Lower Yellowstone Irrigation Project.
- A fence will be installed around the Old Cameron and Bailey Sub-Camp (24DW298) to protect it from disturbance by unloading and storage of rock or other construction activities.
- All construction activities will avoid using the road through the late plains archaic campsite (24DW430).
- All gravel, fill, and rock materials will be obtained from a source approved by Reclamation to ensure compliance with Section 106 of the NHPA.
- Reclamation will continue consultation with the Montana State Historic Preservation Office on the preparation of a formal MOA stipulating the mitigation and treatment plan.

### 4.12.4 Summary

All alternatives could be considered to have potential adverse effects to historic properties under the NHPA. Under NEPA the actions to minimize effects listed above would offset any significant adverse effects and make the impacts insignificant. The Montana State Historic Preservation Officer, tribes, and other interested parties, as appropriate, would be consulted to complete a determination of effects and to identify appropriate actions to minimize effects. These actions to minimize effects would be carried out prior to initiating construction of the Intake Project to offset any adverse impacts.

# 5. Consultation and Coordination

This chapter describes public involvement activities, agency consultation and coordination, and acknowledges the people who have been involved with this NEPA process.

## 5.1. Public Involvement Program

Scoping is an important part of the NEPA process. It serves as the public's opportunity to provide input and direction to the Intake EA throughout its preparation. In 2008, Reclamation and the Corps began a public involvement program to provide the public, organizations, and government agencies with a variety of ways to learn about and participate in the Intake Project. Reclamation and the Corps developed a public involvement strategy that included:

- Holding three formal public scoping meetings
- Meeting with state and federal agencies
- Mailing scoping information to agencies, public, and tribes
- Forming a cooperating agency team
- Issuing news releases
- Posting information on the Montana Area Office Reclamation website

- Publishing and distributing a newsletter and *Public Scoping Summary Report, Intake Diversion Dam Modification, Lower Yellowstone Project, Montana, Environmental Impact Statement* (Reclamation & Corps, 2009)

## 5.2. Cooperating Agency Team

Reclamation and the Corps established a Cooperating Agency Team to facilitate communication among state and federal agencies. The team met frequently and exchanged information throughout the NEPA process. Cooperating agencies provided information based upon their special expertise or jurisdiction related to the Intake Project, assisted with analyses, and reviewed draft documents and analyses. The following organizations participated as cooperating agencies:

- Montana FWP
- Montana Department of Environmental Quality (DEQ)
- Montana Department of Natural Resources and Conservation (DNRC)
- LYIP
- Service

In addition to these agencies, the EPA, Natural Resource Conservation Service, The Nature Conservancy, and the USGS provided input during cooperating agency meetings (Table 5.1).

## 5.3. Biological Review Team

In 2006, the Service created a BRT of fisheries biologists and engineers with expertise in fish passage and pallid sturgeon to review preliminary alternatives. This team consisted of the following:

- George Jordan, Service
- Aaron Delonay, USGS
- Pat Braaten, USGS
- Brent Mefford, Reclamation
- Dale Lentz, Reclamation
- Mike Backes, MFWP (interim replacement for Jason Rhoten who replaced Matt Jaeger)

## 5.4. Meetings

From the early scoping of the project through development of the existing Supplemental EA, staff representing the joint lead agencies have met with staff from other state and federal agencies to gather information on resources, discuss potential impacts on the environment, and clarify procedures for compliance with laws, regulations, and policies. The purpose of these meetings, agencies involved, and meeting dates and locations are listed below in Table 5.1.

**Table 5-1. Resource meeting topic, participants, dates, and locations**

| Topic | Participants | Date | Meeting Method – Location |
|---|---|---|---|
| EA process and team formation | Cooperating Agency Team | 9/24/2008 | Meeting – Billings, MT |

| Topic | Participants | Date | Meeting Method – Location |
|---|---|---|---|
| ESA issues | FWP, Service, Reclamation, Corps | 10/22/2008 | Meeting – Intake, MT |
| Defining No Action | Reclamation and Service | 12/10/2008 | Meeting – Billings MT |
| Success criteria related to comparing alternatives for incremental cost analysis | FWP, Service, Reclamation, Corps | 12/18/2008 | Conference call |
| Larval drift | FWP, Service, Reclamation, Corps, Upper Basin Pallid Sturgeon Workgroup | 12/19/2008 | Conference call |
| Alternatives and public scoping results | Cooperating Agency Team | 1/29/2009 | Meeting – Billings, MT |
| Pallid sturgeon | Service's BRT, Corps, Reclamation | 2/17/2009 – 2/18/2009 | Meeting – Billings, MT |
| ESA compliance and alternatives | Lower Yellowstone Irrigation District No 1 and 2, Savage Irrigation District, and Intake Irrigation District Water Users, Sidney Area Public | 2/12/2009 | Districts' Annual Meeting – Sidney, MT |
| Alternatives | Natural Resources Conservation Service (District Conservationists, Engineers, Region and State Employees) | 2/19/2009 | Meeting – Billings, MT |
| Draft EA chapters | Cooperating Agency Team | 5/11/2009 | Meeting – Billings, MT |
| NEPA and Section 404 of the Clean Water Act | EPA, Corps, Reclamation, Service | 5/19/2009 | Meeting – Denver, CO |
| Status of Intake and Reassessment of Alternatives | Cooperating Agency Team | 12/13/2011 | Meeting – Billings, MT |
| Interagency Technical Brief on Status | EPA, Corps, Reclamation, Service | 4/20/2012 | Webinar |
| Interagency Technical Brief on Design Status | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 3/28/2013 | Billings, MT |
| Intake Value Engineering Study | Corps, Reclamation, Service, MT FWP, LYIP | 4/2/2013-4/4/2013 | Omaha, NE |
| Interagency Executive Briefing | Corps, Reclamation, Service, MT FWP, MT DNRC | 4/29/2013 | Helena, MT |
| Technical Brief to | Corps, Reclamation, Service, | 5/14/2013 | Sydney, MT |

| Topic | Participants | Date | Meeting Method – Location |
|---|---|---|---|
| LYIP on Design Status | LYIP | | |
| Intake Value Planning Study Meeting | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 6/20/2013 | Meeting-Billings, MT |
| Intake Value Planning Study Meeting | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 6/27/2013 | Meeting-Billings, MT |
| Intake Value Planning Study Meeting | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 7/12/2013 | Meeting-Billings, MT |
| Intake Value Planning Study Meeting | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 7/19/2013 | Meeting-Billings, MT |
| Interagency Technical Brief on Design Status | Corps, Reclamation, Service, MT FWP, MT DNRC, LYIP | 9/27/2013 | Meeting-Billings, MT |

## 5.5. Endangered Species Act Consultation

In October of 2009, the Service sent a letter to the Corps to formally revise portions of the RPA in the Service's 2003 amended Missouri River BiOp to the Corps. The letter substituted a new RPA element at Intake Dam and irrigation headworks on the Yellowstone River, Montana, for one which was originally identified to be taken at Fort Peck Dam. Because the Service has already considered the biological effects of the construction of a fish passage project at Intake in the development of the RPA for the BiOp, and determined that it is an integral component to avoid jeopardy to listed species, Section 7 consultation for the construction of this project has been completed. Therefore, the Corps is not required to prepare a BA for the construction of this project.

It was agreed that a formal consultation process would continue on the operation of the Lower Yellowstone Project, including the proposed fish passage and entrainment structures, which would be evaluated in a separate BA. This second consultation would be completed prior to completion of construction of the new Intake Project. After Reclamation completes this EA evaluating construction of the Intake Project and a second BA on operation of that Intake Project, the Service will prepare a BiOp on operation of the new fish passage and screens. It will include an incidental take statement for any pallid sturgeon larvae and/or eggs that might be entrained even with screens installed in the new headworks.

## 5.6. Coordination and Compliance with Other Applicable Laws, Regulations, and Policies

Analysis and implementation of the Intake Project requires consistency, coordination, and compliance with multiple federal and state laws, regulations, executive orders, and policies. The following are applicable to the Intake Project.

### 5.6.1 Native American Consultation

Consultation with tribes is documented in Appendix H.

### 5.6.2 Archaeological Resource Protection Act of 1979

This act protects archaeological resources on federal and tribal lands and requires a permit to remove archaeological resources from these lands. Permits may be issued to educational or scientific institutions only if the removal would increase knowledge about archaeological resources. Compliance with this law would be accomplished through specific environmental commitments for all of the action alternatives (see "Historic Properties" section).

### 5.6.3 Clean Water Act of 1977 (as amended)

The Clean Water Act (CWA) is the principal law governing pollution control and water quality of navigable waterways of the United States. Section 402 of the act establishes a National Pollution Discharge Elimination System permitting program to regulate the point source discharge of pollutants into waters of the United States. Both Montana and North Dakota administer state-level programs pursuant to authority delegated by the EPA.

Section 404, administered by the Corps with oversight from EPA, is another permitting program that regulates activities of the placement of dredged or fill materials into waters of the United States. The Corps issues nationwide permits on a state, regional, or nationwide basis for similar activities that cause only minimal adverse environmental effects both individually and cumulatively. Individual permits may also be issued for specific activities on specific water bodies under Section 404.

Of specific note, the Corps does not issue itself a CWA permit to authorize Corps discharges of dredged or fill material into WUS, but does apply 404(b)1 analysis and other substantive requirements of the CWA and other environmental laws when developing a Civil Works project. In following ER 1105-2-100 and other pertinent planning regulations, the Corps applies the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). Upon thorough development of a preferred alternative, the Corps will complete the 404(b)1 guidelines analysis for the Intake Project (see Appendix B). Montana State Water Quality Certification Permit (Section 401) would also be required.

Section 401, administered by the Montana DEQ, allows states to review and approve, condition, or deny all federal permits or licenses that might result in a discharge to state waters, including wetlands. States make their decisions to deny, certify, or condition permits or licenses primarily by ensuring the activity will comply with state water quality standards. In addition, states look at whether the activity will violate effluent limitations, new source performance standards, toxic pollutants, and other water resource requirements of state law or regulation. The Section 401 review allows for better consideration of state-specific concerns. A 401 Water Quality Certification would be obtained from Montana DEQ, if appropriate.

### 5.6.4 Floodplain Management Assessment

The floodplain management assessment is conducted in accordance with the National Flood Insurance Program (NFIP) as outlined in Title 44 of the Code of Federal Regulations (44 CFR). The proposed project modifications are compared to the effective Federal Emergency Management Agency (FEMA) floodplain data for the project area, which is located in Dawson County, to determine any adverse impacts.

According to FEMA documents, Dawson County, Montana participates in the NFIP and the Intake Dam is located on FEMA Map Panel 3001400009B, dated April 1978. The entire Yellowstone River floodplain is delineated as Zone A at this location, which by FEMA definition, indicates a geographical area shown on a Flood Hazard Boundary Map or a Flood Insurance Rate Map that reflects the severity or type of flooding in the area, for a 1% chance occurrence flood event. Current hydrologic analyses have focused on a 2.4-mile long bypass channel to direct frequent Yellowstone River flows around a new river channel headworks structure and empty into the river downstream from the dam. The proposed bypass channel is intended to improve fish passage along this reach of the river, as well as improve river conveyance, not only for the smaller, more frequent flood events, but also for infrequent flood events which exceed the historic channel capacity and flow within the overbank areas, defined by the steep river banks on either side of the floodplain.

Additional hydrologic analyses will be conducted in the future as the design of the bypass channel features are finalized. Current analyses indicate no impacts associated with the proposed design features. Of particular final design interest will be the state of Montana fish access area located on the downstream left bank of the diversion dam. This access area has associated camp pads and electricity which will be evaluated for potential impacts. The analysis will also address any increase in potential ice jams resulting in flooding.

### 5.6.5 Farmland Protection Policy Act of 1995

The purpose of this act is to ensure that impacts to prime or unique farmlands are considered in federal projects. It requires federal agencies to consider alternative actions that could lessen impacts and to ensure that their actions are compatible with state, local government, and private programs to protect prime and unique farmland. The Natural Resources Conservation Service is responsible for administering this act. Farmlands were considered in the Intake Project analysis using the key indicators of changes in farm acreage and production. Prime and unique farmlands would be protected to the extent possible during implementation of the Intake Project consistent with the act (see Chapter 4, “Lower Yellowstone Irrigation Project” section in 2010 EA).

### 5.6.6 Fish and Wildlife Coordination Act of 1958 (as amended)

The Fish and Wildlife Coordination Act (FWCA, 48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) provides a procedural framework for the orderly consideration of fish and wildlife conservation measures to be incorporated into federal projects and federally permitted or licensed water resource development projects. Agencies that construct, permit, or license projects impacting a water body must consult with the Service and the state agency having jurisdiction over fish and wildlife resources, FWP. Full consideration must be given to the recommendations made through this consultation process.

Section 2 states that fish and wildlife conservation shall receive equal consideration with other project purposes and will be coordinated with other features of water resource development projects. The FWCA specifically authorizes the Secretary of the Interior to prepare a report and provide recommendations on the fish and wildlife aspects of projects, including mitigation. The FWCA report provides input to preparation of draft environmental impact statements.

Reclamation normally appends FWCA reports to NEPA documents. However, both the Service and FWP are participating cooperating agencies and have been working closely with the Corps and Reclamation to initiate and implement studies, surveys, gather and analyze data and contribute to reports since 1994. This continuous input into the decision making process reduces the need for a technical 2(b) FWCA report to prevent or reduce the adverse impacts to fish and wildlife. Therefore, there will be no FWCA report issued. The final NEPA documents will provide preventive measures to avoid impacts and mitigation to offset impacts that are unavoidable.

### 5.6.7 Migratory Bird Treaty Act and Executive Order 13186 (January 2001)

Under the provisions of this act it is unlawful “by any means or manner to pursue, hunt, take, capture [or] kill” any migratory birds except as permitted by regulations issued by the Service. Migratory birds include all native birds in the United States with the exception of non-migratory species managed by states. The Service has defined “take” to mean “pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture or collect” any migratory bird or any part, nest, or egg of any migratory bird (50 CFR Section 10.12). Executive Order (EO) 13186 requires that each Federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations is directed to develop and implement, with the Service, measures that shall promote the conservation of migratory bird populations.

Project level compliance with this law would be accomplished through specific environmental commitments for all of the action alternatives (see Chapter 4, “Wildlife” section).

### 5.6.8 Native American Graves Protection and Repatriation Act (Public Law 101-601)

This act establishes federal policy with respect to Native American burials and graves located on federal or tribal lands. Federal agencies are required to consult with and obtain the concurrence of the appropriate tribes with respect to activities that may result in the disturbance and/or removal of burials and graves from federal lands or lands held in trust for a tribe. To ensure compliance with the Act, Reclamation would consult with the tribes if any unanticipated discoveries are made during the construction phase of the Intake Project. Project level compliance with this law would be accomplished through specific environmental commitments for all of the action alternatives (see Chapter 4, "Historic Properties" section).

### 5.6.9 National Historic Preservation Act of 1966 (as amended in 2006)

The act establishes protection of historic properties as federal policy in cooperation with states, tribes, local governments, and the public. Historic properties are those buildings, structures, sites, objects, and districts, or properties of traditional religious and cultural importance to Native Americans, determined to be eligible for inclusion in the National Register of Historic Places. Section 106 of the act requires federal agencies to consider the effects of proposed actions on historic properties and gives the Advisory Council on Historic Preservation an opportunity to comment. Reclamation is responsible for consultation with the SHPO and/or Tribal Historic Preservation Offices, tribes, applicants, interested parties, and local governments regarding federal undertakings. Compliance with this law would be accomplished through specific environmental commitments for all of the action alternatives (see Chapter 4, "Historic Properties" section).

### 5.6.10 Rivers and Harbors Appropriation Act of 1899

Under Section 10 of the act, the construction of any structure in or over any navigable water of the United States, the excavating from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army. This Intake Project would be implemented with design measures deemed compatible with the act. However, Intake Project design features requiring recommendation and approval would be reviewed by the Corps for permitting consideration in compliance with the act.

### 5.6.11 Executive Order 13112 for Invasive Species

In 1999, an EO was issued to prevent the introduction of invasive species and to provide for their control. It directs federal agencies to identify applicable actions and to use programs and authorities to minimize the economic, ecological, and human health impacts caused by invasive species. To meet the intent of this order, the Intake Project includes environmental commitments to prevent and control the spread of invasive species (see Chapter 4, "Aquatic Communities" and "Lands and Vegetation" sections).

### 5.6.12 Executive Order 11988 Assessment

Executive Order 11988 (Floodplain Management) requires federal agencies to avoid developments on floodplains whenever possible or to minimize potential harm to the floodplains. The intent of the proposed project is to re-establish self-sustaining shallow water habitat for fish and wildlife along the Yellowstone River. In order to be compliant with Executive Order 11988, federal investment in the proposed project modifications must not result in any actions or activities which would adversely impact existing structures, and in particular, critical facilities such as hospitals, schools, power generating plants, etc. Review of the project location indicates no existing structures which could be adversely impacted.

### 5.6.13 Other Executive Orders

Executive Order 11990 (Protection of Wetlands) directs federal agencies to avoid destruction, loss, or degradation of wetlands. Executive Order 13007 (Indian Sacred Sites) orders federal agencies to accommodate Indian tribes' requirements for access to and ceremonial use of sacred sites on public lands and to avoid damaging the physical integrity of such sites. Executive Order 12898 (Environmental Justice) directs federal agencies to identify and address disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. Compliance with these orders was considered in the development of action alternatives in this EA (see Chapter 4, "Lands and Vegetation" and "Historic Properties" sections).

### 5.6.14 State Water Rights

Montana waters belong to the state, with ownership on behalf of all state citizens. Because water belongs to the state, water rights holders do not own the water; they have a right to use the water within state guidelines. Water rights in Montana are guided by the prior appropriation doctrine, or first in time, first in right. A person's right to use a specific quantity of water depends on when the use first began. The first person to use water from a specific source established the first right, the second established a right to the remaining water and so on. Water rights holders are limited to the amount of water that can be beneficially used. Beneficial uses of water include agricultural purposes, domestic, fish and wildlife, industrial, mining, municipal, power, and recreational uses.

The Montana Water Use Act passed July 1, 1973, changed water rights administration by requiring a statewide adjudication process on all water right claims existing at that time. Adjudication is a judicial decision that determines the quantity and priority date of all existing water rights in a basin. It also established a permit system for obtaining water rights for new or additional water developments, created an authorization system for changing water rights and a centralized records system, and provided a system to reserve water for future consumptive uses and maintain minimum instream flows for water quality and fish and wildlife. Senate Bill 76 and House Bill 22 further defined the adjudication process and established a funding mechanism to complete statewide adjudication in 2015.

The Lower Yellowstone Irrigation District #1, Intake Irrigation District, Savage Irrigation District, and Reclamation hold the following unadjudicated water rights in the state of Montana totaling 1,374 cfs:

- 1,000 cfs Statement of Claim
- 300 cfs Statement of Claim
- 18 cfs Statement of Claim
- 42 cfs Statement of Claim
- 14 cfs Provisional Permit (Savage Irrigation District)

### 5.6.15 Montana Environmental Policy Act

State agencies on the Cooperating Agency Team provided input for compliance with the Montana Environmental Policy Act (MEPA). MEPA was passed in 1971 instituting a policy requiring state agencies to consider the environmental, social, cultural and economic impacts of proposals prior to project approval. The purpose of MEPA is to foster state government decisions that are informed, accountable, open to public participation, and balanced. MEPA gives a community the ability to provide input into decision making and helps resolve issues before they become a problem. No other law allows consideration of such issues. The agencies may adopt the Intake EA completed by the co-leads or complete further documentation as they see fit to comply with the MEPA process.

### 5.6.16 Stream Protection Act

Any agency or subdivision of federal, state, county, or city government proposing a project that may affect the bed or banks of any stream in Montana for any project including the construction of new facilities or the modification, operation, and maintenance of an existing facility that may affect the natural existing shape and form of any stream or its banks or tributaries must comply with this act. The purpose of the act is to protect and preserve fish and wildlife resources and to maintain streams and rivers in their natural or existing state. Their concerns regarding fish, wildlife, and riverine environments have been addressed in this document. A stream protection permit would be obtained for the Intake Project from the MFWP, the agency who administers the law, prior to construction.

### 5.6.17 Short-Term Water Quality Standards for Turbidity (318)

Any person, agency, or entity, both public and private, initiating construction activity that will cause short-term or temporary violations of state surface water quality standards for turbidity requires a state permit. The purpose of the permit is to provide a short-term water quality turbidity standard for construction activities, so that construction is carried out in accordance with conditions prescribed by the Montana DEQ, to protect water quality and to minimize sedimentation. Montana DEQ administers the permit, and its concerns regarding water quality, sedimentation, and the Intake Project have been addressed in this EA.

### 5.6.18 Montana Land-use License of Easement on Navigable Waters

Any entity proposing a project on lands below the low water mark of navigable waters requires a state license. Projects include the construction, placement, or modification of a structure or improvements in, over, below, or above a navigable stream. The purpose of the law is to protect riparian area and the navigable status of the water body and to provide for the beneficial use of state lands for public and private purposes in a manner that will provide revenues without harming the long-term capability of the land or restricting the original commercial navigability. The Montana DNRC administers the law, and its concerns have been addressed in chapter four Lands and Vegetation and Recreation sections in this EA.

### 5.6.19 Stormwater Discharge General Permits

Any person, agency, or entity, either public or private, proposing a construction, industrial, mining, or other defined activity that has a discharge of storm water into surface waters must obtain a permit. Under the authority of the Montana Water Quality Act, permit authorization is typically obtained under a Montana Pollutant Discharge Elimination System "General Permit." A permit is generally required for construction activity that will disturb one or more acres, including clearing, grading, and excavating activities.

The purpose of the law is to prevent degradation of surface waters from pollutants such as sediment, waste materials, industrial chemicals or materials, heavy metals, and petroleum products; to protect existing water quality, and to implement and monitor the effectiveness of Best Management Practices (erosion and sediment controls, etc.) used to reduce pollutant loads. The Montana DEQ administers the permit, and the agency's concerns regarding water quality, sedimentation, and the overall project have been addressed in Chapter 4, "Hydrology and Geomorphology," "Surface Water Quality," and "Lands and Vegetation" sections in this EA.

### 5.6.20 401 Water Quality Certification for Other Federal Permits & Licenses

Under Section 401 of the federal Clean Water Act, states and tribes can review and approve, condition, or deny all federal permits or licenses that might result in a discharge to state or tribal waters, including wetlands. The major federal licenses and permits subject to Section 401 are Section 402 and 404 permits (in non-delegated states), Federal Energy Regulatory Commission hydropower licenses, and Rivers and Harbors Act Section 9 and 10 permits. States and tribes may choose to waive their Section 401 certification authority.

States and tribes make their decisions to deny, certify, or condition permits or licenses primarily by ensuring the activity will comply with state water quality standards. In addition, states and tribes look at whether the activity will violate effluent limitations, new source performance standards, toxic pollutants, and other water resource requirements of state/tribal law or regulation. The Section 401 review allows for better consideration of state-specific concerns. Their concerns have been addressed in Chapter 4, "Surface Water Quality" and "Lands and Vegetation" sections in this EA.

## 5.7. List of Preparers

Reclamation and Corps staff responsible for preparation of this Supplemental EA include:

| | |
|---|---|
| Steve Anderson | Recreation Planner, Reclamation Great Plains Regional Office (RO) |
| David Trimpe | Natural Resource Specialist (ESA), Reclamation Montana Area Office |
| Gary Davis | Environmental Specialist, Reclamation Great Plains RO |
| Doug Epperly | Supervisory Environmental Specialist, Reclamation Great Plains RO |
| Dan Fritz | Resources Group Program Manager, Reclamation Great Plains RO |
| Justin Kucera | Natural Resource Specialist, Reclamation Montana Area Office |
| Steven Piper | Economist, Reclamation, Denver Technical Center |
| Tiffany Vanosdall | Lead Plan Formulator/Project Manager, Corps |
| Eric Laux | Environmental Resource Specialist, Corps |
| Kelly Baxter | Economist, Corps |
| Aaron Quinn | Environmental Resource Specialist, Corps |
| Curtis Miller | Hydraulic Engineer, Corps |
| Sandy Barnum | Cultural Resources Specialist, Corps |

## 5.8. Distribution List

### 5.8.1 Agencies and Contact Persons

The entities listed below will receive an Executive Summary of the Draft Supplemental EA and/or the Final Supplemental EA.

**Elected Officials**
Honorable Jon Tester - Senator
Honorable Steve Daines –
Honorable Max Baucus – Senator

**Tribal Officials**
Honorable Richard Brannan —
Chairman Northern Arapaho Tribe
Honorable A.T. Stafne —
Chairman Assiniboine and Sioux Tribes of Fort Peck
Honorable Willie Sharp, Jr. —
Chairman Blackfeet Tribe
Honorable Joe Brings Plenty —
Chairman Cheyenne River Sioux Tribe
Honorable John Houle —
Chairman Chippewa Cree Tribe of the Rocky Boys' Reservation
Honorable James Steele, Jr. —
Chairman Confederated Salish and Kootenai Tribes
Honorable Brandon Sazue
Chairman Crow Creek Sioux Tribe
Honorable Carl Venne —
Chairman Crow Nation
Honorable Ivan D. Posey —
Chairman Eastern Shoshone Tribe
Honorable Joshua Weston —
President Flandreau Santee Sioux Tribe
Honorable Julia Doney —
President Gros Ventre and Assiniboine Tribe of Fort Belknap
Honorable Arlan Whitebird –
Chairman Kickapoo Tribe of Kansas
Honorable Michael Jandreau —
Chairman Lower Brule Sioux Tribe
Honorable Richard Marcellais —
Chairman Turtle Mountain Band of Chippewa
Honorable Geri Small —
President Northern Cheyenne Tribal Council
Honorable Theresa B Two Bulls —
President Oglala Sioux Tribe
Honorable Mitchell Parker —
Chairman Omaha Tribe of Nebraska
Honorable Larry Wright, Jr. —
Chairman Ponca Tribe of Nebraska
Honorable Steve Oritz —
Chairman Prairie Band of Potawatomi Nation
Honorable Rodney M. Bordeaux —
President Rosebud Sioux Tribe

Honorable Twen Barton —
Chairperson Sac and Fox Nation of Missouri in Kansas and Nebraska
Honorable Roger Trudell —
Chairman Santee Sioux Nation
Honorable Michael I. Selvage, Sr. —
Chairman Sisseton-Wahpeton Sioux Tribe
Honorable Myra Pearson —
Chairperson Spirit Lake Sioux Tribe
Honorable Charles W. Murphy —
Chairman Standing Rock Sioux Tribe
Honorable Marcus Levings —
Chairman Three Affiliated Tribes
Honorable Walt Moran —
Chairman Trenton Service Area
Honorable Matthew Pilcher —
Chairman Winnebago Tribe of Nebraska
Honorable Leon Campbell —
Chairman Iowa Tribe of Kansas and Nebraska
Honorable Robert Cournoyer —
Chairman Yankton Sioux Tribe
Honorable Leroy Spang —
President Northern Cheyenne Tribe
Honorable Leon Campbell —
Chairman Iowa Tribe of Kansas and Nebraska

**Federal Agencies**

**Environmental Protection Agency**
Stephen Potts — NEPA Coordinator
John Wardell — Director Region 8 Montana Office
Toney Ott — Environmental Scientist

**Bureau of Land Management**
Gene Terland — Director

**Agricultural Research Service**
**U.S. Fish and Wildlife Service**
Jeff Burglund — Fish and Wildlife Biologist
George Jordan — Pallid Sturgeon Recovery Coordinator

**U.S. Army Corps of Engineers**
Cathy Juhas — Project Manager

**Tribal Agencies**
Shauna Walker – Tribal Historic Preservation Office, Standing Rock Sioux Tribe

**State Agencies**
Jeff Ryan — Environmental Science Specialist Montana Department of Environmental Quality
Rick Strohmyer — Eastern Land Office Area Manager
Department of Natural Resources and Conservation
Richard Opper — Director
Montana Department of Environmental Quality
Jeff Hagener — Director
Montana Fish, Wildlife and Parks
Mark Baumler — State Historic Preservation Officer
Montana Historical Society
Jim Robinson — Department of Natural Resources and Conservation
Greg Hallsten — EIS Coordinator
Montana Department of Environmental Quality
John Little — Regional Parks Manager
Montana Fish, Wildlife and Parks
Brad Schmitz — Regional Fisheries Manager Montana Fish, Wildlife and Parks
John Tubbs — Director
Department of Natural Resources and Conservation Montana Fish Wildlife & Parks
North Dakota Game and Fish Department
Sam Johnson —Department of Natural Resources and Conservation

**County Government**
Julie Goss — Administrator
Richland County Conservation District
Henry Johnson — Commissioner
Richland County Commission
Mark Rehbein — Commissioner
Richland County Commission
Don Steppler — Commissioner
Richland County Commission
Peggy Newton — Administrator
Dawson County Conservation

District
Doug Buxbaum — County Commissioner Dawson County Commission
Jim Skillestad — County Commissioner Dawson County Commission
Bruce Smith — Agriculture and Community Development Dawson County Extension Office
Richland County
Adam Gartner — County Commissioner Dawson County Commission

**City Government**
City of Sidney
Dawson County Economic Development Council
Wade Vanevery — Executive Director Sidney Area Chamber of Commerce and Agriculture
City of Fairview
Kim Trangmoe — Glendive Chamber of Commerce and Agriculture

**Environmental Organization**
Rankin Holmes — Project Manager Montana Water Trust
Craig Sharpe — Executive Director Montana Wildlife Federation
Kat Imhoff — State Director The Nature Conservancy of Montana
Brett Swift — Deputy Director American Rivers – Northwest Regional Office
Bruce Farling — Executive Director Montana Trout Unlimited
Doug Hill — Chapter President Walleyes Unlimited (Mon-Dak) Chapter
Steve Hoffman — Executive Director Montana Audubon
John Hart — President Montana Environmental Information Center
Jerry Nypen — Project Manager Lower Yellowstone Irrigation District
Mary Hanson — Manager Montana Land Reliance
Mike Newton — President Montana Walleyes Unlimited
Jeff Van Den Noort — Chairman Montana Chapter of the Sierra Club
Bob Gilbert — Executive Director Montana Walleyes Unlimited
Teresa Erickson — Executive Director Northern Plains Resource Council
Brady Cullen — The Nature Conservancy
Michael Powelson — The Nature Conservancy
Travis Horton — Native Species Coordinator Fish, Wildlife & Parks
Jeff Tiberi — Coordinator Montana Association of Conservation Districts
Rebecca Wodder — President American Rivers – National Office
April Johnston — Conservation Director American Wildlands
Joe Gutkoski — President Montana River Action
Burt Williams — Yellowstone River Project Manager -The Nature Conservancy

**Water User**
Conrad Conradson — Lower Yellowstone Irrigation Board of Control
Hugo Asbeck — Lower Yellowstone Irrigation District #1
Walt Reichenbach — Lower Yellowstone Irrigation District #1
Don Steinbeisser — Lower Yellowstone
Mark Iversen — Chairman Lower Yellowstone Irrigation District #1
Philip Hurley — Lower Yellowstone Irrigation District #2
Todd Cayko — Lower Yellowstone Irrigation District #2
Dale Danielson — Lower Yellowstone Irrigation District #2
Orvin Finsaas — Lower Yellowstone Irrigation District #2
Dan Rice — Intake Irrigation District
Steve Pust — Chairman Savage Irrigation District
Leeroy Schmierer — Savage Irrigation District
Mel Tombre — Savage Irrigation District
Richard Cayko — Chairman Lower Yellowstone Irrigation Board of Control
Matt Rosendale — Chairman Intake Irrigation District
Bud Groskinsky — Lower Yellowstone

Irrigation Board of Control
Roger Muggli ─ T&Y Irrigation District

**Newspaper**
Sidney Herald
Amanda Breitbach ─ Glendive Ranger-Review
Minot Daily News
Bismarck Tribune
Williston Herald
Miles City Star
Brett French ─ Billings Gazette
Great Falls Tribune
Emilie Boyles ─ News Director Montana East News
High Country News

**Interested Party**
Barbara A Ranf ─ Burlington Northern Railroad
Yellowstone Caviar Project
DJS Farms LLC
Schueler Farm
American Foundation for Wildlife
GPJC
Headington Oil LP
F.F.A.
GPS Sidney Partners
MON-KOTA
Nabors Well Service
Savage Ag Vocation & Growth Endeavor Inc
Cross Petroleum Services
Steve E Park ─ Aparies Inc.
Turcotte Farms Inc.
Thelmer Aalgaard
Joel Albert
Bob & Scott Albin
Richard Albin
Richard Aldrich
John Allen
John Almond
Leroy Amundson
Tyler Amunrud
David Anderson
Jeff Anderson
Orin Anderson
Stephen Anderson
William Anderson
Mary Beth Andrews
Sandra Angel
Michael Armstrong
Frederick Arndt
Gene Asbeck
Glen Asbeck
Harvey Asbeck
James Asbeck
John Asbeck
Patrick Asbeck
Randy Asbury
Loye Ashton
Vivian Atchison
Donna Ault
Terry Averett
Tim Averett
Robert Badt
Edna Bahls
Tim Baisch
Gary Baker
Marty Bakken
Brian Barels
David Barfield
Fred Barkley
Tom Barnent
James Barnes
Tim Barnett
Tony Barone
Craig Bartelson
Jim Basta
Todd Basta
Lyle Bateman
Nancy Baue
Larry Bawden
Elizabeth Baxter
William Beacom
John Beagle
Ingrid Bearman
Jim Becic
Lloyd Becker
Randy Bell
Robert Bell
Rod & Randy Bell
Barry Benson
Arnold Berg
Walter Berg
John Berger
Edward Bergin
Jerry Bergman
Hank Berry
Ilene Berry
Ron Berry
Shawn Berry
Duane BerubeLynn Beyerle
Dennis Bieber
Harlow Bieber
Jeff Bieber
Jim Bieber
Michael Bingen

Mike Black
Rick Blanksma
Mary Bloom
Loren Boese
Larry Bond
David Borgman
Kent Bos
Arthur Bouchard
Bud Bouchard
Don Bouchard
Tim & Evah Bouchard
Paul Boylan
Gordon Bradley
William Brenner
Leon Brodhead
Ken Brose
Kenneth Brost
Darrel Brown
Julia Brown
Ralph Brown
Ron Brown
Steve Brown
Bruce Browne
Doug Brunsvold
Mary Jo & Lance Brunsvold
Tim Bryggman
Jess Burman
Valerie Burnison
Brian Buxbaum
Charles Buxbaum
Edward Buxbaum
Freddie Buxbaum
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# Appendix A.1
# *Plan Formulation*

## Introduction

This appendix presents the history and process for development of the alternatives and the screening criteria used to identify the action alternatives evaluated in the 2010 Intake EA as well as this supplement. It also explains how the project complies with the Implementation Guidance issued by Headquarters, U.S. Army Corps of Engineers (HQUSACE) in December, 2008. Preliminary action alternatives were formulated through an iterative process initiated during informal ESA consultations. Since 2008 the NEPA process (including public involvement, technical information, interdisciplinary and interagency discussions, and professional judgment) has been used to identify the reasonable and feasible action alternatives described in Intake EA Addendum Chapter 2. The No Action Alternative was developed in consultation with the Service. While much of the information in this appendix is duplicative of Appendix A from the 2010 EA, it is necessary to tell the larger story of how alternatives were formulated throughout the process.

## Planning Goals, Objectives and Constraints

Planning goals, objectives, and constraints serve to focus project specific opportunities and requirements through incorporating feedback from Federal and state agencies, Tribes, cooperating entities, and the public through the project scoping process. For the Intake Dam Modification Project a series of three public scoping meetings as well as several informational meetings with various cooperating entities were held to gather input on issues of concern related to the project. A cooperating agency team was established and engaged in participation and provided input throughout the preparation of the 2010 EA. The cooperating agency team was again contacted to provide input into the formulation of the supplement. The final planning goals, objectives, and constraints for this project are summarized below. Additional detailed information is included in the “Purpose and Need” section of the 2010 EA.

**Goals**

The broad goal of any Federal water resources project is to thoroughly evaluate alternatives by comparing project outputs (benefits) against project costs to achieve an optimized solution that maximizes benefits, minimizes costs, and produces outputs which are sustainable. Since the Intake Dam Modification Project involves compliance with the Endangered Species Act (ESA) additional goals are included for both Reclamation and the Corps.

- Goal 1 (Corps) – Implement elements from the Reasonable and Prudent Alternative (RPA) from the Missouri River Biological Opinion (BiOp) to avoid jeopardy and recover endangered pallid sturgeon through aiding with the establishment of natural recruitment and ultimately self-sustaining populations on the Yellowstone River and the Missouri River between Fort Peck Dam and Lake Sakakawea.
- Goal 2 (Reclamation and Corps) – Correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River.
- Goal 3 (Reclamation) – Comply with the ESA by completing consultation under Section 7(a)(2) for operation of Intake Diversion Dam and the Lower Yellowstone Project.

**Objectives**
Since this project is being pursued jointly by Reclamation and the Corps, the final objectives and constraints for the project are all jointly held objectives.

- Objective 1 – Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River.
- Objective 2 – Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal. (Construction of a new headworks and fish screens was completed in 2012 under Phase I of this project, therefore entrainment reduction has been addressed).
- Objective 3 – Continue effective operation of the Lower Yellowstone Project in compliance with the ESA.
- Objective 4 – Contribute to restoration of the lower Yellowstone River ecosystem.

**Constraints**

- Constraint 1 (Reclamation) – Reclamation has contractual obligations to deliver Project water needed to continue viable and effective operation of the Lower Yellowstone Project. The “viable and effective operation” component repeatedly was brought up through the Lower Yellowstone Irrigation Districts due to concerns over the operation and maintenance costs of the alternatives under consideration. The Lower Yellowstone Irrigation Districts currently operate and maintain the facility and will inherit that responsibility for the modified facility, so consideration of long-term operation and maintenance costs was a critical constraint during project formulation.

## Problems and Opportunities

Intake Diversion Dam has impeded upstream migration of pallid sturgeon and other native fish for more than 100 years. The best available science suggests that the diversion dam is likely a total barrier to the endangered pallid sturgeon, due to increased turbulence and velocities associated with the rocks at the dam and in the reach immediately downstream from the dam (Jaeger et al., 2005; Fuller et al., 2008; Helfrich et al., 1999; White & Mefford, 2002; Bramblett & White, 2001; U.S. Fish and Wildlife Service (Service), 2000a, 2003, 2007). Appendices L and M of the 2010 EA address this issue in detail. Monitoring of radio-tagged fish indicates that pallid sturgeon currently can move no further upstream than Intake Diversion Dam and some attempt to spawn below the dam. If spawning occurs below the dam, newly-hatched pallid sturgeon (larvae) likely drift into Lake Sakakawea before they are able to swim. Biologists believe that like other river spawning species, pallid sturgeon need a river environment to survive (Jaeger et al., 2002; Braaten et al., 2008).

The model developed by Kynard et al. (2007) indicates that total drift distance is a limitation on natural recruitment. If these young fish reach the lake environment, their survival rate is believed to be very low because of unsuitable habitat (Kynard et al., 2007). Biologists also suspect that pallid sturgeon larvae are intolerant of sediments in the river-reservoir transition zone (Wildhaber et al., 2007). The cause of larval deaths in the reservoir is unknown but could be due to the lack of food, predation, or related to sedimentation in reservoirs (Bergman et. al., 2008).

The proposed Intake Project would contribute to recovery of pallid sturgeon by providing up to an additional 165 miles of the Yellowstone River for migration, spawning, and development. The distance between the next upstream barrier on the Yellowstone River, Cartersville Diversion Dam, and Lake Sakakawea is about 317 miles. This substantial increase in free-flowing river habitat likely would provide adequate drift distance for at least a portion of the larvae (Upper Missouri River Basin Pallid Sturgeon Work Group, 2009). Access to tributaries, such as the Tongue and Powder Rivers, would provide additional spawning habitat and could increase larval drift distance.

## Inventory and Forecast

The Yellowstone River is one of the largest river systems in the Continental U.S. It retains much of its natural geomorphologic and hydrologic condition due to the low population density and the lack of flow regulating reservoirs along the main stem. The Supplemental EA presents detailed analyses of the updated environmental and socio-economic conditions and effects associated with the alternatives considered. Rather than repeat that information in this appendix, the two most important resources are summarized here, pallid sturgeon riverine habitat and the diversion dam and appurtenant facilities themselves.

The action alternative's scope of effects for the following resources is very similar to the scope of effects evaluated in the 2010 EA for the Rock Ramp and Relocate Main Channel alternatives. As such, the previously analyzed effects are incorporated by reference and the following resources are not re-evaluated in the supplemental EA.

- Climate
- Air Quality
- Hydrology
- Lower Yellowstone Project irrigation districts
- Environmental justice
- Indian trust assets

## Existing Conditions

**Pallid Sturgeon**

Pallid sturgeon occupy the Missouri and Yellowstone Rivers in Montana and North Dakota. These sturgeon use the Missouri River year-round and the Yellowstone River primarily during spring and summer spawning. Klungle and Baxter (2005) estimated 158 wild adult pallid sturgeon inhabit Recovery-Priority Management Area 2 (RPMA 2). This includes the Missouri

River from Fort Peck Dam to the headwaters of Lake Sakakawea and the Yellowstone River below Intake Diversion Dam (Dryer & Sandvol, 1993).

Several population estimates have been developed for the Fort Peck and Yellowstone River reaches (Krentz, 1996; Kapuscinski, 2002; Klungle & Baxter, 2005), with the most recently developed estimate showing 158 wild adults in 2004 (Klungle & Baxter, 2005). This estimate and current sampling efforts indicate the reproductive adults in the Yellowstone and Missouri Rivers remain very rare. Supplemental stocking of pallid sturgeon has been ongoing sporadically since 1998, with various numbers being stocked based on hatchery success for any given year (Service, 2006) in the upper Missouri River basin. Hatcheries involved with propagation of Missouri River pallid sturgeon stocked a combined 15,781 fingerling and yearling-sized pallid sturgeon during 2011, with approximately 4,000 of those being stocked in the RPMA 2, which includes the lower Yellowstone River and Missouri River between Lake Sakakawea and Fort Peck Reservoirs. Pallid sturgeons are stocked to ensure survival of the species in the short term and preserve existing genetics of the wild population. Monitoring data collected through the Pallid Sturgeon Population Assessment Program indicate that stocked pallid sturgeon are surviving, growing, and reaching a size and age that is capable of spawning. Recent survival estimates for hatchery fish stocked into the Missouri River show relatively high rates of survival (Hadley & Rotella, 2009; Steffensen et al., 2010) that are similar to other sturgeon species (Irelands et al., 2002).

Bramblett (1996) documented that pallid sturgeon prefer the Yellowstone River over the Missouri River below Fort Peck. Evidence from Bramblett (1996) strongly suggests that pallid sturgeon spawning occurs in the lower 6 - 9 river miles of the Yellowstone River. This evidence includes many fish moving into the lower Yellowstone River during spawning season, ripe fish occurring in the Yellowstone River, and fish aggregating during the spawning season (late May and early June). While spawning is suspected to have occurred in the Yellowstone River, there is no evidence that any resulting young survive to adulthood and reproduce (Bergman et al., 2008; [reported as M. Jaeger and D. Fuller personal communication in 2009 Draft Recovery Plan for the Pallid Sturgeon]). While in most years it appears that sturgeon migrate up the Yellowstone River, during the 2011 spawning season, the opposite appeared to be true, likely as a consequence to the high runoff in the Missouri River. This atypical run up the Missouri River resulted in the first documented naturally spawned pallid sturgeon above Gavins Point Dam. A naturally spawned pallid sturgeon was confirmed when a day old larvae was found upstream of Wolf Point Montana in the Missouri River (Fuller, 2012).

Pallids in the Yellowstone River prefer sandy substrates and deep channels and select reaches with numerous islands (Bramblett & White, 2001). They primarily inhabit about a 70-mile stretch of river below Intake Diversion Dam. More recently radio-tagged hatchery-reared pallid sturgeon have been placed above the dam (Jaeger et al., 2005). Most of these fish stayed above the Intake Diversion Dam, but some were found in the main canal of the Lower Yellowstone Irrigation Project (LYIP) (Jaeger et al., 2004).

Despite recent evidence of spawning in the lower Yellowstone River, there are no detectable levels of recruitment occurring (Bergman et al., 2008 [reported as M. Jaeger and D. Fuller personal communication in 2009 Draft Recovery Plan for the Pallid Sturgeon]). The Service (1993) has suggested that the Intake Diversion Dam is a barrier to upstream passage that may prevent pallid sturgeon from accessing upstream reaches. The best available science suggests that the diversion dam is a partial barrier to some species (Helfrich et al., 1999; Jaeger et al., 2004; Backes et al.,1994; Stewart, 1986, 1988, 1990, 1991). It is likely a total barrier to other species, including pallid sturgeon, due to impassable turbulence and velocities associated with the rocks at the dam and downstream (Jaeger et al., 2008; Fuller et al., 2008; Helfrich et al., 1999; White & Mefford, 2002; Bramblett & White, 2001; Service, 2000a, 2003, 2007).

Braaten et al. (2008) suggests larval drift distance presently available below Intake Diversion Dam is insufficient in length and settling habitat. Braaten et al. (2012) recently showed via a recapture study that pallid sturgeon originally released as free embryos and larvae can survive beyond the first year of life, indicating the importance and ability of the Yellowstone River and Missouri River to provide conditions that support survival, feeding, and growth of pallid sturgeon early life stages. Without sufficient drift distances, larvae could drift into the headwaters of Lake Sakakawea where it is thought that survival is unlikely. The Garrison reach of the Missouri River is outside the recovery priority areas identified in the Pallid Sturgeon Recovery Plan (Service, 1993). Reaches outside the recovery priority areas are not excluded from recovery actions but are designated as lower priority, because these areas have been altered to the extent that major modifications would be needed to restore natural physical and hydrologic characteristics.

**Existing Dam and Facilities**

The first and major portion of the Lower Yellowstone Project was authorized by the Secretary of the Interior on May 10, 1904. The collective features of the Lower Yellowstone Project provide a dependable water supply sufficient to irrigate approximately 54,300 acres of land along the Yellowstone River in east-central Montana and western North Dakota. The Lower Yellowstone Project is primarily a gravity diversion and distribution system, with up to 1,374 cubic feet per second (cfs) of water diverted from the Yellowstone River into the main canal by the Intake Diversion Dam. The collective Lower Yellowstone Project facilities include the Intake Diversion Dam, canal headworks structure, 4 primary pumping plants (including the Intake and Savage pumping plants), 4 supplemental river pumps, 79 miles of main canal, approximately 234 miles of laterals, and 118 miles of open drains, and over 2,500 water control structures. The total irrigated acreage is 54,300 acres, with an average annual water diversion of 327,000 acre-ft. Electric pumping power service to five of the pumping plants is supplied by the Pick-Sloan Missouri Basin Program.

Since the early 1950s, both the agricultural economy and lands served by the Lower Yellowstone Project have remained relatively stable. In contrast to a dry-land farming trend towards larger, consolidated farms, the number of farm units on the Lower Yellowstone Project has dropped only slightly. Until recently, the primary irrigated crop was sugar beets with some small grains, alfalfa, and corn. Recently commodity prices have caused a shift to more corn and small grain production, with a corresponding decline in sugar beet acreage.

**Intake Diversion Dam**
This 700-feet long dam is a 12-foot high, timber, stone-filled structure that spans the Yellowstone River and diverts water into the headworks of the Lower Yellowstone Project's main canal. The crest of the dam lies about 5 feet above the natural low water mark of the river and 9 feet above the riverbed. A cableway system is used to replace rock at the dam as needed to maintain sufficient elevation for diversion into the main canal headworks.

**Headworks**
The Intake Diversion Dam diverts water from the Yellowstone River through the canal headworks structure into the main canal for distribution to the lateral system. Ample flow in the Yellowstone River precludes the need for a water storage reservoir. Irrigation waters are distributed primarily through a gravity flow system, but three pumping plants on the main canal supply water for a small area not reached by the gravity system. The headworks and fish screens, constructed in Phase I of the project, contain 12 intakes and fish screens controlled at the inlet by metal slide gates. When a gate is open, water above the diversion dam flows through the headworks conduits and into the main canal. Up to 1,374 cfs can be diverted through the headworks into the main canal.

## Future Without-Project Conditions

**Pallid Sturgeon**
The pallid sturgeon recovery plan projects that the remaining wild population of pallid sturgeon in the reach from Ft. Peck Dam to the headwaters of Lake Sakakawea (including the lower Yellowstone River) will become locally extinct (extirpate) by the year 2018. The prospect for making flow and temperature modifications at Fort Peck Dam to benefit pallid sturgeon is unknown due to feasibility concerns, high cost, schedule for design and implementation, and uncertainty in lake elevations which could preclude release of water through the spillway as a means to implement those measures.

Reclamation has been in Section 7 consultation with the Service on the potential effects of current and future operations of the lower Yellowstone Project since Intake Dam was cited as an impediment to pallid sturgeon recovery in the 1993 Pallid Sturgeon Recovery Plan. The pallid sturgeon in the Fort Peck Dam to Lake Sakakawea reach are genetically distinct from other parts of the species range (Heist et. al., 2009), meaning preserving their genetics is essential to the overall extinction vulnerability of the pallid sturgeon population. The Service has already noted that the upper basin sturgeon, as well as the entire population, is vulnerable to extinction (Service, 2007).

**Existing Dam and Facilities**
The existing dam and new headworks are likely to continue to provide reliable water delivery to the main canal and irrigation districts into the future with on-going maintenance. The existing dam is over 100 years old and periodically requires major repairs to replace deteriorated and/or damaged timbers. The last major repair was performed in the late 1970s, so another round of repairs is likely sometime in the next 10 to 20 years. The existing dam would continue to impede upstream fish passage of native fish and continue to completely block migration of pallid sturgeon. In addition, Reclamation would continue consulting with the Service under Section

7(a)(2) of the ESA. Based on Reclamation's experience with Section 7 consultation and ESA compliance on other projects and facilities, the Service would likely issue a BiOp requiring that the facilities be modified to provide improved fish passage by some specific date in the future in order to comply with the ESA. If Reclamation were to fail to comply with the BiOp RPAs, it could result in curtailment of project water deliveries over the long term.

## Formulation of Alternative Plans

### History of Alternative Development

Since the late 1990s Reclamation has been addressing endangered species issues associated with operation and maintenance of its Lower Yellowstone Project. The Corps has been working concurrently to restore habitat and recover endangered pallid sturgeon in the Missouri River Basin. Because of overlapping activities, Reclamation and the Corps have collaborated periodically on technical studies, data collection, and planning for the Lower Yellowstone Project. In 2005, Reclamation and the Corps, along with the Service, the state of Montana, and The Nature Conservancy, signed a Memorandum of Understanding (MOU) to collaboratively address Lower Yellowstone Project pallid sturgeon issues. Since 2005 Reclamation and the Corps, in consultation with the Service, have been partners in pallid sturgeon habitat restoration and recovery.

The original EA was completed in April, 2010. Entrainment protection was addressed with construction of a new headworks structure that included mechanical fish screens. The headworks structure and screens were constructed and in operation for the 2012 irrigation season. However, due to concerns by the lead agencies about rock ramp maintenance, constructability and costs, construction of this component was not implemented. At this time, the lead agencies re-evaluated fish passage options and identified a bypass channel for detailed analysis. Cooperating agencies and stakeholders expressed uncertainty about the bypass channel alternative. In response, Reclamation and the Corps initiated a new planning study effort in June 2013. The goal was to bring the original cooperating entities back to the table to revisit all the alternatives that had been previously identified along with potential new alternatives for achieving fish passage at Intake. This review was completed in early September 2013 and six alternative themes for achieving the goals were developed to an appraisal level of consideration. The themes included an open river channel with pumping, three rock ramp variations, a bypass channel, and conveying water through a new diversion canal. This new collaborative planning effort identified the original Bypass Channel Design, with modification, as the acceptable and implementable fish passage alternative to advance.

This supplement to the 2010 EA was prepared jointly by the Corps and Reclamation to inform decision-makers and the public of the changes to the proposed action, reasonable alternatives, and their environmental impacts.

Development of alternatives began in 1997 during early informal ESA consultation, and it has progressed through various stages. The following documents were developed to help formulate and evaluate alternatives. See the "Literature Cited" section at the end of the 2010 EA for full citations:

- Lower Yellowstone River Fish Passage and Protection Study (Reclamation & Montana Fish Wildlife & Parks, 1997)
- Concept I Report (Mefford et al., 2000)
- Fish Entrainment Study (Hiebert et al., 2000)
- Assessment of Sturgeon Behavior and Swimming Ability for Design of Fish Passage Devices (White & Mefford, 2002)
- 2002 Alternatives Report (Corps, 2002)
- 2002 Value Engineering Study (Reclamation, 2002)
- Test Results of Intralox Traveling Screen Material (Reclamation, 2003)
- Concept II Report (Glickman et al., 2004)
- Value Planning Study (Reclamation, 2005)
- Technical Team Recommendations (Technical Team, 2005)
- Biological Review Team Comments (Jordan, 2006)
- *Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report* (Corps, 2006)
- Biological Review Team Comments (Jordan, 2008)
- *Intake Diversion Dam, Trashrack Appraisal Study for Intake Headworks*, Lower Yellowstone Project – Montana-North Dakota (Cha et al., 2008)
- *Intake Diversion Dam, Assessment of High Elevation Intake Gates*, Lower Yellowstone Project – Montana-North Dakota (Mefford et al., 2008)
- L*ower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Report* (Corps, 2008)
- *Final Environmental Assessment (Corps & Reclamation, April 2010)*
- *Intake Diversion Dam Modification Project Summary of Fish Passage Concepts (Corps, April 2011)*
- *Final Value Engineering Study Report (VMS / Corps, April 2013)*

As a result of informal ESA consultations, various fish passage alternatives and screening options were identified, and the agencies focused on these. The 2002 Alternatives Report, which was a joint effort between Reclamation and the Corps, evaluated an array of different fish passage alternatives and also included various swim studies focused on collecting more information on the swimming abilities of pallid sturgeon and their likelihood to successfully navigate through various fish passage structures (fish ladders, rock fishways, etc.).

**Value Engineering Study**

In July 2002 Reclamation sponsored a Value Engineering Study to identify alternatives that would satisfy essential functions at the highest value (Reclamation, 2002). The study team included biologists, engineers, and maintenance experts from Reclamation, the irrigation district manager, the Service's Pallid Sturgeon Recovery team leader, and a fisheries professor representing FWP. The team used the Concept I Report (Mefford et al., 2000) as a baseline proposal for the study.

The team defined critical functions, criteria for those functions, and associated costs of various options. Using brainstorming techniques, they suggested alternative ideas to perform those functions at a lower cost or an increase in long-term value. The team evaluated, analyzed, and prioritized these ideas to develop the best for comparison. The results were summarized in the 2002 Value Engineering Study (Reclamation, 2002). During the next step, decision-makers from Reclamation's Montana Area Office and the Reclamation's Technical Service Center examined each of the proposals in the 2002 Value Engineering Study and identified alternatives for further evaluation (Reclamation, 2004).

**Value Planning Study**

After execution of the MOU in 2005, the MOU partner agencies, along with the irrigation districts, conducted a Value Planning Study to explore various ways to improve fish passage for the Intake Project. The Value Planning Study used the Value Method to compare and contrast these ideas to identify the options with the highest value (Reclamation, 2005).

**Value Method** - a decision making process to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications but is most often used as a management or problem-solving tool.

The Value Planning Study process followed a structured approach critically examining Reclamation's originally proposed rock fishway alternative to understand features, costs, and performance characteristics. It also identified desirable functions to compare with other alternatives. The value planning study group brainstormed techniques to creatively identify alternative solutions that would perform these functions at a lower cost or with an increase in long-term value. Brainstorming produced 110 ideas that initially were screened to remove duplicative or technically infeasible alternatives, as well as those beyond the scope of value planning.

The remaining ideas were then evaluated, analyzed, and prioritized using the ratings criteria shown in Table A.1.1. Once rated and prioritized, the best ideas were developed to a conceptual level and compared using a more rigorous "choosing by advantages" (CBA) decision making system (Suhr, 1999). The baseline alternative for comparative purposes was the rock fishway originally proposed by Reclamation. Normally, any idea rated as a 1 or 2 would be considered an improvement over the baseline and, thus, would be a candidate for further development. However, based upon professional experience, it was decided that the baseline would likely underperform despite its relatively low cost. Therefore, all ideas recommended for further evaluation were required to have a score of 3 above the baseline score.

**Table A.1.1 - Ratings Criteria for Value Planning Study Alternatives Screening**

| Score | Rating Definition |
|---|---|
| 1 | Likely to lower costs and improve performance |
| 2 | Likely to leave costs unchanged and improve performance OR likely to lower costs and leave performance unchanged |
| 3 | Likely to increase both costs and performance OR likely to have no impact on costs or performance OR likely to decrease both costs and performance |
| 4 | Likely to increase costs and leave performance unchanged OR likely to leave costs unchanged and lower performance |
| 5 | Likely to increase costs and lower performance |

The final step was to combine similar ideas into the final list of alternatives to be evaluated. Table A.1.2 lists the original 110 ideas that were evaluated and their initial screening values.

**Table A.1.2 - Value Planning Study Ideas Considered and Their Disposition**

| Idea | Disposition |
|---|---|
| 1. Remove dam | Combined with 43 |
| 2. Use elevators | Combine with 104 |
| 3. Catch and truck fish upstream | Infeasible |
| 4. Use Lenny's "ooze gallery" | Duplicate of 110 |
| 5. Use side channel | Duplicate |
| 6. Archimedes screw | Infeasible, adult fish too large |
| 7. Return to dry land farming | Infeasible |
| 8. Provide pumping facilities | Duplicate |
| 9. Provide trust fund (equal to project cost) to subsidize farmers | Beyond study scope |
| 10. Change dam angle to block only half channel | Infeasible |
| 11. Use L-shape dam | Rated 3A – develop |
| 12. Decrease slope of dam | Infeasible |
| 13. Build island | Rated 3A – develop |
| 14. Improve head with upstream Reclamation dam | Infeasible |
| 15. Plant fish | Infeasible |
| 16. Provide infiltration gallery | Infeasible |
| 17. Use trust fund interest to subsidize pumping costs | Combine with 43 and 107 |
| 18. Fish lock | Infeasible |
| 19. Wind farm to subsidize pumping costs | Combine with 43 |
| 20. Use irrigation wells | Infeasible |
| 21. Well field next to Yellowstone | Infeasible |
| 22. Off channel detention storage | Infeasible |
| 23. Remove main stem dams | Infeasible |
| 24. Partial removal of dams | Infeasible |
| 25. Use pipelines from other (unnamed) source | Infeasible |
| 26. Rehab irrigation project – water conservation | Combine with 43 and 107 |
| 27. Tie in rural water systems | Infeasible |
| 28. Methane well discharges | Infeasible |
| 29. Build new dam to catch spring flows | Infeasible |
| 30. Build several new reservoirs on lower Yellowstone | Infeasible |
| 31. Pipe from Fort Peck or other upstream sources | Infeasible |
| 32. Reduce Lake Sakakawea water level to increase larval drift time before reservoir | Infeasible |
| 33. Add meander & side channels, reduce slope, lengthen channel for longer drift times | Infeasible |
| 34. Add instream structures to guide larval fish to lengthen channel | Infeasible |
| 35. Construct regional sewage plant; use effluent in irrigation system | Infeasible |
| 36. Pipe from Cartersville Dam | Infeasible |
| 37. Use in-channel infiltration pipes | Rated 5 |
| 38. Guide fish with louver system | Infeasible |
| 39. Make hydro facility including larger concrete fishway | Infeasible |
| 40. Pipe municipal water returns from Glendive | Infeasible |
| 41. Pay Glendive for water returns to mitigate caviar loss | Infeasible; beyond study scope |
| 42. Attract fish with light, sounds, or whatever they really like | Infeasible |
| 43. Remove dam, build pumps & wind farm with Pick-Sloan & create trust | Rated 3A – develop |
| 44. Remove dam; move point of diversion upstream | Combine with 110 |
| 45. Diversion without dam; with pumping backup | Combine with 43 |
| 46. Remove part of dam and convert rest to infiltration gallery | Infeasible |
| 47. Pump to reservoir in winter | Infeasible |

| Idea | Disposition |
|---|---|
| 48. Widen fishway alternative 1A | Rated 3A – develop |
| 49. Obtain Montana grant to develop pumping power | Combine with 43 |
| 50. Establish lots of paddle wheel pumps | Infeasible |
| 51. Use fish ladders | Duplicate |
| 52. Use collapsible dam | Duplicate |
| 53. Floating diversion dam | Duplicate |
| 54. Seasonal push-up dam | Infeasible |
| 55. Remove dam; irrigate only when water high enough to supply head | Infeasible |
| 56. Down canal impoundment to store water with high flows – only divert when high enough to supply head | Infeasible |
| 57. Develop strain of beets requiring no water | Infeasible |
| 58. Use multiple diversions | Rated 5 |
| 59. Use Agricultural Department farm bill monies to rehab irrigation system | Infeasible |
| 60. Buy out irrigators to reduce demand | Outside of study scope |
| 61. Use windfarm to pay irrigators to switch to dry land farming | Infeasible |
| 62. Explore drip irrigation | Water conservation issue |
| 63. Explore sealing canal delivery system to reduce/eliminate seepage | Water conservation issue |
| 64. Use pipe system to reduce evaporation in delivery system | Water conservation issue |
| 65. Fish ramp | Duplicate |
| 66. Fish tunnel | Infeasible |
| 67. High and low water passage designed into dam | Infeasible |
| 68. 21G to 2AG fish channel | Rated 4 |
| 69. Upstream passage designed into bypass screen structure | Infeasible |
| 70. Pump fishway design – false weir | Infeasible |
| 71. Use German retractable dam | Combined with 105 |
| 72. Fish catapult | Infeasible |
| 73. Pay fisherman to put fish upstream of dam | Infeasible |
| 74. Rewards for pallid sturgeon caught by paddle fish fishermen | Infeasible |
| 75. Use bascule gate | Duplication |
| 76. Make whitewater river course through project area | Infeasible |
| 77. In-channel turbine to provide power for pumps | Infeasible |
| 78. Build habitat to attract fish | Combine with 94 |
| 79. Remove rocks washed downstream; reuse rocks; sell rocks to landscapers on east coast | Infeasible |
| 80. Use fish herding black Labrador retrievers | Infeasible |
| 81. Use rock dikes to let water into canal – but not fish - into canal | Infeasible |
| 82. Use multiple small pump plants close to demand | Rated 3A – develop |
| 83. Use differential gates such as Obermeyer to move thalwag | Duplication |
| 84. Clean up rock debris and breech center of existing dam | Infeasible |
| 85. Reroute Yellowstone to current backchannel to maintain irrigation | Infeasible |
| 86. Use solar power pumps | Infeasible |
| 87. Use sounds and lights to reduce entrainment | Duplication |
| 88. Spawning habitat in canal | Infeasible |
| 89. Add new screens at wastewater sites | Infeasible |
| 90. Raise bed of Yellowstone | Infeasible |
| 91. Install twenty sills (6” to 8” high) to get head | Rated 5 |
| 92. Low head hydro plant for supplemental power | Infeasible |
| 93. Increase funding level for pallid sturgeon efforts elsewhere | Infeasible |
| 94. Modify dams to enhance attracting fish | Combine with 48 |
| 95. Crossbreed sturgeon with steelhead | Infeasible |
| 96. Do nothing | Rated 3C – develop; rejected during development |
| 97. Concept II, Alternative 1A – riprap fishway around fishway | Rated 4 |

| Idea | Disposition |
|---|---|
| 98. 1B through dam | Rated 4 |
| 99. 1B grouted | Rated 4 |
| 100. 1C with earthen wall | Rated 4 |
| 101. Flume and baffle fishway | Rated 4 |
| 102. Denil fish ladder | Rated 5 |
| 103. Long low gradient channel | Rated 3A |
| 104. Fish elevators + music | Rated 4 |
| 105. Collapsible gates with rock fishway | Rated 3A |
| 106. Provide infiltration gallery | Questionable feasibility |
| 107. Conventional pump plants on Yellowstone | Combine with 43 |
| 108. Rock ramp fish passage | Rated 3A |
| 109. Infiltration ponds | Infeasible |
| 110. Upstream diversion point without pumps | Rated 3A |

The initial screening identified ten alternatives for conceptual development and evaluation (Table A.1.3).

**Table A.1.3 - Summary of Value Planning Ideas Recommended for Evaluation**

| ID # | Priority 1 | ID # | Priority 2 |
|---|---|---|---|
| 43 | Remove dam, build pumps & wind farm with Pick-Sloan preference power & create trust | 11 | Use L-shape dam[1] |
| 48 | Widen fishway alternative 1A | 13 | Build island |
| 103 | Long low gradient channel | 82 | Use multiple small pump plants close to demand |
| 105 | Collapsible gates with rock fishway | 96 | Do nothing[2] |
| 108 | Rock ramp fish passage | 110 | Upstream diversion point without pumps |

[1] The L-shape dam concept was subsequently subdivided into two versions (Alternative 1A and 1B) that extended upstream 6,600 and 20,000 ft, respectively. [2] The "Do Nothing" alternative was dropped from further consideration, as the team did not feel it met the purpose of providing fish passage and was not useful for comparative purposes.

After conceptual development of each of the ten remaining alternatives, the team applied the CBA system to evaluate and compare those alternatives. Table A.1.4 presents the final scoring of the CBA matrix for the various alternatives. The three alternatives with the lowest scores were eliminated. A matrix of factors and sub-factors was used to organize the analysis. The CBA analysis resulted in three tiers of alternatives:

- **Tier One -** the top four alternatives that scored relatively high in the importance of their advantages;
- **Tier Two -** the next three alternatives whose total scores are lower than the top group, but some individual team members ranked very high;
- **Tier Three -** the final three alternatives with the lowest overall scores.

The Value Planning Study (Reclamation, 2005) recommended that the Long, Low-Gradient Channel Alternative, Rock Ramp Alternative, Remove Dam and Build Single Pumping Plant Alternative and the Widen Fishway Alternative be carried forward for further consideration. The Remove Dam and Move Diversion Upstream Alternative, Multiple Pump Stations Alternative, and Collapsible Gates Alternative also were identified for further study. Finally, the study concluded that the Island, L-Shaped Dam 6,600 ft, and the L-Shaped Dam 20,000 ft alternatives be eliminated from further consideration, because these alternatives had the lowest scores.

**Technical Team Recommendations**

After completing the Value Planning Study, Reclamation invited representatives from the Lower Yellowstone Project, the state of Montana, The Nature Conservancy, the Corps, and the Service to a meeting (see Chapter 5 for a list of participants). The purpose of the meeting was to recommend alternatives that should be further evaluated to support the ESA consultation process. The multi-agency team met on November 28, 2005, and jointly identified a set of progressive filters to screen the Value Planning Study alternatives. The three filters were to be applied in consecutive order from first to third, so that if there was insufficient information to apply a filter to an alternative or the alternative did not meet the first filter, it would not be evaluated against the other two. The filters the team identified were:

1) **Biological Filter** - Probability of success in meeting ESA objectives;
2) **Water Delivery Filter** - Reliability in maintaining water delivery to the project; and
3) **Engineering and Construction Filter** - Engineering, design, and constructability factors.

**Table A.1.4 - Compilation of CBA Scores and Rankings.**

| Alternative | L-Shaped Dam, 6,600' | L-Shaped Dam, 20,000' | Island | Widen Fishway | Multiple Pump Stations | Long, Low-Gradient Channel | Remove Dam and Move Diversion Upstream | Rock Ramp | Collapsible Gates | Remove Dam and Build Single Pumping Plant |
|---|---|---|---|---|---|---|---|---|---|---|
| **Proposal #** | **1A** | **1B** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Individual Team Member Scores** | 240 | 220 | 300 | 400 | 310 | 490 | 310 | 510 | 280 | 370 |
| | 321 | 249 | 395 | 469 | 421 | 573 | 436 | 554 | 391 | 497 |
| | 382 | 382 | 562 | 751 | 661 | 847 | 663 | 755 | 644 | 757 |
| | 135 | 125 | 204 | 568 | 590 | 609 | 573 | 538 | 410 | 568 |
| | 239 | 214 | 244 | 270 | 315 | 420 | 330 | 395 | 260 | 370 |
| | 132 | 124 | 143 | 362 | 400 | 396 | 450 | 286 | 185 | 412 |
| | 443 | 353 | 523 | 611 | 629 | 801 | 621 | 720 | 537 | 711 |
| | 280 | 260 | 280 | 530 | 410 | 490 | 500 | 560 | 280 | 480 |
| | 310 | 260 | 377 | 419 | 452 | 529 | 398 | 493 | 287 | 520 |
| | 160 | 150 | 205 | 500 | 420 | 704 | 375 | 575 | 325 | 465 |
| | 170 | 160 | 180 | 480 | 350 | 610 | 420 | 670 | 350 | 420 |
| | 215 | 215 | 235 | 265 | 325 | 295 | 420 | 355 | 160 | 325 |
| **TOTAL SCORE** | 3027 | 2712 | 3648 | 5625 | 5283 | 6764 | 5496 | 6411 | 4109 | 5895 |
| **RANK** | **9** | **10** | **8** | **4** | **6** | **1** | **5** | **2** | **7** | **3** |

To further refine the Value Planning Study results and compare alternatives, the CBA matrix was revised to measure performance factors against the baseline. To apply this approach, the team defined a baseline for each factor and assessed whether deviations from the baseline were either positive or negative, as well as the degree of each deviation. Positive deviations were characterized as either "better" or "much better," and negative deviations were either "less than good" or "poor."

The negative deviations were of concern to decision makers. Fish passage alternatives that required fish to find an entrance to a passage structure were of special concern. Uncertainty about fish attraction to passage entrances raised a red flag for those alternatives that lacked passage across the full width of the river.

Table A.1.5 presents the refined Value Planning Study results matrix using symbols and includes preliminary cost estimates. The technical team identified the Rock Ramp with an In-Canal Fish Screen as the alternative most likely to meet biological and ESA requirements, and most likely to be acceptable to interested parties. In addition, the team identified the Single Pumping Plant and the Move Diversion Upstream Alternatives as also viable to provide the desired fish passage.

Reclamation and the Corps proceeded with further preliminary design and evaluation of these three alternatives from 2005 through 2009. Preliminary design information was developed in anticipation of the need for better information for the Draft EA and to prepare preliminary cost estimates.

**Biological Review Team**
After the Corps (2006) report was completed, the Service formed a team of pallid sturgeon experts, called the Biological Review Team (BRT) (see Chapter 5 for a list of team members). The team held an initial meeting on August 17 and 18, 2006, to review the preliminary alternatives. The BRT recommended specific design considerations to improve the probability of successful pallid sturgeon passage and entrainment protection at Intake (Jordan, 2006). These recommendations included:

- An improved trashrack
- Increasing the elevation of intakes
- Applying National Marine Fisheries' standards for salmonid screening to screen design
- Further study on larval impingement survival
- Non-step rock fishway design modeled after existing Yellowstone River riffles
- Model of 0.5%, 0.75% and 1.0% non-step ramps
- Development of a physical model to evaluate depths and velocities
- Ramp design to allow fish to avoid headworks
- Remove the Relocate Diversion Upstream Alternative

**Table A.1.5 - Final Value Planning Alternative Screening Matrix (Reclamation, 2005)**

**ESA Modifications - Alternatives Evaluation Matrix**

| Alternative Name and (VP Study Number) | Rank from VP Study | Fish Screen - Field Construction Cost ($) | Fish Passage Field Construction Cost ($) | Total Field Construction Cost ($) | Total Project Cost ($) | Annual O&M Cost (Excluding Energy) ($) | Annual Energy Cost--Pick-Sloan rate of 10.76 mills/kWh ($) | Annual Replacement Cost ($) | Total Annual Operation, Maintenance and Replacement Cost ($) | Biological Monitoring Cost ($) | Biological Monitoring Duration (yrs) | Likelihood of ESA Success | Benefits to All Native Fisheries | Constructability | Water Delivery Reliability | Acceptability: Recreational Community | Acceptability: Environmental Community | Acceptability: Irrigation Project Water Users |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Present Condition** | | | | | | $ 19,000 | | | | | | | | | | | | |
| **Diversion Dam Alternatives** | | | | | | | | | | | | | | | | | | |
| **Widen Fishway (3)** | 4 | $ 8,100,000 | $ 7,200,000 | $ 15,300,000 | $ 20,961,000 | $ 24,000 | | $ 160,000 | $ 184,000 | $ 3,189,000 | 10 | ▼[a] | ◊[a] | ● | ▲ | ▲ | ▼[a] | ○ |
| **Long Low Gradient Channel (5)** | 1 | $ 8,100,000 | $ 18,000,000 | $ 26,100,000 | $ 35,757,000 | $ 39,000 | | $ 430,000 | $ 469,000 | $ 3,189,000 | 10 | ▼[a] | ◊[a] | ▲ | ○ | ▲ | ▼[a] | ○ |
| **Rock Ramp (7)** | 2 | $ 8,100,000 | $ 22,000,000 | $ 30,100,000 | $ 41,237,000 | $ 25,000 | | $ 378,000 | $ 403,000 | $ 1,703,000 | 6 | | ▲ | ○ | ▲ | ○ | ○ | ○ |
| **Open River Alternatives** | | | | | | | | | | | | | | | | | | |
| **Single Pumping Plant (9)** | 3 | $ 8,100,000 | $ 27,000,000 | $ 35,100,000 | $ 48,087,000 | $ 30,000 | $ 108,000 | $ 744,000 | $ 882,000 | $ 667,000 | 2 | ● | ● | ○ | ○ | ▼[b] | ● | ◙[c] |
| **Move Diversion Up River (6)** | 5 | $ 8,100,000 | $ 31,000,000 | $ 39,100,000 | $ 53,567,000 | $ 27,500 | | $ 614,000 | $ 641,500 | $ 667,000 | | ● | ● | ◊[d] | ▼[d] | ▼[b] | ● | ▼[d] |

| Alternatives Considered But Eliminated | Rank from VP Study | Reason for Elimination |
|---|---|---|
| **L-Shaped Dam (1B)** | 9 | This alternative was dropped from further consideration due to the significance of construction required to implement, high risk of potential failure from flood waters, ice jamming, erosion, and channel movement. |
| **Collapsible Gates (8)** | 7 | This alternative was eliminated due to concerns relative to operation and maintenance. This alternative would also remain a barrier to fish passage while in operation since the majority of the river would be blocked to provide sufficient head for delivery of water into the canal. |
| **Island (2)** | 8 | While this alternative would partially open the river channel, it was dropped from further consideration due to water risk, construction risk, ability to modify in the future and acceptability. |
| **Multiple Pump Stations (4)** | 6 | This alternative originally was dropped from further consideration because is a duplicate of the single pumping plant alternative, but it was included in the Draft EA in response to public scoping comments. |
| **Do Nothing (10)** | | This alternative does not meet the requirements of the Endangered Species Act |

**Legend**

| | | | |
|---|---|---|---|
| Much Better | ● | Red flag: less than good | ▼ |
| Better | ▲ | Poor | ◙ |
| Good | ○ | Unknown | ◊ |

[a] *It is not known whether fish will be able to locate a fishway entrance, or if the unnatural conditions of a fishway would subject them to predation. This uncertainty results in a degree of risk that pallid sturgeon will not be able to find the off-channel structure and pass without unacceptable delay. The environmental community may find the uncertainty associated with these alternatives undesirable.*

[b] *There would no longer be a structure in the river to concentrate paddlefish at one location. There would probably still be a sport fishery, but it may be spread out along the river, which could negatively affect the associated economic benefit of caviar collection.*

[c] *The irrigation district is opposed to the pumping plant alternative due to the increased operation and maintenance concerns and associated cost.*

[d] *This is a relatively new concept of constructing a canal headworks structure in a major river without a diversion dam to divert water in low river flow conditions. There would be considerable risk related to long-term water delivery if the river channel migrated. The water users would be uncomfortable with these risks. Additional study would be required.*

The team convened again on February 12, 2008, to evaluate the fish screen options being developed for the proposed Intake Project. The team recommended the following (Jordan, 2008):

- Screen design should include approach velocities of 0.4 feet per second (fps) based on White and Mefford (2002);
- In-canal screen with new trashrack (Cha et al., 2008) has potential;
- In-channel screen would be preferable over an in-canal screen; and
- Sluiceway options require additional detailed study on sediment load and transport analysis to more accurately estimate the amount of water and size of sluiceway required to reduce sediment concerns.

A third meeting on February 17 – 18, 2009, reviewed the action alternatives and developed a method to score alternatives on a relative scale to incorporate biological input. The report (Jordan, 2009) offered recommendations for improvement of the alternatives, raised specific concerns, and asked questions about the alternatives.

**NEPA Initial Screening**

NEPA screening began by seeking public input on the No Action Alternative, four fish passage alternatives, and two fish screen options identified during previous Intake Project studies. Public scoping meetings were held during October 2008 to invite public comment on these alternatives, identify issues related to them, and collect ideas about other alternatives not previously investigated (Reclamation & Corps, 2009). A number of commenters suggested revisions to the alternatives as well as several new alternatives (Reclamation & Corps, 2009).

**Public Meeting in Glendive, Montana**

In response to public comment, all of the fish passage alternatives were revised and several were eliminated, as explained in this section. One previously eliminated alternative was identified as worthy of reconsideration, the Multiple Pumping Stations Alternative described in the next section. Table A.1.6 presents the eight alternatives under consideration prior to the initial NEPA screening process and their disposition after screening.

**Table A.1.6 - Draft EA Alternatives and Their Disposition**

| Alternative | Disposition |
|---|---|
| **1. No Action** | Evaluated in detail as the **No Action Alternative**, as required by NEPA. |
| **2. Rock Ramp** | Evaluated in detail as the **Rock Ramp Alternative**. |

| | |
|---|---|
| **3. Relocate Diversion Upstream** | Eliminated from detailed study. Further hydraulic analysis determined that a diversion dam/weir with rock ramp would be required to provide sufficient head for reliable diversion of water under low flow. |
| **4. Relocate Main Channel** | Evaluated in detail as the **Relocate Main Channel Alternative**. |
| **5. Single Pumping Plant** | Eliminated from detailed study. Further hydraulic analysis determined that a diversion dam/weir with rock ramp would be required to provide sufficient head for reliable diversion of water under low flow. |
| **6. Multiple Pumping Plants** | Conceptual design developed in response to public scoping, but eliminated from detailed study because of reliability and entrainment concerns and construction and O&M costs. |
| **7. Removable Rotating Cylindrical Screens** | Evaluated in detail as **Removable Rotating Drum Screen Option**. |
| **8. V-Shaped Screen** | Eliminated from detailed study. Further evaluation required modification to include an in-river trashrack. This alternative is duplicative of the **Removable Rotating Drum Screen Option.** Both screen options would perform the same function, but the V-Shaped Screen with the trashrack would be more expensive to construct and maintain and would expose juvenile fish to an unnatural environment for a longer duration than the other screen option. |

After the public scoping meetings, alternative screening criteria based upon Council on Environmental Quality guidelines, legal mandates, and previous Intake Project studies were developed to formulate alternatives for detailed study, and to identify alternatives (or features of alternatives) to be eliminated.

The screening criteria for alternatives were:

**Alternatives Screening Criteria**

- Provide upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River;
- Minimize entrainment of pallid sturgeon and other native fish into the main canal;
- Continue effective operation of the Lower Yellowstone Project as authorized and in compliance with the Endangered Species Act;
  - Alternative does not adversely impact the ability of the Lower Yellowstone Project to meet crop irrigation requirements.
- Contribute to restoration of the Lower Yellowstone River ecosystem;
  - Reconnecting the Lower Yellowstone River from the confluence of the Missouri River, past the Intake Diversion Dam, upstream to the next barrier at Cartersville Dam near Forsyth, Montana, would allow free movement of aquatic species, including endangered pallid sturgeon and other native fish.
- Alternative not redundant or similar to other alternatives; and
- Alternative not prohibitively greater in cost or in environmental impacts than the other alternatives.

## Alternatives Considered But Eliminated

According to NEPA, the responsible federal agency must "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources (42 USC § 4332 Section 102(E)). Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" [*Federal Register* 46(55)].

During the scoping process, the public commented on various alternatives and features. Table A.1.6 shows the disposition of the alternatives and screen options disclosed during the initial scoping in October 2008. After preliminary analysis some of these appraisal-level alternatives and features were eliminated from detailed study using screening criteria. This EA Addendum evaluates three alternatives from the earlier studies and six alternative themes from the recent 2013 planning studies. The following are the alternatives eliminated from detailed study after scoping and the reasons for eliminating them.

### Alternatives Eliminated After Initial Scoping in 2008

***Relocate Diversion Upstream Alternative***

Removal of the existing Intake Diversion Dam and construction of a new canal and headworks structure upstream was eliminated from further consideration for three reasons: 1) it was duplicative of the rock ramp alternative, 2) required crossing of the Yellowstone Valley Railroad at two locations, and 3) mandated purchase of substantial real estate for implementation.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative. Because this alternative removed the existing dam, which the BRT recommended for optimal fish passage, it was presented during public scoping.

The original concept was to move the point of diversion for the canal upstream far enough to allow diversions of water into the canal without a dam/weir. Although no dam would be needed, initial design features included several rock sills in the river channel to prevent head cutting after dam removal, as well as a rock dike field and revetment to stabilize the channel location at the point of diversion. This would reduce the risk of the channel migrating away from the new diversion site.

This alternative would require construction of a new headworks structure at the diversion site and excavation of approximately 12,500 feet of new canal to extend the existing canal upstream to the new diversion site. Topography along the new canal alignment is a relatively high hillside (60 feet above the river), and the railroad running through the site skirts along an excavated bench adjacent to the river channel. Figure A.1.1 shows an aerial photo and site layout for this alternative with a rock ramp shown in orange.

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir to raise and divert water during low flow. Three thousand cfs was set as the minimum flow in the river to evaluate the reliability of alternatives for diverting flow into the canal. Under minimum flow conditions a 5-6 foot high dam/weir would be required to provide sufficient head for diversion of 1,374 cfs flow into the canal (Figure A.1.1). The additional dam/weir would be a fish passage impediment much like the existing dam (although about 5 feet lower) that could be combined with a rock ramp to provide fish passage.

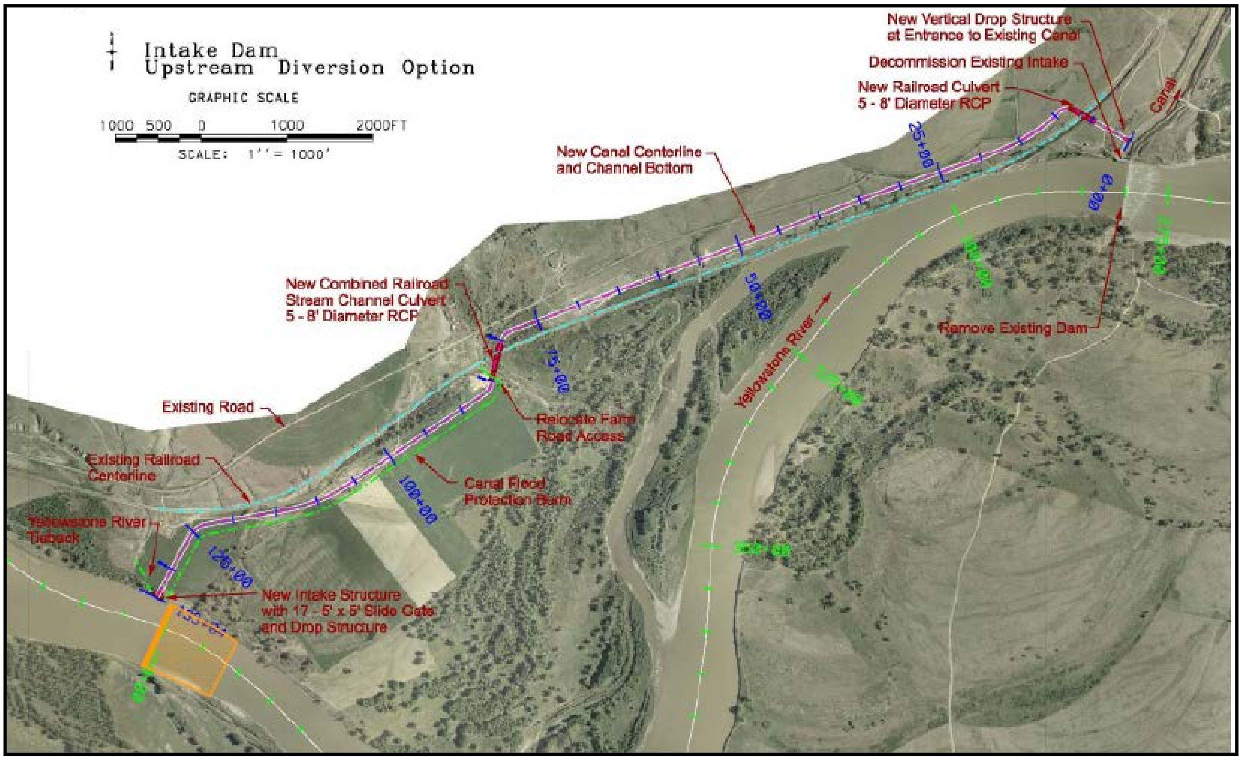

**Figure A.1.1 - Relocate Diversion Upstream Alternative With Rock Ramp**

Due to the proximity of the railroad to the river, the new canal alignment would run on the landward side of the railroad, requiring a 60-foot deep excavation for over half the length of the new canal. Using minimal slopes, a bottom width of 50 feet, and incorporating a mid-slope berm for slope stability, the overall top width of the excavation would be approximately 250-300 feet. The new canal alignment would cross the railroad at two locations through five 8-foot diameter culverts. The upstream end of the canal, where it runs along the left-bank floodplain, would feature tie-back levees extending from the new headworks structure to the floodplain limit. The levees would prevent the canal from damage or filling with sediment during Yellowstone River floods. These levees would be sized to protect against a 100-year ice-affected flood event.

Approximately 120 acres of private farmland would be acquired, and two center pivots likely would be affected. In addition, two rights-of-entry under the Yellowstone Valley Railroad would be needed. The deep canal excavation would remove approximately 3.7 million cubic yards of material, which would require another 100-115 acres for disposal. Although some material could be re-used by Montana Department of Transportation or other interests, temporary stockpiling would be necessary. The conceptual cost estimate of this alternative was $67 million.

Construction of a new facility, including excavation of the additional canal, acquisition of real estate, working with the railroad, and other issues in combination with a rock ramp redundant to the Rock Ramp Alternative eliminated this alternative from further consideration.

***Single Pumping Plant Alternative***

Removing Intake Diversion Dam and constructing a single pumping plant at the canal headworks site was eliminated from further consideration for five reasons: 1) it duplicated the Rock Ramp Alternative because a rock ramp is also needed in the Single Pumping Plant Alternative to ensure operation during low flows; 2) it was substantially higher in initial construction costs than any other alternative under consideration; 3) it required substantial real estate for implementation; 4) continued effective operation of the Lower Yellowstone Project could not continue because the irrigation districts probably could not afford to pay the O&M costs; and 5) power demands would be higher than any other alternative, would not be supported by the current power grid, and would not be reliable without a backup generator system, which was not included in preliminary cost estimates.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative because the initial design of this alternative included removal of the existing dam and restoration of the river bed. The BRT recommended this for optimal fish passage; therefore it was presented during public scoping.

The original concept was to remove Intake Diversion Dam and construct a large pumping plant at the canal inlet that would pump water from the Yellowstone River into the canal without a dam/weir. Other design features included several rock sills in the riverbed to prevent head cutting, as well as a rock dike field and revetment to stabilize the channel at the pumping plant site. This would reduce the risk of the channel migrating away from the pumping plant.

A new pumping plant would be constructed upstream from the existing headworks structure with removable rotating drum screens. Topography at the proposed pumping plant is a relatively high hill bounded on the north and west by the railroad, on the south by the river, and on the east by the existing canal. Figure A.1.2 shows an aerial photo and site layout for this proposed alternative. The new pumping plant would discharge into a stilling basin and a new canal section would transition into the existing canal upstream from the existing county road bridge.

Hydraulic modeling revealed that this alternative, like the previous one, would be technically infeasible without a dam/weir to raise and divert water during low flow (Figure A.1.2). Under minimum flow conditions an 8-foot high dam/weir would be required to provide sufficient head to divert 1,374 cfs flow into the pumping plant. The new dam/weir would be lower than the existing Intake Diversion Dam, which ranges from 10-11 ft high. Because the new dam/weir would be a fish passage impediment similar to the existing dam, a rock ramp would be needed to provide fish passage over it, making this alternative redundant with the Rock Ramp Alternative.

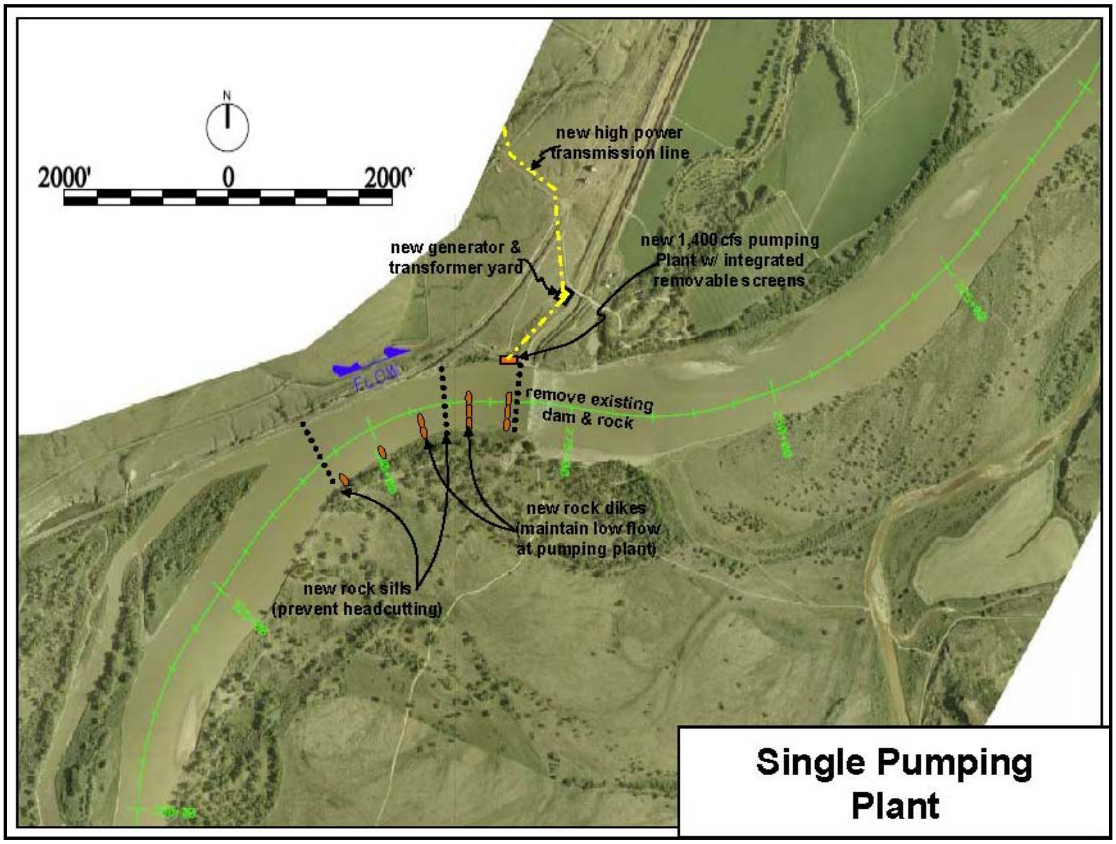


**Figure A.1.2 – Single Pumping Plant Alternative Original Concept.**

The preliminary estimated cost of constructing the plant was well over a $100 million. In addition to the construction costs, the total average annual energy required by such a pumping plant would be 7,000 megawatt-hours and would operate from April to the end of September (Cha & Zelenaka, 2008). The estimated annual O&M cost for power alone would be $315,000, which would be paid for by the irrigation districts. In addition, because of the frequent power outages in the area, a backup generator would be needed, which was not included in the initial cost estimate. Also of concern would be the load on the local power grid, which could not supply that level of power to the plant without substantial improvements.

Acquisition of approximately 24 acres of real estate would be required for construction and equipment staging. Much of that is private land. A temporary cofferdam extending approximately 100 ft out into the Yellowstone River channel would be needed during construction as well.

Therefore, redundancy with the Rock Ramp Alternative, construction of an expensive new facility, acquisition of real estate and additional O&M costs that would adversely affect the irrigation districts eliminated this alternative from further consideration.

***Multiple Pumping Stations Alternative***

Removing Intake Diversion Dam and constructing multiple river pumping stations was eliminated from further consideration for six reasons: 1) custom-designed fish screens have not been tested and the sediment auger could kill entrained fish ; 2) power demands would be higher than any other alternative, would not be supported by the current power grid, and would not be reliable without a backup generator system; 3) construction costs would be much higher than the other alternatives; 4) real estate issues would be greater than other alternatives; 5) effective operation of the Lower Yellowstone Project could not continue because the irrigation districts probably could not afford to pay the O&M costs; and 6) the construction footprint is the most widely distributed of all alternatives.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative, because the initial design of this alternative would remove the existing dam to open fish passage. That recommendation changed after technical experts reviewed the Value Planning Study and recommended dropping the alternative from further consideration. They found that it was duplicative of the single pumping plant alternative and would be incompatible with the existing canal irrigation system. However, in response to public and agency comments during scoping, this alternative was reconsidered. After discussion with cooperating agencies, Reclamation and the Corps contracted with an engineering consulting firm to develop a conceptual level design of the alternative.

The conceptual design proposed removing Intake Diversion Dam, closing the existing headworks, and constructing seven pumping stations on the Yellowstone River to deliver water to the Lower Yellowstone Project (Figure A.1.3). The pumping plants would be constructed at various locations along the Lower Yellowstone Project. The pumps would be screened to minimize entrainment and would discharge into existing canals to supply the irrigation districts.

The conceptual design evaluated two possible configurations for each pumping plant station – floating or fixed pumping stations. The first concept, the floating pumping station, was originally conceived to allow unrestricted fish passage while delivering a reliable water supply to the irrigation districts without building permanent structures in the river. However, the floating pumping configuration was found to be infeasible because of the depth required for submergence of floating screens large enough to meet the water demand of the irrigation districts.

Sufficient, reliable, stable locations with sufficient depth and length for the screens could not be identified in the river with the best available information. The Yellowstone River with its large and small floating debris, ever-changing channel depth and location, and sediment deposition, all impact the feasibility of the floating pumping stations. Without permanent structures in the river, more extensive (longer and wider) fish screens would be needed, which at some locations would cover a large segment of the river channel and make installation in the spring and removal in the fall very difficult.

The complexity of this option affects reliability and O&M costs. Flexible pipelines extending from the pumping stations to the shore would be in constant danger of being snagged by and collecting floating debris. The size of the flexible pipelines would be a potential river hazard and barrier within the river and would be difficult to keep full of water.

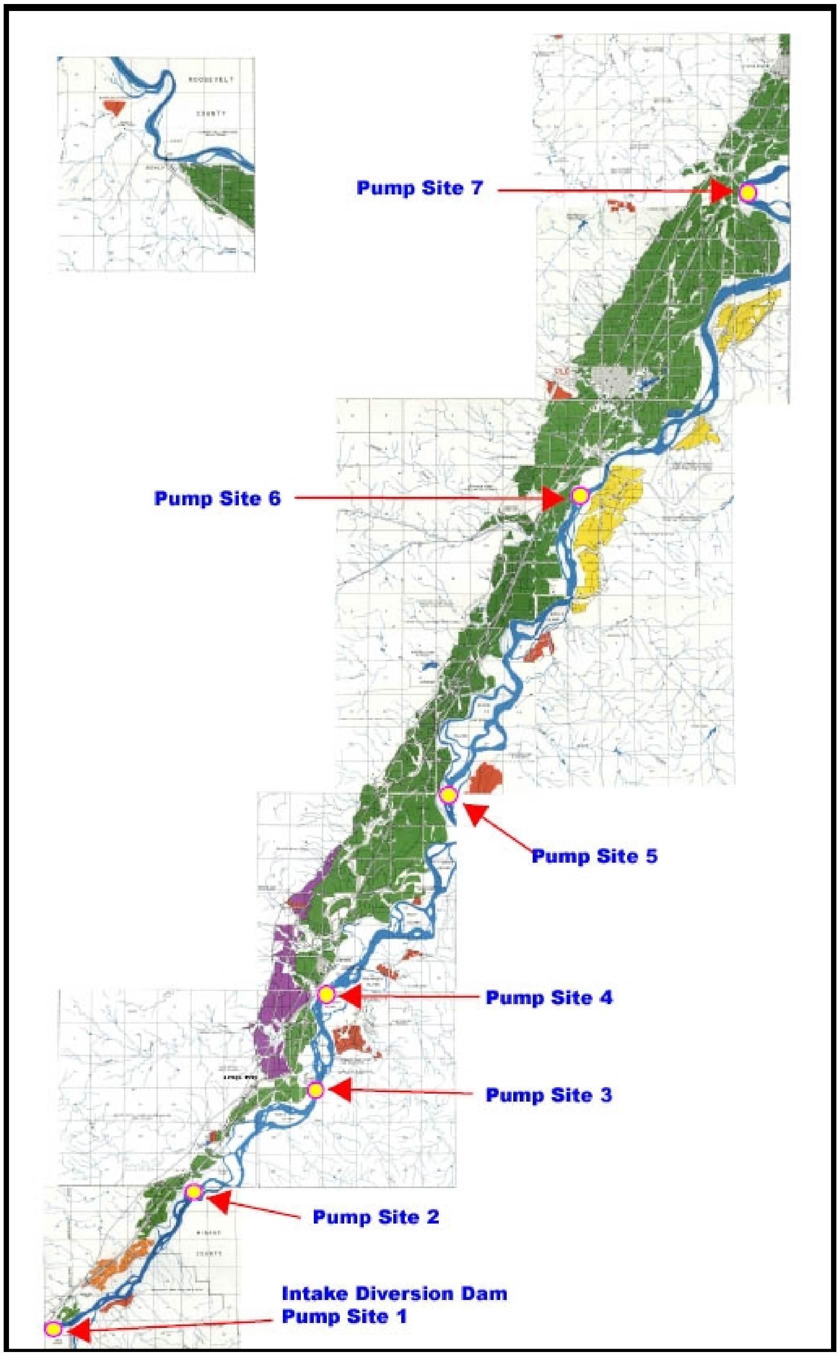


**Figure A.1.3 - Proposed Locations of Pump Stations**

The second concept was the fixed pumping station. It would have several engineering advantages over the floating stations, including improved protection from floating debris, less maintenance and labor, longer life expectancy, stabilized submergence requirements, pump design stability and reliability. A typical conceptual layout of the fixed pumping system is shown in Figure A.1.4.

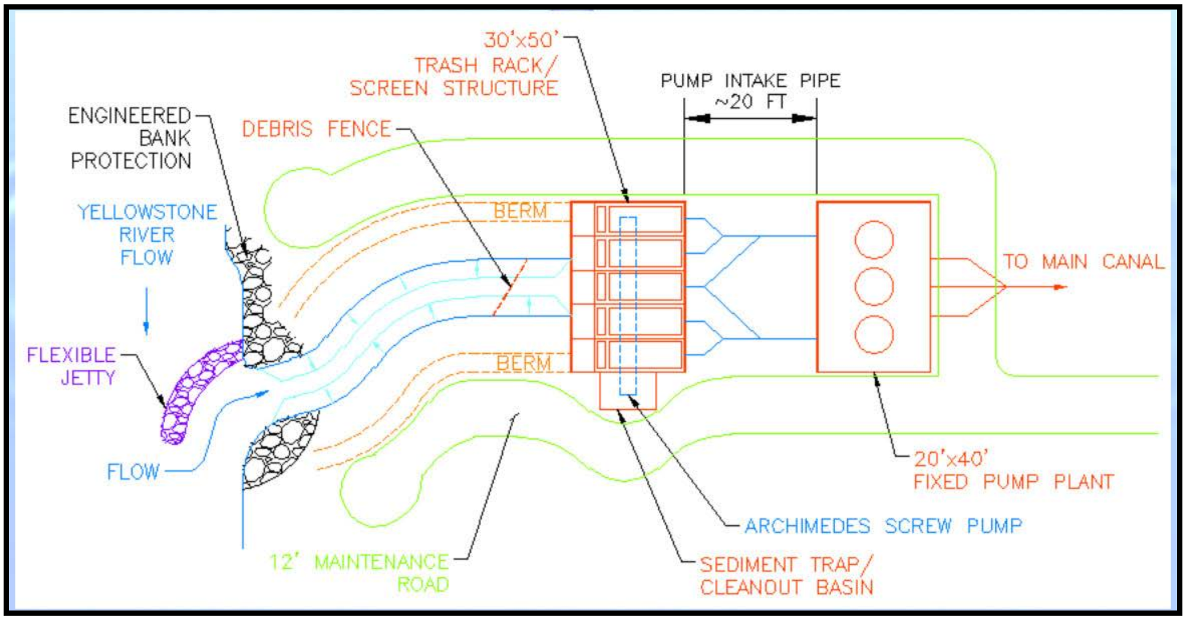


**Figure A.1.4 – Conceptual Design of Fixed Pumping Station.**

Each of the seven stations would include a building housing three pumps and pump motors and power lines, as well as improvements in the local power grid. The buildings would be constructed above the 100-year flood plain, and the size of the pumps and pump motors would be site-specific. A channel would be excavated from the Yellowstone River to each fixed pumping station to convey water. A structure to house trashracks and custom-designed fishscreens would be constructed in this channel with a sediment trap and an auger. A jetty would be constructed in the river channel to reduce silt accumulation in the inlet channel and some bank stabilization would be required along the entrance to each inlet channel.

Because the irrigation canal system was designed for gravity flow of water primarily from a single water source at Intake, this alternative would require some restructuring of the Lower Yellowstone Project canal system to accommodate a water supply from multiple points along the canal. It is estimated that 12 additional check structures would need to be constructed within the main canal to maintain the water depth and elevations required to deliver water to the lateral canals for distribution to the fields. Since the additional check structures would decrease the velocity of the water in the main canal, additional sediment deposition would be expected in the upper part of the system.

Preliminary construction costs and annual O&M costs were both estimated to be greater than the Single Pumping Plant Alternative. Annual O&M costs associated with this alternative would be a substantial increase over the cost of the current water delivery system and most likely beyond the capacity of the irrigation districts (see EA Chapter 4, “Social and Economic Conditions” section). The O&M of this alternative would exceed all the other alternatives, as it would have the additional requirements of maintaining and operating new check structures in the main canal, increased sediment removal in the main canal, maintaining access roads to each pump site, removing sediment in the inlet channels from the river to the pumping stations, as well as from the sediment traps, maintaining pumps and pump motors, maintaining rock jetties in the river, and paying power costs. Power costs would be expected to be much greater than the Single Pumping Plant Alternative, which was estimated to be $315,000 per year.

This alternative had the most widely distributed construction footprint of all the alternatives considered. Each station would require new roads or improvements to existing roads to access pump stations and construction of pipelines from each pumping station to the main canal. Building 2 miles of roads 16-feet wide would disturb about 4 acres. Building approximately 7 miles of 54-inch diameter pipelines would require open trench excavation about 25 feet wide, for a total disturbance area of 21 acres. Assuming a 100-foot inlet channel for each pumping station, construction of 7 stations would disturb about 2.5 acres. In all, approximately 27.5 acres would be directly impacted by construction. Acquisition of 26 easements and 6 railroad crossing permits would be needed for road and pipeline construction. Six of the 7 pumping stations would be constructed on private farmland.

Although this alternative would remove the impediment of Intake Diversion Dam, there are biological issues with this alternative. Juvenile pallid sturgeon could move along the jetty and turn into the pumping station channel through the debris fence, where they could be entrained in the sediment trap, which is cleaned by an auger (Archimedes screw pump) that could prove fatal to fish. The fish screens would be custom-designed for the pump stations, because no suitable commercial screens were identified. However, most of the biological issues could potentially be resolved with further refinement of the alternative, given sufficient time and money.

***Infiltration Gallery Alternative***

The Infiltration Gallery concept would use an infiltration gallery to divert water for irrigation. Infiltration galleries are long sections of screened pipe buried at a shallow depth under the river channel (Figure A.1.5). The screened pipes would collect water from below the river channel, and direct it into a system of collector pipes that would gravity-feed water into a pumping plant(s). The collector pipes and pumping plant(s) would be large structures sized to divert 1,374 cfs into a new outlet structure in the irrigation canal. The Intake Diversion Dam would be removed to allow pallid sturgeon and other native fish to migrate upstream.

This alternative would also have logistical, construction, and O&M issues. The current headworks location at Intake, Montana, may be suitable for an infiltration gallery, because the Yellowstone River channel is composed of coarse gravel and cobble; however, the large silt load and organic debris in the river would plug the gravel pack around the screened pipe and require frequent back-flushing. Because of the unknown stability of the riverbed without Intake Diversion Dam, there could be more deposition (covering the gallery with excessive material) or more degradation (uncovering or undermining the screened pipes). Screens buried deeper tend to seal and require more frequent back-flushing.

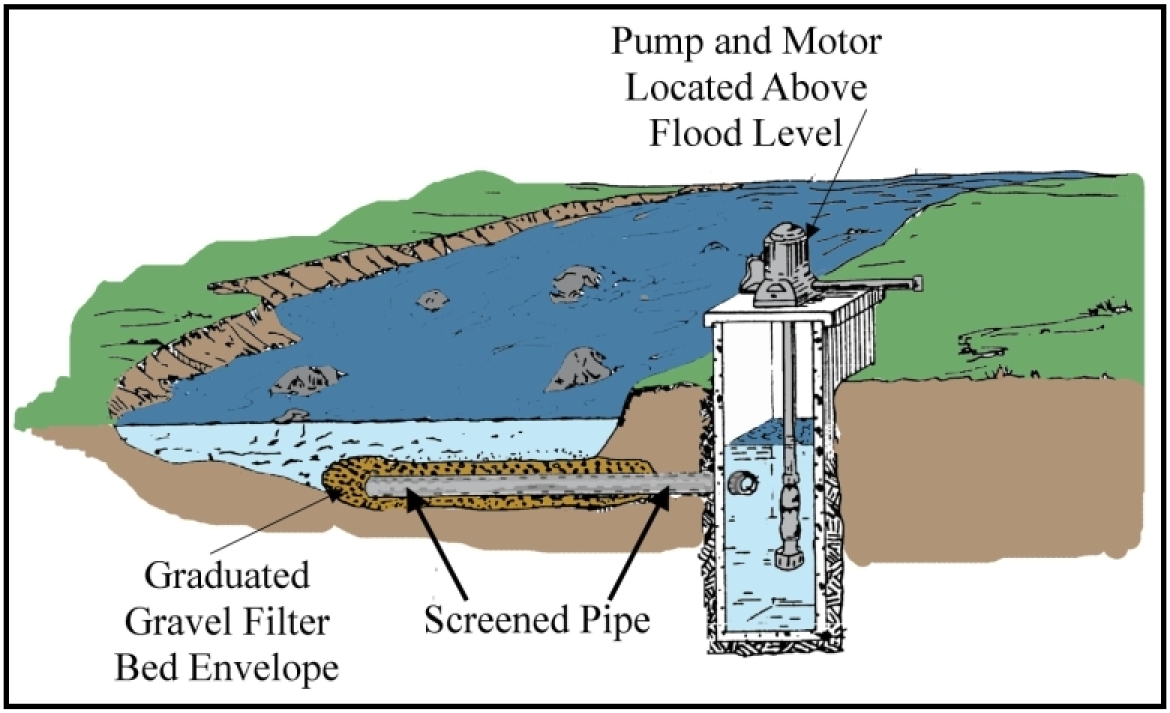


**Figure A.1.5 – Conceptual Layout of an Infiltration Gallery.**

Approximately 1,120 ft of screened pipes, up to 36 inches in diameter would be needed, based on calculations for the rotating removable drum screens; however, to allow for back-flushing the number of screened pipes would have to be increased by probably 25-50%. The pipes could be installed upstream of the existing headworks and run perpendicular to the bank. These would connect to a large collector pipe running into the pumping plant(s). Construction would disturb an area along the riverbank approximately 500 ft long. Because space is limited between the railway line and the existing headworks, an extensive riverbed area would be disturbed to install infiltration pipes.

Construction of an infiltration gallery in the river channel would require shallow excavation to bury screens and pipes and install a graduated gravel filter bed around each pipe to block sediment from passing into the pumping plant. During construction, river flows would be directed around the work area using temporary barriers, where possible. Construction would require complete dewatering of the riverbed and excavation to install infiltration gallery pipes probably extending 100 ft or more into the river. Excavating any open cut into a river bed is difficult and costly as the material continually sloughs into the trench. Excavated materials could be used to cover the collector pipes, with excess excavated fill shaped over the disturbed riverbank. The control station would have a control valve and back-flush plumbing, and the pump outlet would use a flow meter to regulate diversions. In the pumping plant(s), the inlet pipes likely would be routed into a wet-well chamber to equalize flow.

There are several relatively large risks and unanswered questions associated with the infiltration gallery concept:

1) How often would fine silt and organics clog the filters requiring back-flushing?

  - Back-flushing would require reversible pumps or additional pumps, automated back-flush instrumentation and valves, and an additional water source to back-flush the screens.
2) After removal of the existing dam, would the river channel degrade and scour, and if so, how could the pipes be protected from exposure?
   - The scour could require armoring of the bed over the pipes or construction of sills across the channel to prevent scour.
3) Would sufficient water be available during low flows?
   - The amount of water flowing into the screened pipes is directly affected by the depth of water over the pipe. Under low flow additional pipes might be needed to provide an adequate water supply.

Removing Intake Diversion Dam and constructing an infiltration gallery was suggested by EPA, but it was eliminated from further consideration, because this alternative would require at least one and most likely multiple pumping plants, which makes it redundant with the Single Pumping Plant Alternative. In addition, the same reasons for eliminating the Single Pumping Plant Alternative would apply to the Infiltration Gallery Alternative (see above). For example, power demand would be as high as or higher than the Single Pumping Plant Alternative, but unlike the Single Pumping Plant, back-flushing would also be required. Its only advantage over the Single Pumping Plant Alternative would be elimination of fish screens in a new headworks; however, excavation and construction of the infiltration gallery likely would be as costly and would disturb much more river channel than the Single Pumping Plant Alternative.

***V-Shaped Screen Option***

This option was originally identified during the 2002 Value Engineering Study (Reclamation, 2002). The original screening concept was a long flat plate screen constructed at an angle across the canal (Mefford et al., 2000). Due to concern over the duration of fish exposure to the screen it was revised to a v-shaped configuration by the Concept II Report (Glickman et al., 2004). Ice damage would be avoided by constructing the screen in the canal behind the existing headworks structure (Figure A.1.6).

This fish screen option would have two stainless steel flat plate screens, in a v-shaped configuration, to funnel fish to the downstream end where they would be carried in a 36-inch pipe back to the river. The screening structure would have a steel bar trash rack with 2-inch bar spacing at the upstream end to prevent large fish and large debris from entering the screening structure. At the downstream end a large adjustable gate would control water to provide sufficient head for the bypass pipe to gravity flow even when the Yellowstone River is high.

Originally this option lacked a trashrack, but on-going informal consultation with the Service resulted in a significant modification to this option prior to public scoping. The BRT was concerned that large, adult fish entering the canal would be blocked by the trashrack at the upstream end of the fish screen structure (Jordan, 2006) These fish would be trapped in an artificial canal environment indefinitely, potentially requiring capture and relocation each fall. In

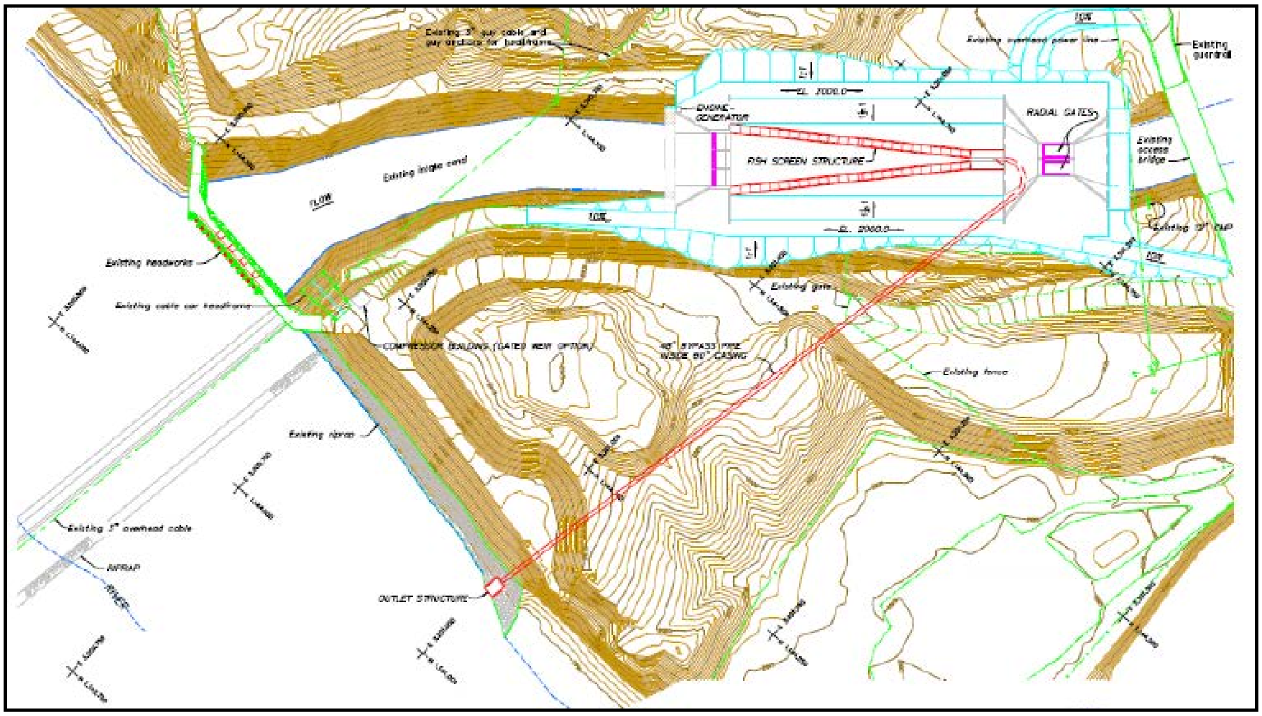


**Figure A.1.6 – V-Shaped Fish Screen Option.**

response to this concern, Reclamation designed a trashrack to be placed on the river side of the existing headworks to block adult fish and large debris from entering the canal. The trashrack would be a new concrete structure with panels that could be removed during the winter to avoid ice damage.

Construction of the v-shaped screen structure would likely occur during the winter to avoid and/or minimize impacts to canal operations. A cofferdam would be built approximately 100 feet out into the Yellowstone River channel to redirect river flow during trashrack construction.

After the V-Shaped Screen Option was redesigned to include the trashrack, it was determined that this option was redundant with the Removable Rotating Drum Screen Option. Both options were designed to meet National Marine Fisheries and Service fishery criteria. However, the V-Shaped Screen Option would require an additional trashrack structure to keep the adult fish out of the canal environment. Having two mechanical systems would increase O&M costs. Construction of the trashrack would increase the cost of this option by approximately 53% as compared to the Removable Rotating Drum Screen Option.

Construction of a v-shaped flat panel screen within the upstream reach of the canal was eliminated from further consideration for three reasons: 1) it was duplicative of the Removable Rotating Drum Screen Option, 2) would expose juvenile pallid sturgeon and other native fish to an unnatural environment for longer duration than the drum screens, and 3) initial construction costs would be substantially higher than the drum screens.

***Relocate Main Channel***

This alternative would move the main channel of the Yellowstone River from its current location to bypass the existing Intake Diversion Dam. The relocated channel would have a steeper slope than the natural riverbed in order to reliably divert flow into the main canal without pumping. This newly excavated channel would provide relatively unimpeded fish passage, although there would be some erosion-control features. The relocated channel would be paired with new headworks and removable rotating drum screens or other screens that meet the screening criteria to prevent entrainment of fish into the main canal. It also would allow regulation of diversion flows into the Lower Yellowstone Project.

The main channel relocation alternative would have the following features:

- Excavated main channel
- Concrete control structure
- In-channel grade control structures (sills and rock riprap revetment)
- Irrigation canal extension
- New headworks with screens and
- Tieback levees

Excavated Main Channel Feature

The primary component of this alternative is excavation of a new 12,500-foot (2.4-mile) long channel segment to provide fish passage. The existing channel would be partially filled and the existing Intake Diversion Dam buried. The new channel would diverge from the natural channel of the Yellowstone River approximately 8,000 ft upstream from the Intake Diversion Dam and would reconnect to the natural channel approximately 5,000 ft downstream. The longitudinal slope of the new channel would be approximately .085%, which is slightly steeper than the natural channel. For comparison purposes the natural slope of the Lower Yellowstone River is variable, but typically ranges from between .05% - .065%.

The new channel would simulate a natural channel with a compound cross-section and the banks would tie into existing ground. All channel sides would have a 4 to 1 slope. The new channel would have three components:

1) Low flow channel 50-feet wide by 2-feet deep,
2) Normal flow channel 600-feet wide by 6-feet deep, and
3) High flow channel 1,250-feet wide.

Fish would use the low-flow channel during low flows, while the wide, high-flow bench would minimize flood impacts that could result from a channel with a higher slope than the existing channel. The 100-year flood elevation at the upstream end of the proposed channel would be equal to or less than the existing 100-year flood elevation.

Approximately 6.1 million cubic yards of soil would be excavated to construct the channel. To minimize flood flow impacts, the entire channel probably would be constructed using either mechanical excavation or hydraulic dredging, as opposed to partially constructing the channel and allowing natural flows to finish it by eroding out the remaining material. Under both the mechanical excavation and hydraulic dredging scenarios, approximately 3.4 million cubic yards of material excavated from the new channel would be used to fill the existing channel of the river. The existing Intake Diversion Dam would be buried in place. In addition approximately 150,000 cubic yards of the excavated fill would be used to construct tieback levees. The remaining 2.5 million cubic yards of material would be hauled to an upland disposal site.

Concrete Control Structure

Upstream from Intake, a concrete control structure would stabilize the inlet to the new channel at an elevation high enough to divert 1,374 cfs into a new canal headworks. The concrete control structure would hold the upstream end of the new main channel in place and protect it from ice gouging and erosion. This control structure would resemble a 600-foot wide concrete weir with a 10-foot crest width and a 2 to 1 slope on the front face. However, unlike a weir, the downstream side would tie directly into the bottom of the excavated main channel providing a seamless transition and unimpeded fish passage rather than sloping down to the riverbed like a typical weir. The concrete control structure would incorporate a 50-foot wide by 2-foot deep low flow channel to match the new low flow river channel. The crest elevation of the control structure would rise approximately 5 - 6 feet above the natural channel bottom.

Real Estate Requirements

The Relocate Main Channel Alternative features would be located primarily on Joe's Island, which is in the Yellowstone River floodplain. Some of this property was acquired by Reclamation during construction of the original Lower Yellowstone Project and is still administered by the agency. Other lands on Joe's Island are Montana State Trust lands or part of the old river channel. The ownership status of the old river channel has not been determined. Additional real estate interest (title or easement) would be acquired on approximately 33 acres for disposal of excess excavated material. In addition, temporary rights-of-entry and/or easements might be necessary for construction staging areas. A pre-construction survey to determine land boundaries and subdivisions would be conducted to clarify ownership status so that real estate interests could be obtained.

Construction Considerations

This would be a fairly large construction project, considering the volume of material to be excavated to construct a new channel. Because the Yellowstone River is large, construction access to either side would follow separate routes, since a temporary bridge would be infeasible. Access from the left bank would be used to construct the headworks and screening structure, canal extension, and tieback levees. Access from the right bank would be used to construct the concrete control structure, excavate the new channel, and construct sills and the upstream revetment. In addition, designated staging and stockpiling areas would be necessary to accommodate equipment, materials, and work crews during construction.

Construction of this alternative likely would take 3 years, if sufficient funding were available. It would begin with installation of a cofferdam around the site of the new headworks. By using a cofferdam, flow in the existing river channel could be maintained allowing uninterrupted operation of the Lower Yellowstone Project irrigation facilities. Concurrently, excavation of the new channel would proceed from the center of the channel outwards upstream and downstream.

After the headworks and canal extension were completed, flows would be diverted through the new headworks, while finishing excavation of the channel and building the tie-back levees. Operation of the screens could be supplied by the existing local power grid.

Relocating the main channel was an alternative considered in detail in the 2010 EA. The cost estimate for this alternative was $50 million, however many of the cost increases that were found in the earlier rock ramp alternative would apply here as well, therefore the cost estimate would be considerably higher. Due to logistical incompatibility with Phase I of the project, which has already been constructed, this alternative has been eliminated from further detailed consideration and an updated cost estimate was not conducted.

## Alternatives Considered During Planning Studies in 2013

A rock ramp was originally proposed in the 2010 EA as a fish passage alternative. This alternative was favored by cooperating entities as the most likely option considered to improve fish passage at Intake. However, due to constructability, maintenance, and cost concerns, the lead agencies believed it was necessary to re-consider other options, and preliminary design work was started on a bypass channel alternative – an alternative considered but not analyzed in detail in the 2010 EA. The bypass channel alternative included a river-wide concrete weir designed to provide adequate water surface elevations for both diversion of water into the proposed bypass channel and delivery of irrigation water through the newly completed headworks. Construction of a new concrete weir would eliminate the need to repeatedly place rock along the crest of the existing diversion structure to maintain necessary head requirements for both the bypass channel and the new headworks. The preliminary cost estimate of the bypass channel alternative was about $59 million.

Due to concerns raised by stakeholders and cooperating entities about the bypass channel, a new planning effort was initiated that brought the original cooperating entities (the Corps; Service; the State; the Irrigation Districts) together to revisit the alternatives that had been previously identified along with potential new alternatives for fish passage at Intake. The planning effort started with a meeting on June 20, 2013 and continued into September 2013. The objective of the meetings was to get involved parties to identify acceptable and implementable alternatives that would merit more detailed review.

Reclamation facilitated seven cooperating agency collaborative meetings between June 20, 2013 and September 13, 2013 to re-initiate efforts to identify viable fish passage alternatives at Intake. The goal was to identify preliminary alternatives that could provide fish passage while maintaining the viability of the Project including the ability to divert irrigation water without an unbearable increase in Project O&M costs. The specific meeting objectives were to identify fish passage alternatives and apply screening criteria to narrow the list. Reclamation and the Corps also conducted preliminary cost and feasibility (design, constructability, and biological) analyses of these alternatives. The cost and feasibility information was shared with the group to continue to refine alternatives and identify a final range of alternatives. Since not all alternatives or all elements of the alternatives were supported by all cooperating entities the group continued investigating measures that could be used to overcome cooperating entity design and O&M concerns. This review was completed in early September 2013, and six alternative themes for achieving the goals were developed to an appraisal level of consideration. The themes included an open river channel with pumping, three rock ramp variations, a bypass channel, and conveying water through a new diversion canal called the Island Alternative. In addition, conservation measures were evaluated for the potential to reduce water demand under most of the alternatives. The alternative themes considered in this new planning study are presented below.

1. Theme A-Open Channel with Multiple Ranney Wells
2. Theme B-Original Rock Ramp
3. Theme C-Rock Ramp with Reduced Weir Elevation
4. Theme D-Combination Rock Ramp and Weir
5. Theme E-Realigned Bypass Channel w/ Modified Weir
6. Theme F-Island

This collaborative planning effort identified the current Bypass Channel Design as the acceptable and potentially implementable fish passage alternative to pursue if changes and issues identified under Alternative Theme E were addressed and incorporated, if proven beneficial, into the current Bypass Channel design. Table A.1.7 reflects the ranking determined for each alternative theme evaluated by the planning team.

Table A.1.7. ESA modifications – alternatives evaluation matrix for Intake Diversion Dam

**Lower Yellowstone - Intake Diversion Dam**
**ESA Modifications - Alternatives Evaluation Matrix**

| Alternatives | Head Works Cost ($M) | Field Construction Cost ($M) | Conservation Measures Cost ($M) | Total Project Cost ($M) | Annual O&M Cost (Excluding Energy) ($M) | Annual Energy Cost ($M) | Annual Replacement Cost ($M) | Total Annual Operation, Maintenance and Replacement Cost ($M) | Likelihood of ESA Success | Water Delivery Reliability | Constructability | Acceptability: State Acceptability | Acceptability: District Acceptability | Acceptability: BOR Acceptability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Original Rock Ramp (w/conservation measures, and potential lower elevation)**<br>- Evaluate if a lower weir and ramp elevation improves fish passage<br>- If lower elevation does improve fish passage potential is there efficiencies within the district to help reduce weir and ramp elevation<br>- Evaluate what these efficiencies can be and cost of these measures | $28 | $91.6 | $0 | $119.6 | | | | $0 | 3 | 5 | 2.5 | 3 | 5 | 4 |
| **30% Design Bypass Channel(w/modifications and Federal Assurances)**<br>- Evaluate options to move the current bypass channel alignment out of the existing high flow channel<br>- Physical modeling of bypass channel entrance and exit<br>- Federal Assurances in writing<br>- Modified weir design, reduce weir crest width from 25' to 6' | $28 | $59.9 | $0 | $87.9 | $0.14 | | | $0 | 3 | 5 | 3.5 | 2 | 3 | 3 |
| **Alternatives Considered But Dropped** | | | | | | | | | | | | | | |
| **Open Channel w/ Multiple Ranney Wells** | $28 | $215.6 | $0 | $243.6 | | $2.7 | | $2.7 | 5 | 3 | 3.5 | 5 | 1 | 3 |
| **Rock Ramp w/ Reduced Elevation (1989')** | $28 | $69.4 | $10 | $107.4 | | | | $0 | Did Not Receive A Ranking | | | | | |
| **Combination Rock Ramp and Weir** | $28 | $91.0 | $0 | $119.0 | | | | $0 | 2 | 5 | 2.5 | 2 | 4 | 2 |
| **Realigned By-pass Channel w/ Modified Weir** | $28 | $59.0 | $0 | $87.0 | $0.14 | | | $0 | Did Not Receive A Ranking | | | | | |
| **Island** | $28 | $37.0 | $0 | $65.0 | | | | $0 | 4 | 2 | 2.5 | 4 | 1 | 3 |

## Alternative Theme A. Open Channel with Multiple Ranney Wells

**Alternative Description:**
This proposal consists of four main components: the existing headworks would continue to be used to divert irrigation water when river flows are sufficient to do so; replacing the existing diversion dam with multiple pumping stations along the river downstream from existing weir; implementation of water conservation measures throughout the irrigation delivery system to reduce the amount of water needed for the project (see Conservation Measures supplemental alternative description); and installing renewable energy sources to supplement power demand for the pump system. Due to time constraints, the renewable energy options were not investigated as part of this proposal.

**Proposed Pump Systems:**
The multiple pumping stations option consists of numerous radial collector wells installed at seven locations adjacent to the Yellowstone River to supply irrigation water to the main canal. Water would be carried from the pumps to the main canal by several buried pipelines. Using radial collector well type systems with fixed pumps would eliminate the need to construct permanent structures within the Yellowstone River.

Radial collector wells, one type being a Ranney® collector well, are generally comprised of a vertical reinforced concrete shaft (caisson)—typically 16 feet in diameter—excavated to a target depth at which well screens project laterally outward in a radial pattern. In a practice referred to as riverbank filtration, the wells are designed to induce infiltration from a nearby surface water source, combining the desirable features of groundwater and surface water supplies.

Where alluvial deposits form aquifers that are hydraulically connected with surface water sources, water supply systems can be installed to induce infiltration to recharge the water being pumped from the aquifer, providing water that is naturally filtered to provide very uniform water quality and temperature. As water is pumped from the well, the water table lowers, reversing the hydraulic gradients within the aquifer, which induces recharge to filter through riverbed and riverbank deposits providing a sustained flow of naturally filtered water to the well or infiltration system.

Ranney® collector wells are the preferred method for developing moderate to very high capacity riverbank filtration (RBF) supplies. RBF collector wells will be installed adjacent to the Yellowstone River (surface water source) at seven sites indicated on the map with their lateral well screens projected beneath the riverbed to optimize induced infiltration supplies. These wells can be installed with designated setback distances to increase the degree of filtration achieved. The result is an abundant, dependable supply of high-quality water with a constant temperature and low turbidity.

Ranney wells have been designed with capacities up to 123cfs. In this alternative, each well site must produce approximately 200cfs. Two collector wells will be needed at each site. In the right location, a Ranney well will produce the same volume of water as several vertical wells while using less area than a conventional well field. Additionally, a properly designed Ranney well has enough screens to minimize the entrance velocity of groundwater, reducing the frequency of required maintenance (see Figure A.1.8).

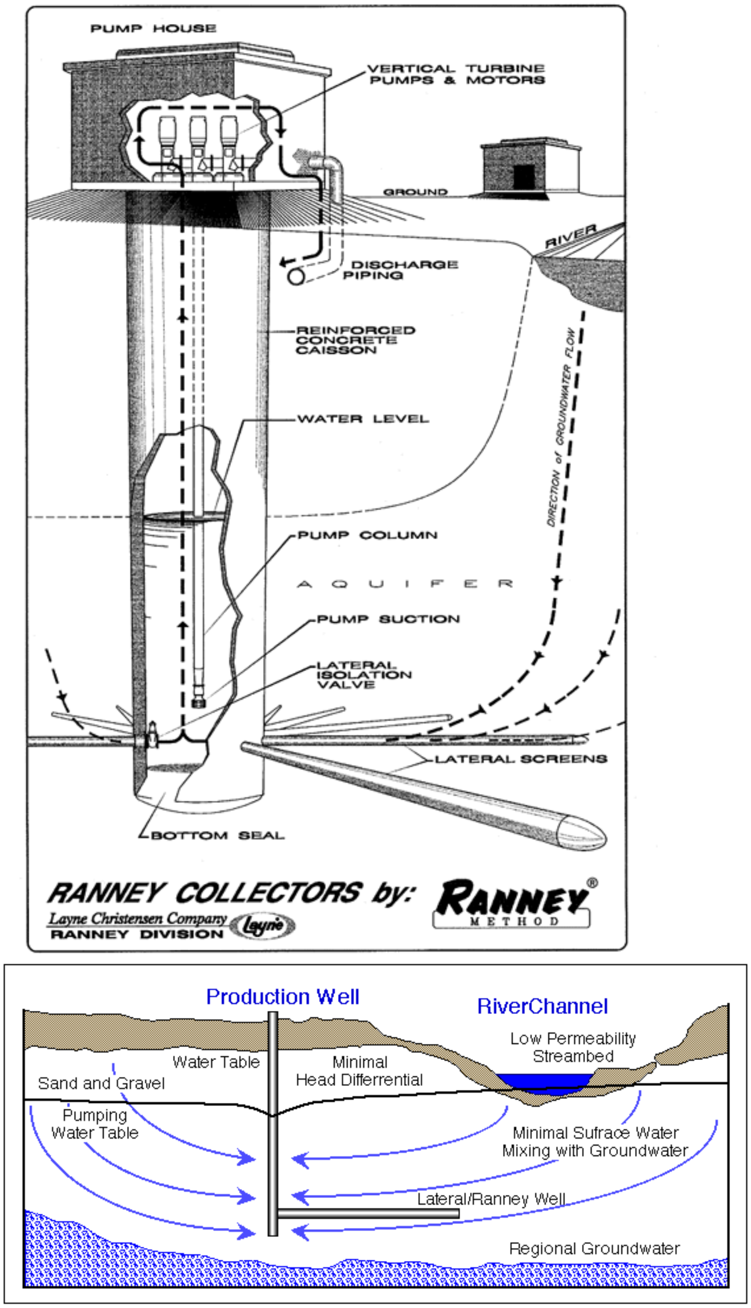

**Figure A.1.8. Example Collector Well**

### Existing Irrigation Canal Operation:

The existing canal consists of about 72.5 miles of unlined canal and the flow into the canal is diverted from the Yellowstone River when flows are high enough to allow diversion. The canal currently functions as a conveyance system and is controlled by a downstream operational concept where the water demand or scheduled deliveries determine the flow into the canal. In a report by Henry T. Falvey & Associates dated April 9, 2009 critiquing the use of multiple pumps to supply water to this system, it was identified that about 80% of the flow is distributed in the downstream third of the canal. This report stated that the upper reaches are considered to be a connector system and lower reaches a delivery system.

Ditchriders patrol the canal to maintain the required flows at each irrigation turnout. As reported in the referenced report, the time for water entering the canal to traverse to the end of the canal is approximately 1 ½ days with a mean velocity in the canal of 2.5 feet/second. Mismatches in the inlet and the delivery flows can be anticipated because delivery orders are taken one day in advance of need.

**Modified Irrigation Canal Operation:**
The design of the canal with the pumping system is exactly opposite to that of the existing gravity system. A canal that is supplied with pumps is commonly called a collector system and is a supply-oriented system. A supply-oriented system is operated differently than a demand-oriented system, and this difference must be recognized in planning and design of modification to the canal system such as requiring the installation of more check structures in the upper reaches to ensure that water can be diverted into the existing turnouts.

Learning how to operate the new system will require retraining of both the water master and the ditchriders. The response time of the system can be reduced; however, more emphasis will be placed on leakage and wasting. With this system, the amount of water that is lost will be decreased.

**Overall System:**
The new headworks at Intake would continue to allow gravity diversion from the Yellowstone River when flows are high enough to supply the head necessary for the system; however, the system would utilize the multiple Ranney Well pump systems at times of lower river flows to supplement the system.

The total power load for the pumping stations would be approximately 17 megawatts. Power could be supplied from existing power supplies and potentially could be supplemented by project-specific sources such as a wind farm or solar generation, but these options were not investigated due to time constraints. Implementation of the proposed pumping plant would include the following elements: (1) removal/disposal of the existing diversion dam and restoration of dam site; (2) construct new pumping plants with site work for roads, parking, and infrastructure; and (3) construct new high power transmission line to route power to the pumping stations and auxiliary/backup power generation capability in the event of power outages.

**Conclusion**
This alternative was dropped because of the high cost to install the Ranney Well System and the high energy costs that would be placed upon the district. Concerns with service reliability, brownouts, and power outages were also discussed. These issues could cause disruption in canal flows and affect operation of the whole system. It was determined that there were cheaper, potentially more effective alternatives remaining.

### Alternative Theme B. Original Rock Ramp

**Alternative Description:**
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 2,000-foot length, creating the necessary 0.5% slope considered favorable for pallid sturgeon passage. The ramp crest elevation would be set at 1990.5 feet to provide 1,374 cfs to the LYIP at flows above 3,000 cfs.

**Weir**
A replacement concrete weir would be located downstream of the new headworks to elevation 1,990.5 ft which would create sufficient water height to divert 1,374 cfs into the main canal. The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam in the spring of the year.

The weir crest would vary in elevation, including at least one low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option and for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of “drilled” shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete “cap” to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

**Rock Ramp**
A rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low flow channel in conjunction with the low flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 390,000 tons of rock riprap for the ramp, 40,000 tons of spalls/gravel, and another 60,000 tons of riprap for the toe of the ramp (for energy dissipation) would be needed for construction of the ramp.

**Flood Plain Control**

To help with depths and velocities over the crest of the weir, this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe's Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more "out-of-bank" area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area with the idea being that as flows increase within the Yellowstone River, velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain, the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and other native fish species.

The large eddy that currently forms on the south side of the existing dam is being eliminated by the design of the rock ramp where the feature causing the eddy is filled in with rock.

## Alternative Theme C: Rock Ramp with Reduced Weir Elevation

**Alternative Description:**
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 1,500-foot length, creating the necessary 0.5% slope thought to be favorable for pallid sturgeon passage. The ramp crest elevation would be set at the reduced height of 1989 ft to provide 1,150 cfs to the irrigation districts at a flow of 3,000 cfs (see Figure A.1.9). The remaining water right would be supplemented through pumping and project efficiencies such as center pivots and canal/lateral linings. The system was designed to run at full capacity so checking structures would need to be incorporated into this alternative to maintain sufficient water height within the main canal.

**Weir**
A replacement concrete weir would be located downstream of the new headworks to elevation 1,989 feet which is approximately 1.5 feet lower than what is needed to divert the full water right at 3,000 cfs. At flows of 6,100 cfs and above, the irrigation districts could divert their entire water right and supplemental pumping would not be needed.

The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam during the spring.

The weir crest would vary in elevation, including at least one low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of “drilled” shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete “cap” to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

**Rock Ramp**
A rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with

rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low flow channel in conjunction with the low flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces.

**Flood Plain Control**

To help with depths and velocities over the crest of the weir this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe's Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more "out-of-bank" area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area with the idea being that as flows increase within the Yellowstone River velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain, the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and native fish species.

**Efficiencies/Weir Height Reduction**

This proposal looks at the opportunity to reduce the height of the rock ramp proposed in Alternative Theme B by reducing the peak demand required by the Irrigation District. The rock ramp in Alternative Theme B is designed to convey the full water right of 1,374 cfs at a minimum river flow of 3,000 cfs. This alternative will combine several levels of improved water management and supply augmentation, with the corresponding reduction of rock ramp height to attempt to identify the most advantageous combination of this hybrid proposal.

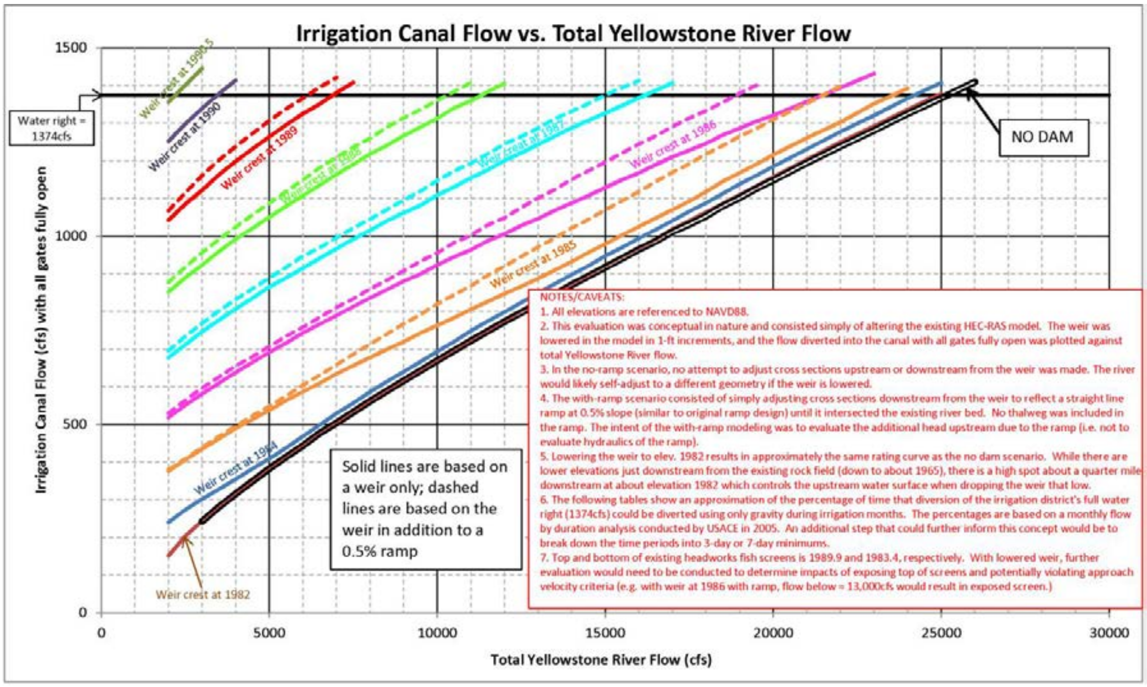


**Figure A.1.9. Flow Splits Between River and Irrigation Canal at Different Weir Crests**

## Conclusion

This alternative was dropped but important components were combined with the original rock ramp alternative. The thought behind the lower ramp elevation was to help improve fish passage success at the same time reducing the cost of construction. Analysis was conducted at such a preliminary level, engineers could not confidently say what impacts a lower rock ramp and weir elevation would have on fish passage as it pertained to velocities. Significant cost savings were not achieved in the preliminary estimate for this alternative.

## Alternative Theme D: Combination Rock Ramp and Weir

**Alternative Description:**
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp on approximately half of the river. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 2,000-foot length, creating the necessary 0.5% slope thought to be favorable for pallid sturgeon passage. The ramp crest elevation would be set at a height of 1990.5 feet to provide 1,374 cfs to the irrigation districts at a flow of 3,000 cfs and higher.

**Weir**
A replacement concrete weir would be located downstream of the new headworks to elevation 1990.5 ft which is needed to divert the full water right at 3,000 cfs. The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability, which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam during the spring.

The weir crest would vary in elevation, including at least one, low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of "drilled" shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete "cap" to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

**Rock Ramp**
A rock ramp would be constructed downstream of the replacement weir on approximately half of the river. The ramp would be built by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low-flow channel in conjunction with the low-flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 172,000 tons of rock riprap for the ramp, 20,000 tons of spalls/gravel, and another 30,000 tons of riprap for the toe of the ramp (for energy dissipation) would be needed for construction of the ramp.

**Flood Plain Control**

To help with depths and velocities over the crest of the weir this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe’s Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more “out-of-bank” area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area. The idea being that as flows increase within the Yellowstone River velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and native fish species.

**Conclusion**

This alternative was dropped because it was comparable in cost to the original rock ramp but only provided half the river passage. The thought for considering this alternative was if the ramp width is cut in half, the costs could potentially be cut by half. Estimates from preliminary cost analysis did not validate the original assumption. A primary factor in why this alternative did not prove to be cheaper was that to keep the water on the half rock ramp, a very large retaining wall would need to be constructed from the weir crest to the toe of the ramp and upstream. This increased costs to the cost levels estimated for the original rock ramp design.

## Alternative Theme E.  Realigned Bypass Channel with Modified Weir

### Alternative Description

The Corps  has designed a bypass channel around the existing point of diversion that is currently at the 30% design stage.  This alternative modifies the Corps' current design by:

- relocating the bypass channel to maintain the integrity of the existing high flow channel,
- reducing the width of the weir crest from 25 feet to approximately 6 feet, and
- providing variable flow velocities on the weir crest and downstream slope through slight undulations in crest height.

A primary feature of this alternative would be the construction of a bypass channel to divert approximately 15% of total river flow into the bypass under all flow scenarios above 3,000 cfs. The original By-pass channel was designed to typically divert 15% of the total flow during typical spring and summer discharges and diversion percentages varied from 10% at extreme low flows to 17% at extreme high flows.  Under this alternative with existing high flow channel still active, either the bypass channel would not take the same percentage of flow at high flows (during migration) or the weir would need to be raised to account for flow into the existing high flow channel.

The proposed bypass channel alignment would be modified from the existing alignment to isolate it completely from the existing high flow channel along the south side of Joe's Island. This would be accomplished primarily by relocating the river entrance to the bypass downstream to avoid the mouth of the high flow channel.  The current alignment is approximately 15,500-feet long with a slope of approximately 0.0006 feet/feet (natural Yellowstone River slope is approximately 0.0004feet/feet to 0.0007 feet/feet).  It is expected the re-aligned bypass channel would comply with the BRT's recommendations regarding flow velocity and depth and would likely approximate the "original" dimensions.  The bypass channel cross-section would be 40' wide at the bottom with side slopes varying from 1V:12H to 1V:3H.  The original bypass channel design requires excavating approximately 1.2 million cubic yards of material from Joe's Island; however, this would increase considerably if the upstream end of the existing chute was not used.

A structure designed to control flow into the bypass would be constructed at the upstream river entrance to the bypass channel.  The structure would likely be composed of riprap with a concrete sill and would be backfilled with natural river rock to give the appearance of a seamless channel invert.

Two vertical control structures (riprap sills) would be constructed to maintain channel slope and provide for early identification of channel migration.  These structures would be constructed by over-excavating and backfilling the excavation with river rock to appear as a seamless channel invert while providing stability.  A riprap sill would also be constructed at the downstream fish entrance to the bypass to maintain channel elevations.  Additionally, riprap would be installed on at least two outside bends with higher potential for failure.  Additional protection may be required in the future if, through adaptive management, assumptions about channel stability are proven incorrect and channel migration or degradation begins to impact passage efficacy.

A new concrete weir would be constructed approximately 40 feet upstream of the existing rock structure to provide sufficient water surface elevations to divert the appropriate flows through the bypass channel and headworks. The existing rock structure would be integrated into the new concrete structure by placing fill between the new and old structures. The new diversion weir would consist of a cantilevered structural wall consisting of "drilled" shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts).

The area between the new weir and existing structure and the area immediately upstream of the new concrete weir would be filled with sands and gravels excavated from the bypass channel and capped with riprap to provide a seamless transition between the old and new structures. The top of the structure would be a concrete "cap" to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

Once pallid sturgeon migrate upstream past the weir using the bypass channel, they must also be able to migrate back downstream. The weir design would include a notched section that would produce sufficient depth of flow for downstream passage. Additionally, the existing rock weir and downstream rock field would be modified to create a thalweg of sufficient depth to allow downstream fish passage.

An access road would be constructed along the north side of the river to allow access for heavy equipment during construction. Following completion, the road would be removed and the area would be restored to pre-construction conditions. Existing access roads to Joe's Island would be improved as needed to allow access.

Features of this alternative would be located primarily on Joe's Island. This land was acquired by Reclamation during construction of the original Intake project and is still administered by Reclamation. All construction, staging and disposal would occur on Reclamation lands.

**Conclusion**

This alternative was dropped; however, many of the changes proposed in this alternative are being evaluated and considered for incorporation into the current 30% design of the bypass channel.

## Alternative Theme F. Island

**Alternative Description:**
This alternative includes utilizing the existing island in the Yellowstone River upstream of the headworks to split river flows between a proposed canal and the Yellowstone River (see Figure A.1.10). The proposed constructed canal section would convey flows to the newly constructed headworks. The majority (approximately 600 feet) of the existing Intake Dam would be removed and a new 100-foot section of dam would need to be constructed to direct water into the existing headworks. A 9,600-foot long canal would be created by constructing a 3,400-foot long by 10-foot wide (top width) dike that extends from the existing Intake Dam on the headworks side of the river to the upstream island. About 100 feet of Intake Dam from the headworks side would be replaced with a newly constructed concrete dam. The new 100 ft wide dam would need to include appurtenances to pass flood flows, sluice sediment, and return fish from the canal to the main channel.

The canal around the island would be approximately the same width as the existing side channel, 150-foot bottom width with 1:1 side slopes. The last 3,400 feet of canal created by the dike would have a 70-foot bottom width with 1:1 side slopes. Excavation along this canal would be required to lower the canal invert to allow for flow conveyance. The entrance to the canal would be at an elevation higher than the river inlet. A concrete sill would also be required to stabilize the canal entrance. The entrance would also need to be designed to reduce debris entrainment (i.e., trash rack) and minimize ice flow damage to the canal.

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir across the entire width of the Yellowstone River (near the new canal entrance) to raise river levels and allow water diversion during low flow. The weir across the Yellowstone River would be located just downstream of the new canal entrance. This weir would have an elevation between 1991 and 1993 feet. At this elevation, given the river bottom at this location, the weir will be between 5 to 7 feet higher than the natural river bottom. A fish passage structure will be required, (e.g. rock ramp or bypass channel).

The new 100-foot wide concrete dam next to the existing headworks screening structure would utilize two 10-foot wide radial gates to pass excess water that enters the canal but is not needed for irrigation diversion. These gates would also be used to pass floating debris. Four 8-foot wide by 6-foot tall vertical lift gates would be used to sluice deposited sediments away from the headworks structure. A fish bypass would also be built to return fish that enter into the canal back to the river.

The island would be protected by placing a 10-foot wide rock dike along the river-side perimeter of the existing island. Material dredged from the 9,600-foot long canal would be placed into the interior of the island’s rock dike perimeter. The upstream side of the island and upstream floodplain would also require stabilization so that the canal would not get flanked during high flows. The 3,400-foot long dike would overtop during flood events with a frequency that has yet to be determined. The dike would need to be designed for overflow.

Design options include:

- Build dike with roller compacted concrete to increase stability and reduce maintence of the structure.
- Include vehicle passage on the dam and dike for maintenance of the canal and entrance.
- Use collapsible gates to divert water into canal instead of concrete weir. "Checking up" the water to obtain a full diversion is only needed for flows less than 7,000 cfs.

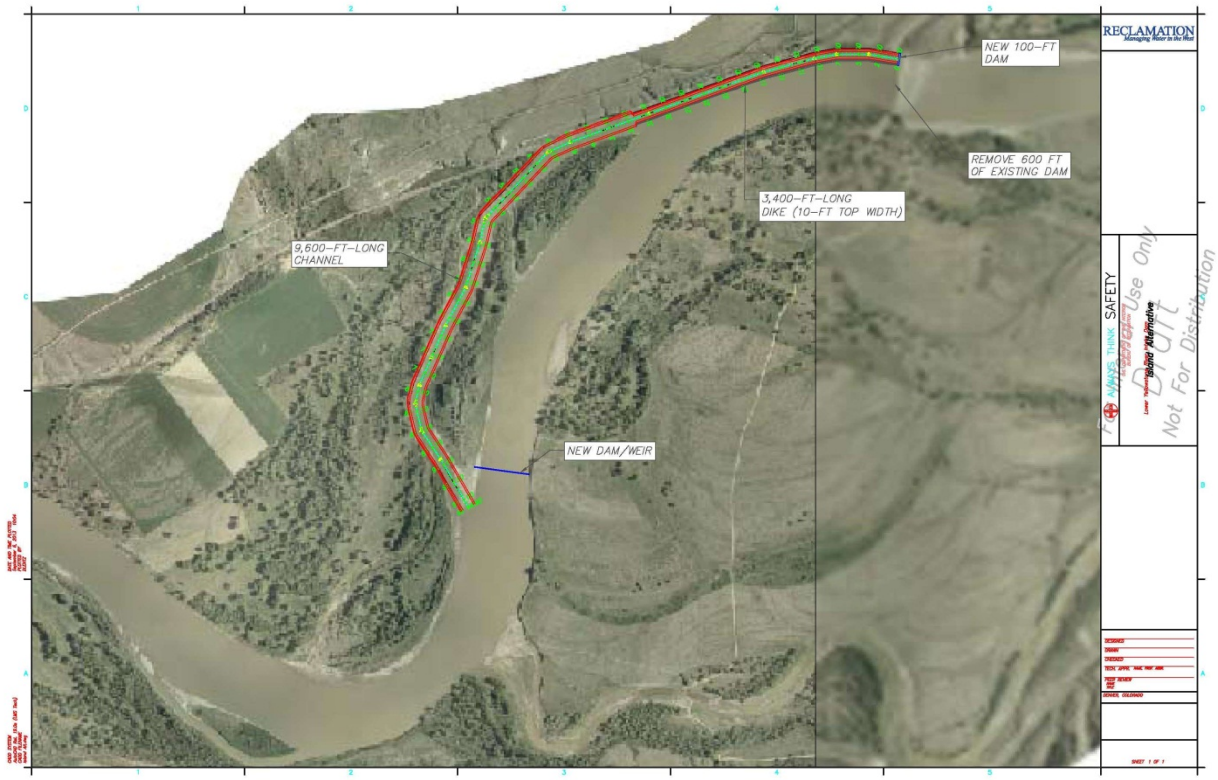


**Figure A.1.10. Island Alternative**

## Conclusion

This alternative was dropped because of concerns regarding the river migrating away from the newly constructed headworks when the diversion dam was removed and the O&M cost will be considerable for the new dike system required on the outside bend of the river. It was also a concern that the hydraulics of this alternative would not allow the district to receive its full water right when the river flows dropped close to 3,000 cfs. Issues of sediment and fish entrainment were also discussed but not resolved. Concerns about stability and long term O&M costs were expressed. The main reason for not pursuing this alternative further was that it proved to be technically infeasible without constructing a weir/dam across the full width of the Yellowstone River.

**Alternatives Identified for Further Study**

Five fish passage alternatives and two fish screen options were initially identified for further analysis in the 2010 EA based on previous studies of the Lower Yellowstone Project. These were presented in the public scoping meetings held in October 2008. Using scoping input from cooperating agencies and the public, these alternatives were screened through criteria and modified into the three alternatives evaluated in the Final EA. During preparation of the Supplemental EA, input was gathered from the cooperating agencies on potential alternatives. All alternatives that were previously evaluated were reviewed and reconsidered. These alternatives were screened through the criteria and three alternatives are included in the Supplemental EA Addendum; No Action, Bypass Channel and Rock Ramp.

The Rock Ramp Alternative was considered in the 2010 EA and identified as the preferred alternative. Updated technical information and analysis of the rock ramp is documented in this supplemental EA. Due to maintenance, constructability, and cost concerns about the rock ramp design, a bypass channel alternative design was initiated. Due to concerns raised by some of the cooperating entities regarding uncertainty about the bypass channel, a new planning study effort was initiated to bring the original cooperating entities back to revisit all the alternatives that had been previously identified along with potential new alternatives for fish passage at Intake. The planning effort started with a meeting on June 20, 2013 and continued into September 2013 to get all parties working together to identify acceptable and potentially implementable alternatives that would merit more detailed review. As a result of these meetings, the Bypass Channel Alternative was identified for further analysis.

The alternatives evaluated in the EA Addendum are:

- **No Action (Continue Present Operation) -** Under this alternative, Reclamation would continue present operation of the dam and headworks to divert water from the Yellowstone River for irrigation purposes, as authorized. This means operating the irrigation project without any modifications to provide fish passage alternatives until Reclamation completes required ESA consultation activities with the Service and implements any ESA requirements regarding fish passage resulting from that consultation. The Corps has completed construction of a new headworks and fish screens for entrainment protection which is being operated by the Lower Yellowstone Irrigation District (LYID) during the 2012 irrigation season for the first time. Reclamation completed consultation with the Service on operation of the system in March 2012.

- **Bypass Channe**l **–** The primary feature of this alternative would be constructing a bypass channel from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. It would also replace Intake Diversion Dam with a concrete weir to raise the surface elevation of the river in front of the new headworks for diversion into the main canal. The bypass channel would improve fish passage and contribute to ecosystem restoration.

- **Rock Ramp** – The primary features of this alternative would be replacing Intake Diversion Dam with a concrete weir and boulder and cobble rock ramp. This would raise the surface elevation of the river upstream of the weir for diversion into the main canal, while improving fish passage and contributing to ecosystem restoration.

A more detailed description of each of the alternatives carried forward is presented in Chapter Two of the Supplemental EA as well as Appendix A.2 (Engineering).

## Evaluation of Alternative Plans

For ecosystem restoration projects, benefits are typically non-monetized, but project outcomes can be quantified in terms of habitat units. The objective of the Intake Dam Modification Project is to provide fish passage and entrainment protection to endangered pallid sturgeon. Providing fish passage would reconnect access to up to 165 river miles of habitat for spawning and recruitment of pallid sturgeon which may assist in the recovery of a self-sustaining population.

To assist with evaluation of alternatives, the Service again called on the BRT to provide input to the process. According to the BRT, both action alternatives meet the objective of passage based on anticipated hydraulic performance compared against desirable depth and velocity criteria that meet the needs of pallid sturgeon. The Corps uses Cost Effectiveness/Incremental Cost Analysis (CE/ICA) to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs. A detailed analysis of CE/ICA is located in Appendix E. In summary, the Bypass Channel Alternative would provide 7,469 habitat units (HUs), for an incremental cost of approximately $319, while the Rock Ramp Alternative would provide 7,649 HUs for an incremental cost of approximately $8,597. Considering the steep increase in incremental cost to achieve a slightly higher level of HU outputs, the Bypass Channel is the preferred alternative, even if adaptive management measures are required.

## Comparing Alternative Plans

Chapter 4 fully discloses the environmental impacts of the proposed alternatives, which are summarized below in Table A.1.8. The table identifies whether each alternative would have a long-term beneficial, long-term adverse, temporary effect, or minimal effect on a resource. The table takes into account implementation of the actions to minimize effects described in Chapter 4 of the 2010 EA, the supplemental EA and Appendix I.

**Table A.1.8 – Summary of Environmental Impacts that Could Result from Construction and O&M of the Action Alternatives**

| Resource | Rock Ramp Alternative | Bypass Channel Alternative |
|---|---|---|
| **B** – Beneficial Effect **A** – Adverse Effect **M** – Minimal Effect **T** – Temporary Effect **N** – No Effect | | |
| Climate | **N** | **N** |
| Air Quality | **T** | **T** |
| Hydrology | **N** | **N** |
| Geomorphology | **M** | **M** |

| Resource | Rock Ramp Alternative | Bypass Channel Alternative |
|---|---|---|
| **B** – Beneficial Effect **A** – Adverse Effect **M** – Minimal Effect **T** – Temporary Effect **N** – No Effect | | |
| Surface Water Quality | T N | T M |
| Aquatic Communities - Fish | B | B |
| Aquatic Communities - Mussels | T M | T M |
| Aquatic Communities - Macroinvertebrates | T M | T M |
| Federally-Listed Species and State Species of Special Concern | B T M N | B T M N |
| Lower Yellowstone Project Irrigation Districts | T | T |
| Recreation | T M | T M |
| Social and Economic Conditions - Regional | T B | T B |
| Social and Economic Conditions - Irrigation Districts | M | M |
| Environmental Justice | N | N |
| Natural Resource Lands | T M | T M |
| Wildlife | T M | T M |
| Historic Properties | M | M |
| Indian Trust Assets | N | N |

## Selecting a Plan

Reclamation and the Corps have identified the Bypass Channel as the preferred alternative. Unlike the No Action Alternative, the Bypass Channel Alternative would meet the purpose and need of the proposed action. Compared to the rock ramp, it would provide a more natural passage route and would require much less fill to be placed within the main channel of the Yellowstone River. Because the construction footprint is larger, the bypass channel does create more temporary and permanent impacts to several natural resources, including riparian and wetlands, however these impacts are considered minor.

Fish Passage benefits modeling, while not all inclusive of all parameters that may affect fish passage, does indicate that the Rock Ramp option may be slightly better at providing passage to pallid sturgeon and other fish communities, but both alternatives would provide much greater benefits than the no action alternative. Based on results of CE/ICA, the Bypass Channel Alternative was identified as the preferable alternative in that it most efficiently provided habitat unit outputs (Appendix E).

## Recommendations

In response to Section 3109 of WRDA 2007 (P.L. 110-114) and the October 2009 and March 2010 letters from the Service amending RPA elements from the 2003 Amended Biological Opinion, the Bypass Channel Alternative as presented in this Supplemental EA and Plan Formulation Appendix is recommended for implementation. This alternative will provide the opportunity for fish passage around the Intake Diversion Dam, restoring access to up to 165 river miles of historic critical habitat for the endangered pallid sturgeon and other native fish. Specific benefits include providing access to up to 165 river miles (280 river miles total upstream from

Lake Sakakawea) of high quality habitat deemed essential for successful natural spawning, recruitment, and rearing of pallid sturgeon which could contribute to establishment of a self-sustaining population in that segment of the Missouri River basin.

**INTAKE DIVERSION DAM MODIFICATION**

**LOWER YELLOWSTONE PROJECT**

**PRELIMINARY DRAFT EA-ADDENDUM**

# APPENDIX A2

# ENGINEERING

The following Attachments comprise the Engineering Appendix to the subject EA Addendum.

# Intake Diversion Dam Modification

# Lower Yellowstone Project, Montana

## Intake Fish Bypass Option Evaluation Summary

# Attachments

**May 2012**

Updated July 2012

**LIST OF ATTACHMENTS/TABLE OF CONTENTS**

**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Intake Fish Passage Option Evaluation Summary**
**May 2012**

**Attachment 1a**

# Ice Forces on Intake Dam
# Lower Yellowstone River, 30% Design

**Prepared by:**
**Andrew Tuthill, Cold Regions Research and Engineering Laboratory (CRREL)**



Return to TOC

**Ice Forces on Intake Dam, Lower Yellowstone River:**
**30 Percent Design**

Andrew M. Tuthill

US Army Corps of Engineers
Cold Regions Research and Engineering Laboratory
72 Lyme Road, Hanover, NH 03755

## 1. Introduction

Omaha District of the Corps of Engineers (NWO) is redesigning The Yellowstone Intake Dam on the Lower Yellowstone River to include a 1600-ft-long rock ramp for fish passage and a new headworks structure with sixteen 6-ft-diameter circular intakes. The intakes will be screened and the screens removed during the winter season to avoid ice damage. The new dam will have a 1V:3H upstream face will be constructed of concrete. Plans are being developed for a downstream rock ramp with a trapezoidal cross section and a mild slope grading from a 0.002 to 006 slope in the downstream direction. Current plans call for the ramp to be constructed of large rocks with smaller size infill material.

The lower Yellowstone River is subject to heavy ice formation, dynamic ice breakups and ice jams. Ice action and ice forces are therefore a critical design factor, particularly for the rock ramp since this is a new and relatively untested type of structure in an extreme ice environment. In this report, CRREL provides ice force estimates for the headworks, dam and ramp for the 30 percent design being developed by NWO.

## 2. Previous Studies

In 2006, CRREL provided NWO with ice force estimates for the 10 percent design (Haehnel and Tuthill, 2006). This study included a literature review of past studies and designs related to ice forces on rock structures and armor stone. The study analyzed the Lower Yellowstone River ice regime and historic ice jam events as they related to the 10 percent design. Ice force estimates were developed for a rock dam similar to the existing one with a 1V:2H upstream face and a 1V:10H downstream rock ramp with rows of large boulders to create a pool and riffle sequence. The study addressed removal of rock from the dam, damage to the dam by ice forces and removal of boulders from the proposed rock ramp structure.

Based on the results of physical model tests at CRREL (Sodhi et al. 1996, Sodhi et al., 1997, Sodhi and Donnelly, 1999), for an estimated maximum ice thickness of 21 in, the estimated $D_{50}$ to resist rock movement on the upstream face of the dam would need to be approximately 6 ft. Following the methods prescribed in AASHTO (1998), assuming an effective ice strength of 110 psi , the estimated ice force on the upstream face of the dam resulting from the crushing failure of a 400-ft diameter ice floe was estimated to be 5600 kips or 14 kips/ft. This assumed that the floe would fail along its 400 ft-wide contact with which is unlikely.

Most vulnerable to movement by ice were the 5-ft-diamter boulders protruding from the rock ramp which could experience ice forces as great as 140 kips compared to the estimated 7 kips needed to overturn them.

Omaha District completed a 30 percent design hydraulics study in Sept. 2009 that selected a top of headworks elevation of 2012.5 ft based on estimated maximum ice affected stages at the



Return to TOC

project (NWO, 2009). By their calculations, this elevation provided a 95% assurance of containing the 100-year return interval ice jam event. Based on a review of historic ice events, and maximum accumulated freezing degree days (AFDD), a maximum estimated thermal ice thickness of 31 inches estimated[1]. A solid ice cover of this thickness was used in the HEC-RAS model at the 100-yr open water discharge to estimate maximum ice-affected water levels at the project. The HEC-RAS ice jam routine was also used for a range of winter-season discharges. These ice accumulation thicknesses were much greater than the solid cover thickness. Jam thicknesses ranged from about 10 ft just downstream of the dam to 13 ft upstream for the lower discharges and were between about 7 and 8 ft for the 100-year discharge.

**3. Literature Update**

The 30% ice force analysis contains a review of pertinent literature not included or post-dating the 2006 10% design ice force report by CRREL. The most important development since 2006 is a somewhat improved understanding of rock placement methods in terms of resisting rock movement due to ice.

Daly et al, (2008) conducted 1:20 scale physical model tests of ice impacts on a rock breakwater for Barrow Alaska. In the tests, a 1V:1.5H ramp supporting armor stone was shoved against a 5-ft-thick 87 psi ice sheet. They found that by selectively placing the rocks so that they interlocked, the embankment's resistance ice damage was significantly increased.

CETN (1985) defines selected placement as the "careful selection and placement of individual armor stones to achieve a higher degree of interlocking". Canfield (1998) gives specifics on selective stone placement saying that stones should be keyed and fitted, maximizing contact on all sides and recommending a minimum of three points of contact for stones within the same layer.

For example, in one tests by Daly et al (2008), randomly-placed 4-ton stone suffered extensive damage, while the same size rock selectively placed experienced little damage. Assuming a roughly spherical shape and a specific gravity of 2.7, a 4-ton rock would be about 3.6 ft in diameter, considerably less than the 5-ft thickness of the sliding ice sheet.

In previous model tests of ice impacts on riprap by Sodhi et al. (1996), Sodhi et al. (1997) and Sodhi and Donnelly (1999), it was concluded that, to prevent rock movement, the mean size ($D_{50}$) of randomly-placed stone needed to be 2-3 times the ice thickness. This was the basis of the 6-ft rock diameter estimate for the dam in the 10% ice force analysis.

The literature review for the 30 percent design found other pertinent information in terms of ice action on structures. Since it is unlikely that environmental driving forces (current, gravity and wind) are great enough to fail a very large floe or an ice sheet in crushing over a large width, static ice forces due to thermal expansion of the ice sheet typically govern the design of dam faces in northern climates. Morse et al., (2009) gives an ice force range of 6.9 to 10.3 kips/ft used in the design of vertical concrete dam faces in Canada. US Army (1999) gives a slightly higher range of 10-15 kips/ft for ice loadings on dams and rigid structures.

Gerard (1983) describes important river ice processes from ice formation to breakup, focusing on scenarios that produce the greatest ice forces on river structures. In addition to estimates of the ice type, ice thickness and ice strength, an accurate ice force estimate must consider hydraulic

[1] Memo: "Computation of Ice Thickness", provided by NWO.



Return to TOC

factors such as discharge, stage and water velocity. Frazil ice accumulations, though typically not as strong as sheet ice, have been observed to mobilize and exert pressures of approximately 1.7 pounds per square ft (psf). The usual design situation occurs when a strong ice cover is lifted and moved by the current to impact a structure. This usually takes place at the onset of dynamic breakups which are common to the lower Yellowstone.

Discussions with NWO and project operators suggest that the breakup process and ice structure interaction are more complex than this however, sometimes consisting of multiple surges were ice floes become stranded in the channel, overbank areas and even on the dam crest and ramp. Subsequent discharge increases and releases of upstream jams, can remobilize this ice causing large, solid floes to impact the dam crest and ramp over a wide range of discharges and water levels. A site visit was made on January 14, 2011 to gather additional information to better understand the breakup process and the ice-structure interaction. Findings from the trip are described in Appendix A.

Historic breakup ice events have been the greatest single cause of damage to Intake Dam over its 100 year history. For example, the breakup of 1911 destroyed much of the wooden apron and lower sheet pile cutoff wall and the ensuing bed erosion caused nearly the dam to fail. Repairs included the replacement of the wooden sheet pile wall with steel sheet piling and the placement of 3800 cubic yards of armor stone on the apron and downstream. Review of early reports indicate that dam designers underestimated ice effects in the initial structure and much effort and expense was required to remediate these design deficiencies. It was originally thought that ice would pass the dam crest at depths of 3 ft or greater and the 9 plus ft of floe above the apron would provide a “water cushion”, preventing ice floes from hitting the wooden apron. The first few ice runs proved this not to be the case as large ice floes coming over the dam at speeds greater than 10 ft/s tended to pile up and pound against the apron and downstream bed protection for hours on end. Unlike open water conditions where bed shear and potential for rock movement increase with discharge and depth, ice gouging of bed material is more prevalent where the ice run occurs at lower flows and depths. Appendix A provides more detail on the early history of ice damages and remedial measures.

It is important to note that the present day structure at Intake bears little resemblance to the 1910 timber dam with its ogee crest and downstream wooden apron. The estimated 115,000 CY of rock fill that has been added over the years has created a downstream rock ramp filling the apron area and eliminating the backroller. Assuming a river width of 700 and an average layer thickness of 3 ft, the ramp would extend about 1500 ft downstream of the dam not all that different in form from the proposed new ramp.

In addition to direct ice impacts and ice gouging, the presence of a an ice jam or rough ice cover can increase bed shear and cause hydraulic scour as a result of decreased flow area, higher near bed water velocity and increased turbulence. This is mentioned since, should a jam form on the ramp, under-ice scour might mobilize the choke gravel placed between the larger stones. Beltaos, 2001 describes the methods of estimating bed shear in the presence of an ice cover.

**5. Design Details**

The 30% calls for a concrete dam with an upstream slope of 1V:3H. The dam crest is concrete with a trapezoidal cross section with a minimum elevation of 1988.1 ft. For the new downstream rock ramp, a trapezoidal channel with a mild slope (0.002-0.006) is anticipated. The ramp would be constructed of large ($D_{100}$ = 2.5-3.0 ft) rocks with a choke gravel infill material to stabilize the larger rocks. Fig. 1 shows the project plan configuration and bathymetry.

The headworks will have a top elevation of 2012.5 ft. NWO (2009) specifies a target (low flow) water surface elevation of 1991.4 ft, and bottom of headworks elevation of 1981.4. The 6.5 ft diameter fish screens have top and bottom elevations of 1989.9 and 1983.4 ft respectively.

**5. Ice-Hydraulic Processes Related to ice Loads on the Project**

The ice analysis for the 10% design found the lower Yellowstone River to be subject to heavy ice formation, dynamic ice breakups and ice jams. Because the Yellowstone flows northeastward from warmer to colder climate, the ice breakup progresses downstream in a series of jams and releases, and ice jam severity tends to increase in the downstream direction as the breaking front encounters stronger thicker ice. Numerous ice jams and ice jam floods have occurred upstream of Intake at Glendive and downstream at Sidney (Haehnel and Tuthill, 2006). Jams have also been reported at Intake (Appendix A), in the vicinity of the Richland County Line, Elk Island and Savage. All this suggests that the project reach is subject to the dynamic formation and release of ice jams. The most recent severe ice jam event on the Yellowstone occurred in February 7-13, 1996. Fig. 2. shows Yellowstone River discharge and AFDD for that winter at Miles City and Sidney.

On faster flowing rivers such as the Yellowstone, the predominant ice type is frazil which forms as small particles in supercooled open water reaches. The frazil crystals stick together (flocculate) to form floes that tend to increase in size with distance traveled. The floes may accumulate along the channel sides to form border ice or stall in slack areas or channel obstructions to build an ice cover in the upstream direction. Only where water currents are slow ($\leq$ 1 ft/s) can in situ thermal ice growth be expected. In the 1 to 1-1/4 ft/s velocity range, the frazil floes will accumulate edge-to-edge in a process known as juxtaposition. At higher water velocities, the floes will stack or “shove” into a thicker ice accumulation. The HEC-RAS model contains an ice routine that calculates ice accumulation thickness by these processes for both the freezeup and breakup cases.

Average December-January discharge at Sidney gage is 5800 cfs with a standard deviation of 1680 cfs for the 1910-2009 period. A higher freezeup discharge will cause a thicker freezeup ice accumulation, since the water velocities and shear forces on the ice underside will be greater. An extreme case freezeup discharge is defined as the long term December-January average flow plus two standard deviations or 9160 cfs. Fig. 3 shows HEC-RAS calculated water surface profiles and water velocities for the freezeup discharge range indicating the predominant ice formation mode to be juxtaposition and shoving of frazil floes. Figs. 4 and 5 show HEC-RAS simulated freezeup ice covers in the project reach for discharges of 5800 and 9160 cfs respectively. This suggests that it would be possible for an 8-ft-thick frazil ice mass to release from upstream and impact the project at the onset of breakup. Immediately upstream of the dam the water velocity is low enough to allow the in situ growth of thermal ice, the maximum thickness of which can be calculated from AFDD data. On the rock ramp, the calculated under-ice velocity is sufficiently high to allow ice cover thinning by erosion. In this case the under-ice erosion velocity was set at 5 ft/s.

From review of past ice jam events, is estimated that a late-season, thick ice cover such as the one shown in Fig. 5 will release in the project reach at a discharge of about 20 Kcfs[2]. Fig. 6 shows this pre-release condition. It is also assumed that a breakup ice jam in the project area will release

[2] Review of the early project reports indicates that the ice could release once depth at the dam crest exceeded 3 ft at river flows as low as 9,000 cfs.



Return to TOC

at a discharge of about 40 Kcfs[3]. This is based on the Sidney Gage data that give the annual peak on 3/14/1996 of 19.48 ft (instantaneous peak Q = 30 Kcfs) as ice-affected while the 3/6/1994 peak of 24.03 ft (peak Q=75 Kcfs) is listed as open water. In 1994 ice jams were reported at many locations on the lower Yellowstone, but the river may have been clear of ice by the time of the instantaneous peak on 3/6. HEC-RAS was used to calculate breakup ice jam profiles in the vicinity of the project at discharges of 30 and 40 Kcfs (Figs. 7 and 8 respectively).

Once the ice cover releases, it is assumed that the floes and thicker frazil ice masses travel downstream and impact the project at approximately open water surface elevations (WSE). Open water surface and velocity profiles were calculated for discharges of 20, 40, 60, 80 and 100 Kcfs (Fig. 9) These elevations were used to estimate the height range that the ice floes and ice masses impacted the headworks and dam crest. The WSE at dam crest for 20 Kcfs open water flow conditions was approximately 1995 ft (Fig. 10). It is possible that the floes and frazil ice masses could impact the headworks higher elevations under post breakup conditions of increasing discharge.

**6. Estimation of Ice Forces**

Ice forces and ice pressures were estimated for the dam crest the headworks and diversion inlets and the rock ramp. In the original analysis, it was assumed that the maximum ice forces would occur at the onset of ice breakup when the moving ice is the strongest and floe size the largest as suggested by Gerard (1983). It was also assumed that the lower discharge threshold for breakup on this part of the Yellowstone is about 20 Kcfs and the upper limit before ice jams release is about 40 Kcfs. Information gathered on the Jan. 14, 2011 trip suggest that the discharge range for breakup ice impacting the structure is much larger however, on the order of 9000 to above 100,000 cfs (Appendix A).

Two scenarios are considered. The first was for a large, 30-inch-thick, 167 psi ice floe impacting the headworks and dam crest[4]. The 167 psi (24 KSF) effective ice strength was taken from AASTO (1998) "where ice breakup occurs at melting temperatures but the ice moves in large pieces and is internally sound". The 30 inch thickness estimate was based on 31-inch maximum ice thickness calculation provided by NWO. The second scenario considered an 8-ft-thick frazil ice mass releasing at 20 Kcfs and impacting the headworks and dam crest at the onset of ice breakup.

In this analysis, it is assumed that the rock ramp will be constructed of large rocks ($D_{100}$ = 2.5-3.0 ft) with smaller size rock and choke gravel in between. The ice force estimates assume a 30-inch-thick 167 psi floe and an 8-ft-thick frazil ice mass impacts the surface formed by the larger rocks.

Movement of the smaller size infill material, because it lies below the ice-boulder contact, was assumed to be less susceptible to displacement by impacts by the large floes, provided the larger rocks are not displaced. Under ice hydraulic scour is a possibility however and shear on the ramp was calculated with a breakup ice jam in place at an assumed pre-release river discharge of 40 Kcfs (Figs. 8 &13).

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[3] These ice cover and breakup ice jam release discharges are very approximate and will vary greatly depending on ice thickness and ice strength.

[4] In a conference call with NOW concern was expressed that the 110 psi ice strength "where breakup occurs at melting temperatures and the ice structure is somewhat disintegrated" was un-conservative. The 167 psi ice strength applies to "where breakup of major ice movement occurs at melting temperatures but the ice moves in large pieces and is internally sound."



Return to TOC

6.1. Ice Forces on Dam Crest

*Impact by large solid ice floes*

The ice forces due to a large floe impacting the dam crest were estimated following the methods prescribed in AASHTO (1998). The maximum ice force applied to the structure is limited either the momentum of the floe or failure of the ice and the code accounts for both of these aspects. First the ice force associated with ice failure is computed using

$$F_c = \left(\frac{5h}{w} + 1\right)^{0.5} phw \tag{1}$$

$$F_b = \left(\frac{0.5}{\tan(\phi - 15)}\right) ph^2 \qquad \text{for } \phi > 15° \tag{2}$$

where $F_c$ is the force exerted on the structure when the ice fails in crushing and $F_b$ is the force if the ice fails in bending. Also, $w$ is the length of the ice-structure line of interaction; if the structure is narrow (e.g. a pier), $w$ is the width of the structure. If the structure is wide, $w$ is the approximate diameter of the floe. $p$ is the effective pressure the ice can exert on the structure (an indication of the ice strength), $h$ is the ice thickness and $\phi$ is the angle between the structure face and vertical.

The lesser of the two forces, $F_c$ or $F_b$, is the design force for the structure. In cases where the $w/h \geq 6$, or $\phi < 15°$ then $F_b$ is not computed and it is assumed that the ice fails in crushing and $F_c$ is used. In the case of a large floe impacting the dam crest, w >> h so only crushing failure $F_c$ applies.

If an ice floe is small, the momentum of the floe is not sufficient to cause the ice to fail on impact. In this case it is the momentum of the floe that determines the impact force. AASHTO (1998) accounts for this by applying a load reduction factor, $K_t$, to the design load computed from either eqs. (2) or (3) above. The load reduction factor, as shown in Table 1, is a function of $A/h^2$, where $A$ is the plan area of the floe. The code stipulates that $K_t$ of 0.5 is the minimum value that can be used.

The upstream face of the Intake Dam is approximately 600 ft wide. A reasonable maximum floe size is 2/3 the river width or about 400 ft (Fig. 11). A maximum sheet ice thickness of 30 in was assumed. A $p$ value of of 167 psi was used for reasons explained above. For a floe of this size $A/h^2 > 1000$, thus $K_t = 1.0$. In the case of ice floes impacting inclined structures, a reduction coefficient can be used. For the 1V : 3H face of the intake dam (horizontal angle = 32°) the reduction coefficient is 0.5. (US Army, 1999).

Using these input values in eq. 2 gives

$$F_c = 12{,}200 \text{ kips} / 400 \text{ ft} = 31 \text{ kips/ft}$$

The load that the dam face must withstand due to the impact of a large solid ice floe would be 12,000 kips or 31 kips/ft, assuming the floe fails along its entire 400 ft width which is extremely unlikely. More likely, the width of interaction and total ice force would be much less. If the floe crushed along half its width, the maximum load on the dam would be about 15 kips/ft which



Return to TOC

corresponds with the high end of the range given in the design literature. It was originally assumed that the top of the floe would be slightly above the 20 Kcfs water surface elevation of 1995 ft and the bottom of the floe at about 1993 ft. Under this scenario, the floe would contact the dam crest only near its edges which are at an elevation of about 1992. In light on the findings of the Jan 2011 field visit, moving ice floes can impact the dam face and abutments (including the headworks) over a much wider range of elevations, say 1985 to 2000 ft which would correspond to a 10-80 Kcfs flow range.

**Table 1**. Load reduction factors to account for small floes (AASHTO 1998).

| $A/h^2$ | Load reduction factor, $K_t$ |
|---|---|
| 1000 | 1.0 |
| 500 | 0.9 |
| 200 | 0.7 |
| 100 | 0.6 |
| 50 | 0.5 |

*Impact by a thick frazil ice mass*

From the Literature (Gerard, 1983 and AASHTO, 1998) large frazil ice masses moving against structures can exert shear forces as great as 2 kips/ft$^2$ (KSF). Classic ice jam theory assumes the coefficient of friction for sliding or jammed ice to be 1, so shear forces and normal forces on the dam face would be roughly equivalent. As in the solid ice floe case, the frazil ice mass would be expected to impact the structure over a wide range of elevations between 1985 and 2000 ft.

6.2. Ice Forces on the Headworks

*Impact by large solid ice floes*

In the case of the headworks, it was assumed that a 30-inch thick 167 psi floe, 200 ft in diameter impacts the headworks at a 20 º angle (Fig.12). At the 1998 ft water surface elevation, the bottom of the floe will be 1995.7 ft, well above the 1989.4 ft tops of the rectangular openings.

By the same steps outlined in Section 6.1, the impact force of the floe on the headworks at a 20 º angle is 4200 kips. In the case of ice impacting a vertical face ($\phi = 0 < 15^o$) AASHTO (1998) says that the failure will occur in crushing rather than in bending. Distributed over 200 ft, this amounts to 21 kips/ft. By the above argument, it is very unlikely that the floe would fail along its entire width and the high end of the design literature of 15 kips/ft is recommended.

*Impact by a thick frazil ice mass*

An 8-ft-thick frazil ice mass exerting 2 kips/ ft$^2$ could theoretically exert a force of 16 kips/ft along the headworks. Based on the upper-limit value from the ice force literature, 15 kip/ft is recommended for both the solid floe and frazil ice mass cases. At the 1995 ft water surface elevation, the bottom of 8-ft-thick frazil ice mass would be at about 1988 ft, slightly below the 1989.4 ft tops of the fish screen openings. Accounts by locals indicate that the ice can act on the existing dam at elevations at or above 2000 ft however[5]. It is therefore recommended that the design load on the headworks above the 1995 ft elevation and below the 1988 ft elevation be 5 kips/ft.

[5] Correspondence with Lyle Peterson 2/10/10, Structural Engineer, NWO.

*Need and feasibility of ice protection features for headworks*

Structures built in the channel to protect the headworks from ice would experience ice loads at least as great as those calculated for the headworks. These features would likely need to be bottom-founded such as dolphins, sheet pile cells or fixed shear booms. Conventional floating ice boom, with a maximum ice restraint capacity of about 2 kips/ft would not restrain breakup ice on the Yellowstone. Because the protective structures would be out in the channel rather than along the side, they would experience direct rather than oblique ice impacts and higher ice loadings than the headworks. From the above discussion it is estimated that the ice will act on the headworks over a 12-ft height range from about 1985 to 2000 ft (8 to 20 ft above the bed) and the moments on the protective structure would be great.

The most economical solution may be to design the headworks to withstand the estimated ice loads rather than rely on protective structures out in the channel to deflect or absorb the ice impacts.

6. 3. Ice Forces and Riprap Design for Ramp

Analysis of ice forces on the rock ramp and riprap design includes a review of existing design guidance and literature on case studies of similar projects. Although coastal revetments have been designed resist extreme ice ride-up and large riprap has been used to protect revetments and bridge abutments on rivers with dynamic ice runs, no instances were found where a such a large area of river bed has been protected from ice impacts as the proposed Intake rock ramp.

Due to this lack of guidance, the 10% design used the conservative rule of thumb that the average riprap diameter $D_{50}$ should be twice the maximum expected ice thickness leading to a value of about 6 ft Sodhi et al. (1996), Sodhi et al. (1997) and Sodhi and Donnelly (1999). This guidance was based on physical model tests of ice rideup on riprap revetments sloped less than 3H:1V where the maximum damage occurs when the ice sheet pushes between the piled ice rubble and the riprap to dislodge individual rocks. Assuming layer thickness $T = 1.5 \times D_{50}$ , the rock blanket would need to be 9 ft-thick. From economic and construction reasons, this design was deemed infeasible.

It was then speculated that the $D_{50}$ could be reduced by selectively placed armor stone as described by Daly et al. 2008. In this 1:20 physical model study, selectively placed 3.6 ft diameter armor stone withstood ride-up of a 5-ft-thick ice sheet on a 1.5H:1V breakwater proposed for Barrow, AK. This approach was deemed unfeasible for the Intake ramp for two reasons. First, the armor stone being uniformly graded, would be less well suited to resist damage by hydraulic shear than conventional riprap which is better graded and more angular, allowing the pieces to interlock. Second, the estimated cost of individually placing large rock over the 700 ft ×1600 ft area was considered prohibitive.

The above cited cases differ from the Intake ramp situation in several ways. First, unlike a revetment, the rock ramp at Intake will be relatively flat [6] and the ice is expected to act more or

[6] The longitudinal slope of the ramp will increase by 0.2% increments of from 0.2% near the crest to 0.6% near the bottom over its 1600 ft length. The channel will be trapezoidal in cross section with a 70-ft-wide thalweg and gentle side slopes ranging from 1 to 3 %.

less parallel to the ramp surface. Second, the Intake ramp bed protection will be subject to considerable hydraulic shear and lift forces during open water flood flows.

In the Intake ramp case, the ice will interact with the ramp in at least three ways. The first is under-ice hydraulic scour where the ice cover occupies a large portion of the flow area potentially increasing near-bed water velocity, turbulence and bed shear. Ice adhesion to bed material and uplift due to stage increase is also possible. The third and potentially most destructive mode is gouging of the riprap by moving ice during an ice run. This is the process that likely damaged the original dam apron and downstream rock protection in 1911 (Appendix A). Ice-hydraulic shear, ice uplift and ice gouging are considered in this analysis

*HEC-RAS Analysis of potential ice impacts to ramp*

The hydraulic and ice conditions at in the ramp reach were re-examined to better understand ice structure interaction by the above described modes. From the historical review of ice jams on the lower Yellowstone, it appears that most ice jams occur in the 20-40 Kcfs flow range. Ice runs can occur over a wider range of flows. An interesting note is that the daily average at Sidney for the damaging ice run of 3/9/1911 was only 9000 cfs (Appendix A) but this may be an outlier. Ice jams were simulated in the Intake reach for flows of 9160, 20,000 and 40,000 cfs using HEC-RAS and the proposed rock ramp geometry. Default ice jam parameters were ice jam internal strength = 45°; ice jam porosity = 0.4, under-ice erosion velocity = 5 ft/s. Figures 6.3.1-6.3.15 show ice jam profiles, under-ice water velocities and ice jam cross sections taken at locations on the ramp 110, 744 and 1340 ft below the dam crest.

In the 9160 cfs jam case, the maximum ice thickness is about 10 ft and the highest under ice water velocities about 3.5 ft/s. For the 20,000 cfs jam, ice thickness near the downstream end of the ramp reached 12 ft and maximum velocity was again about 3.5 ft/s. For the 40,000 cfs jam, ice thickness reached 15 ft and maximum water velocity was about 3.3 ft/s. In the 20 and 40 Kcfs cases the right flood plain is mostly inundated which limited stage rise in the main channel. Water velocities with a jam in place on the ramp are relatively mild (≤ 4 ft/s) due the staging effect of the jam on the ramp and downstream. The release of this downstream jam would trigger a rapid drop in upstream stage, high water velocities and potential gouging of the bed as ice on the ramp and the upstream river moved out. This “pulling the plug” phenomenon occurred during the 3/28/1912 ice-out at Intake (Appendix A).

Following jam release, the river +is assumed to return to more-or-less open water flow conditions during the ice run past the project. Figures 6.3.16 and 6.3.17 show water surface profiles and average water velocities for open water discharges of 9160, 20,000, 40,000 and 70,000 cfs. In the 40 and 70 Kcfs cases average water velocities on the ramp are in the 8-10 ft/s range and depths exceed 10 ft in general agreement with the BR model. If the river were conveying a heavy ice run, water depths might be a little higher and average velocities lower for a given discharge, but the HEC-RAS results provide a good approximation of hydraulic ice conditions.

Figures 6.3.18-6.3.22 show cross sections at locations along the ramp 94, 386, 744, 1047 and 1341 ft below the dam crest for the breakup flow range. The blue symbols represent ice floes that draw 2 ft at the 20 Kcfs discharge. This ice thickness and discharge would be fairly common during an ice run on the lower Yellowstone. The figures show that under these conditions, the side slopes of the rock ramp would experience impacts from the moving floes. Several factors would produce more severe conditions in terms of ice gouging. First would be the tendency for the moving ice to bunch up or raft to produce multi-layer thicknesses in portions of the ram area. A 4-ft thick accumulation of moving floes would potentially impact a much larger portion of the ramp area at the 20 Kcfs flow level. Second, based on the 1911 breakup, ice may run past the project at discharges lower than 20Kcfs cfs. In this lower discharge case, a 2-ft average floe thickness would potentially impact much of the ramp area than at the assumed 20 Kcfs lower threshold for breakup.

Also important to consider is the duration of the ice runs which can be quite long. During a heavy ice year, much ice must pass the Intake project before the river clears out. For example, the initial 3/12/1911 ice run occurred over a 5.5 hour period followed by a second run from farther upstream that went on from 6 pm to "late into the night". In light of this, ice damages to the bed protection may occur from multiple small hits over a large area rather than a few large ones.

Finally, the hydrograph peak associated with river breakup may be followed by a larger open water peak. If the ramp is damaged by moving ice during the initial crest, the bed protection may be more vulnerable to hydraulic scour during the open water peak that follows.

*Under-ice Hydraulic Shear on the Rock Ramp*

Under-ice bed shear was calculated for a breakup ice jam at the structure at an assumed maximum discharge of 40 Kcfs (Fig. 13.). It is assumed that discharges in excess of 40 Kcfs will cause the ice jam to release, and open water bed shear calculations would then be appropriate. Total shear $\tau$ was estimated from the depth-slope product based HEC-RAS calculated values

$$\tau = \gamma y_{ui} S \qquad (3)$$

where $\gamma$ = the unit weight of water, $y_{ui}$ is the under ice depth and $S$ is the water surface slope. For flow beneath an ice cover the total water shear is distributed between the underside of the ice cover and the river bed. Methods for calculating under-iced shear and bed shear are described in Tuthill et al, (2009). In flow beneath an ice cover, the maximum water velocity typically occurs near the mid depth (within 40-60 percent of the total depth) and the under ice hydraulic radius is divided into ice-affected and bed-affected portions, depending on the roughness of the ice cover and the bed material. As a first-cut estimate we will assume that bed shear accounts for about half of the total shear, average under-ice bed shear for rock ramp = 0.7 psf with a maximum of 2.0 psf, and a minimum of 0.3 psf. (see attached spreadsheet). This shear force is assumed to act on the both the larger rocks and to a lesser extent the smaller infill material in the concavities between the rocks. In the case of the smaller material, a shear force of 2.0 psf could initiate movement of material up to 5 inches in diameter by the the Meyer-Peter criteria for the initiation of motion:

$$\frac{\tau_c}{(S_s - 1)\gamma D} = 0.047 \qquad (4)$$

Where $\tau_c$ is the critcal shear stress $S_s$ is the specific weight of the rock (assumed 2.65), $\gamma$ = the unit weight of water (= 62.4 lb/ft$^3$) and $D$ is the representative diameter of the infill material.

As a comparison, the bed shear resulting from an open water discharge of 70,000 was calculated at about 3 psf , using inputs of $S$ = 0.005 and $R$ = 10 ft. This indicates that bed protection designed to resist movement of under extreme open water conditions will be adequate for hydraulic bed shear with a stationary ice jam on the ramp.



Return to TOC

*Ice freezup forces and lifting of large rock or infill material.*

For the large rocks on the ramp, sheet ice or thick frazil ice masses may adhere to the large rocks particularly near the edges of the ice cover. With the onset of breakup, the water and ice level in the channel will rise. At some point the ice cover will fracture free from the channel edges and move downstream. The concern is that buoyant force of the ice will be great enough to pull rocks from the ramp. Calculations indicate that the submerged weight of the rocks is greater than the buoyant force of the adhered ice, even in the case of an 8-ft-thick frazil ice mass. The adhered ice when it moves will likely remove some of the infill material.

*Minimum rock size needed to withstand ice forces on ramp*

The approach taken was to sizing the bed protection rock size to resist movement due to ice gouging had three parts. The first step was to size riprap bed protection to withstand extreme open water conditions using method described in US Army (1994) and NCHRP (2006) and applying rules thumb to adjust the design for impacts of ice and debris. The second step was to compare the preliminary riprap design for the Intake ramp to bed protection on others rivers with extreme ice action. A final step was to review hydro-meteorological data associated with historic ice-outs on the lower Yellowstone to estimate the frequency of ice events that could potentially damage the bed protection.

A preliminary bed protection design for extreme open water conditions was developed using methods described in US Army (1994). Worst case open water hydraulic conditions of water velocity $V$ = 12 ft/s and depth $d$ =12 ft were taken from the "Ramp Passage Optimization" Report of the BR physical model study dated 11/4/2010.

Using Eq. 3-3, and the inputs listed in Table 2 gives a $D_{30}$ of 0.77 ft. Assuming a $D_{85}/D_{15}$ ratio of 1.9 and a size distribution similar to those in Table C8.1 of NCHRP (2006) gives a $D_{50}$ of 1.0 ft and a $D_{100}$ of 1.8 ft. In the initial open water case, the recommended minimum factor of safety $C_s$ of 1.1 was used. The minimum thickness T* is the greater of the $D_{100}$ or 1.5 × the $D_{50.}$ Assuming a final blanket thickness of about 4 ft gives a thickness coefficient $C_t$ of 0.8. US Army, (1994) gives the rule of thumb that "for riprap subject to attack by large floating debris (the layer) thickness should be increased by 6-12 in, accompanied by appropriate increase in stone size". This guidance is reiterated in Province of British Columbia (2000). Adding the maximum of 12 inches would increase the layer thickness from 2.7 to 3.7 ft and proportionally, increase the $D_{50}$ to 1.3 ft or 16 in. This rock size distribution is similar to the Class IV riprap described in Table C8.1 of NCHRP (2006) and is not that different to the preliminary riprap design being developed by NWO.

**Table 2.**

| Intake Dam Ramp Riprap Design using EM 1110-2-1601 | | |
|---|---|---|
| | | |
| Channel Width | 600 | ft |
| Radius of curvature | 1200 | ft |
| Local flow depth d | 12 | ft |
| Average water velocity V | 12 | ft/s |
| Unit Wt of water | 62.4 | lb/ft3 |
| Angle of side slope | 3 | deg |
| Side slope correction K1 | 0.99 | |
| Unit wt of rock | 165 | lb/ft3 |
| Factor of safety Sf | 1.1 | |
| Stability coefficient for incipient failure Cs | 0.375 | |
| Vertical velocity distribution coefficient Cv | 1.22 | |
| Thickness coefficient Ct | 0.8 | |
| Acceleration due to gravity | 32.2 | ft/s3 |
| | | |
| D30 | 0.77 | ft |
| Assumed D85/D15 | 1.9 | |
| D15 | 0.7 | ft |
| D50 | 1.0 | ft |
| D85 | 1.3 | ft |
| D100 | 1.8 | ft |
| 2*D50 | 1.9 | ft |
| 1.5*D100 | 2.7 | ft |
| Layer Thickness | 2.7 | ft |
| | | |
| Increased layer thickness due to ice impacts | 1 | ft |
| Increased rock size due to ice impacts | 1.4 | times |
| Assumed D85/D15 | 1.9 | |
| D15 | 0.9 | ft |
| D50 | 1.3 | ft |
| D85 | 1.7 | ft |
| D100 | 2.5 | ft |
| 2*D50 | 2.6 | ft |
| 1.5*D100 | 3.7 | ft |
| Layer Thickness | 3.7 | ft |

*Riprap designs at other projects with severe ice action*

Several bed and bank protection projects on rivers with extreme ice action are described for comparison to the Intake ramp. The first a guide bank and embankment spur design for the Tanana River Alaska Railroad Crossing at Salcha, AK. The CRREL ice jam database contains numerous reports of severe ice runs and ice jams in this section of the Tanana River, indicating ice action comparable to the Yellowstone at Intake. The guide bank is an angled rock spur that directs flow around the left abutment of the main bridge span. It consists of a raised berm and a flat-lying 4-ft-thick riprap blanket that extends 100 ft out into the main channel. This riprap blanket, by its location will be subject to the full force of ice action in the river. The design developed by HDR (Doeing and Swift, 2009) calls for AKDOT Class III and IV riprap in this area. Assuming AKDOT Class IV riprap is similar to the Class IV riprap described in Table C8.1 of NCHRP (2006), the $D_{50}$ would be 15 inches or 1.3 ft and the $D_{100}$ about 2.2 ft.



Return to TOC

A second location subject to extreme ice impacts is the Penobscot River at Bangor, Maine. Here the river banks are lined with riprap revetments with a $D_{50}$ on the order of 1.5 ft and a $D_{100}$ of nearly 3 ft. The banks slope at about 2.5H: 1:V. Based on general observations of bank protection and rock structures along northern New England rivers with dynamic ice runs, the average riprap size to withstand the ice appears to be roughly equivalent to the maximum ice thicknesses, which falls in the 1.5 – 2 ft range. Well graded riprap bedded in clayey banks appears to survive better than uniformly graded riprap.

*Frequency of ice events that could potentially damage the bed protection.*

The above analysis suggests that the rock may experience some damage during years with extreme breakup ice runs. This section reviews hydro-meteorological in an effort estimate the frequency of events that could potentially damage the bed protection on the ramp. These data are listed in Table 3. In the report "Computation of Ice Thickness: Yellowstone River at Glendive, MT", NWO provided ice-out dates at Glendive from 1969-2000. Additional ice-out dates were estimated from daily average discharges at Glendive and Sidney for the years of 2001-2008. The LYIP records provided detailed information on the ice breakups of 1910, 1911 and 1912 at Intake (Attachment A). The Years with known ice events on the lower Yellowstone are highlighted in yellow along with dates and daily average discharges at the Sidney Gage. For all these events, with the exception of 1911, daily average discharge $Q_b$ is $\geq$ 25,000 cfs and calculated ice thickness $T_i \geq 20$ in.[7] The list of known ice events is relatively uncertain as many years with severe ice runs may be missing from the record. Searching the list for other years where $Q_b \geq$ 25,000 *and* $T_i \geq 20$ in produced and additional 5 probable event years between 1969 and 2008, bringing the total to 8 for the 39 year period of record. By this reasoning the annual probability of a severe ice event on the lower Yellowstone is 8/49=16% , or a recurrence interval of about 6 years.

[7] Ice thickness is calculated as $0.5 \times \sqrt{\text{maximum net AFDD}}$



Return to TOC

**Table 3**. Calculated ice thickness and discharge for ice out events on the lower Yellowstone River, 1910-2008.

| Year | Maximum Net AFDD | Calculated IceThick. (in) | Observed Iceout Date at Glendive | Estimated Iceout Date at Glendive | Average Discarge (cfs) on Iceout Date at Glendive | at Sidney |
|---|---|---|---|---|---|---|
| 2008 | 2098 | 22.9 | | 30-Mar | 5,700 | |
| 2007 | 1465 | 19.1 | | 16-Mar | 8,000 | |
| 2006 | 1175 | 17.1 | | 13-Mar | 6,000 | |
| 2005 | 771 | 13.9 | | 7-Mar | 4,850 | |
| 2004 | 967 | 15.5 | | 20-Mar | 5,400 | |
| 2003 | 1413 | 18.8 | | 17-Mar | 29,500 | 28,000 |
| 2002 | 1364 | 18.5 | | 12-Apr | | 5,600 |
| 2001 | 1332 | 18.2 | | 25-Mar | | 8,000 |
| 2000 | 1843 | 21.5 | 4-Mar | | | 6,600 |
| 1999 | 945 | 15.4 | 3-Mar | | | 9,400 |
| 1998 | 1168 | 17.1 | 21-Mar | | | 9,750 |
| 1997 | 2211 | 23.5 | 20-Mar | | | 16,000 |
| 1996 | 2167 | 23.3 | 16-Mar | | | 25,000 |
| 1995 | 1302 | 18.0 | 14-Mar | | | 4,500 |
| 1994 | 1650 | 20.3 | 5-Mar | | | 40,000 |
| 1993 | 1717 | 20.7 | 8-Mar | | | 11,500 |
| 1992 | 484 | 11.0 | 28-Feb | | | 6,200 |
| 1991 | 1221 | 17.5 | 15-Mar | | | 7,000 |
| 1990 | 929 | 15.2 | 5-Mar | | | 9,500 |
| 1989 | 1851 | 21.5 | 27-Mar | | | 20,000 |
| 1988 | 1268 | 17.8 | 21-Mar | | | 7,500 |
| 1987 | 550 | 11.7 | 5-Mar | | | 9,000 |
| 1986 | 1905 | 21.8 | 27-Feb | | | 25,000 |
| 1985 | 1891 | 21.7 | 24-Mar | | | 10,000 |
| 1984 | 1639 | 20.2 | 18-Feb | | | 8,800 |
| 1983 | 846 | 14.5 | 19-Feb | | | 13,000 |
| 1982 | 2098 | 22.9 | 21-Feb | | | 16,000 |
| 1981 | 759 | 13.8 | 22-Feb | | | 10,500 |
| 1980 | 1242 | 17.6 | 27-Mar | | | 9,800 |
| 1979 | 2808 | 26.5 | 17-Mar | | | 35,000 |
| 1978 | 2396 | 24.5 | 21-Mar | | | 39,000 |
| 1977 | 1453 | 19.1 | 16-Mar | | | 6,000 |
| 1976 | 1278 | 17.9 | 19-Mar | | | 11,500 |
| 1975 | 1158 | 17.0 | 11-Apr | | | 13,000 |
| 1974 | 1430 | 18.9 | 6-Mar | | | 8,300 |
| 1973 | 1234 | 17.6 | 10-Mar | | | 12,000 |
| 1972 | 2190 | 23.4 | 12-Mar | | | 39,000 |
| 1971 | 1905 | 21.8 | 16-Feb | | | 39,000 |
| 1970 | 1472 | 19.2 | 1-Apr | | | 7,000 |
| 1969 | 2448 | 24.7 | 20-Mar | | | 25,000 |
| 1962 | 1929 | 22.0 | | 18-Feb | | 30,000 |
| 1959 | 1774 | 21.1 | | 20-Mar | | 42,000 |
| 1943 | 2138 | 23.1 | | 21-Feb | | 50,000 |
| 1936 | 2968 | 27.2 | | 6-Mar | | 27,000 |
| 1912 | 2524 | 25.1 | 28-Mar | | | 83,200 |
| 1911 | 1811 | 21.3 | 3-Mar | | | 9,000 |
| 1910 | 2064 | 22.7 | 4-Mar | | | 30,000 |
| | | | Observed Ice Out Date at Intake | | | |

*Discussion*

The 30% riprap design for the rock ramp is based on existing design guidance. The total factor of safety is 1.5, 1.1 of which was the initial factor of safety in Eq. 3-3 and 1.4 by adding an additional 12 in to the layer thickness and scaling up the rock size proportionally. Although riprap revetments have been built to survive extreme ice action along northern rivers, no precedent was found for where an entire river channel is protected in a way similar to the proposed rock ramp at Intake. Due to the lack of design guidance specific to the Intake ramp case and the lack of comparable bed protection designs of this scale and cost, the level of confidence in the 30% design is well below 100%.



Return to TOC

The existing design guidance closest to the Intake case is for direct ice rideup on riprap revetments where the recommended $D_{50}$ is twice the maximum ice thickness. From practical and cost standpoints this design is not feasible for the intake ramp.

The 30% design presented in this report calls for a $D_{50} \geq 1.3$ ft, $D_{100} \geq 2.5$ ft and a blanket thickness of at least 4 ft. In support of this less conservative design are several factors. First, the slope of the ramp surface is very small (≤ 0.06% longitudinally and ≤ 3% on the side slopes). Second, the surface of riprap on the ramp will be fairly smooth. Provided the smaller infill material is not removed, this will provide a better sliding surface for ice floes reducing the forces on the bed protection.

Concerns and unknowns remain. Some damage and O&M is to be expected following extreme ice events. A first concern is the potential the cumulative ice impacts of long duration ice runs affecting a large area of the ramp, rather than a fewer large hits over a more limited area. A second concern is the tendency for bunching up and rafting of ice floes that increases the potential severity of ice gouging of the bed. A third is the fact that ice runs can occur at relatively low discharge and stages which, based on the 1911, experience increases the likelihood of ice damages to the ramp.

**Table 4. Summary of Estimated Ice Forces**

| *Project Component* | *Mechanism* | *Ice Load* |
|---|---|---|
| Dam Crest | Direct impact by large ice floes and static forces due to thermal expansion of the cover | 15 kips/ft |
| Headworks 1992.7-1995.2’ | Crushing impact by strong ice floes | 15 kips/ft |
| Headworks 1987.6-1995.6’ | Stresses from moving frazil ice mass | 10 kips/ ft |
| Headworks › 1995’ and ‹ 1988’ | Stresses from moving frazil ice mass | 5 kips/ft |
| Rock Ramp Riprap (assuming 165 pcf stone) | Sliding of thick frazil ice masses | 460 psf |
| | Impact and gouging by large ice floes | $D_{50} \geq 1.3$ ft<br>$D_{100} \geq 2.5$ ft<br>$T \geq 4.0$ ft |
| Rock Ramp Infill Material | Under ice hydraulic scour, | 2.0 psf |

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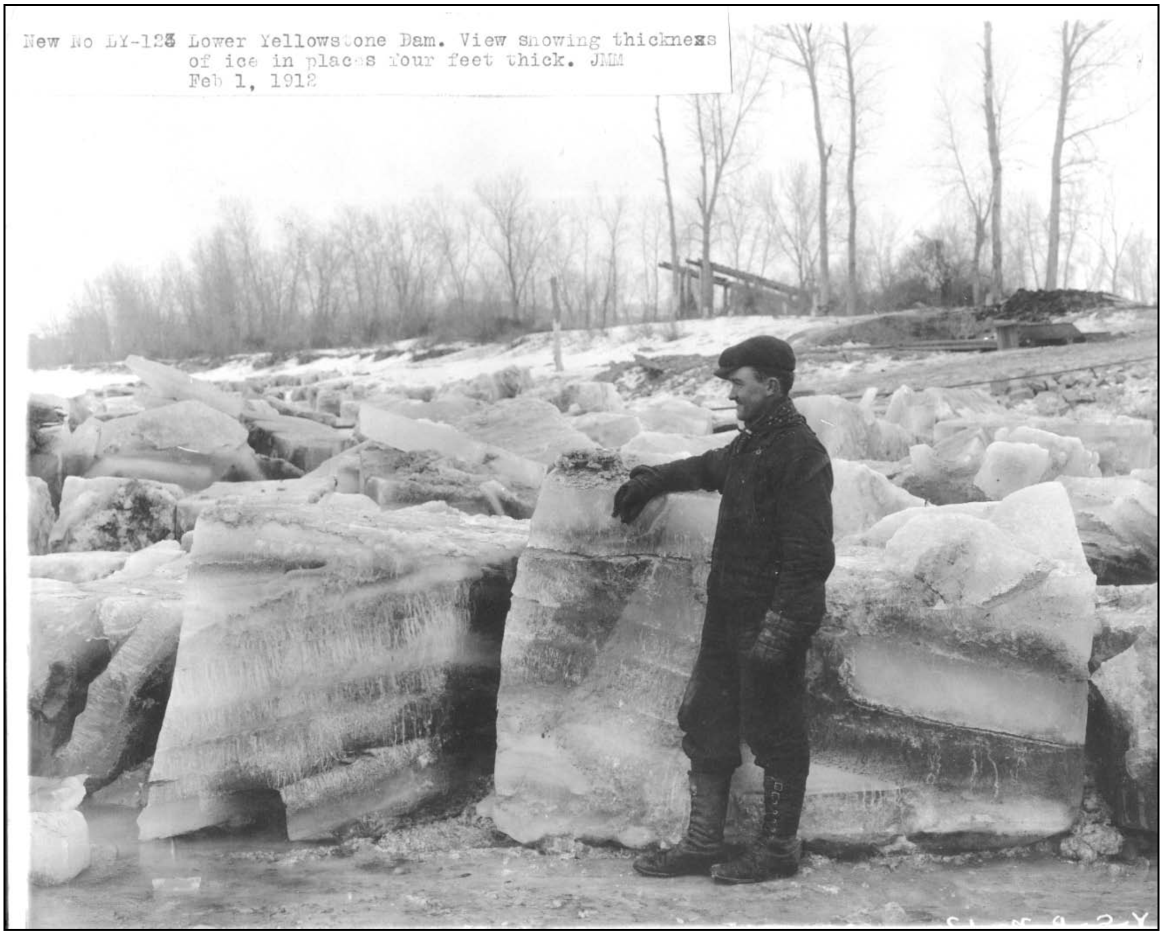
Ice run at newly completed Intake Dam on 3/4/1910



Return to TOC


New No LY-125 Lower Yellowstone Dam. View showing thicknes
of ice in places four feet thick. JMM
Feb 1, 1912

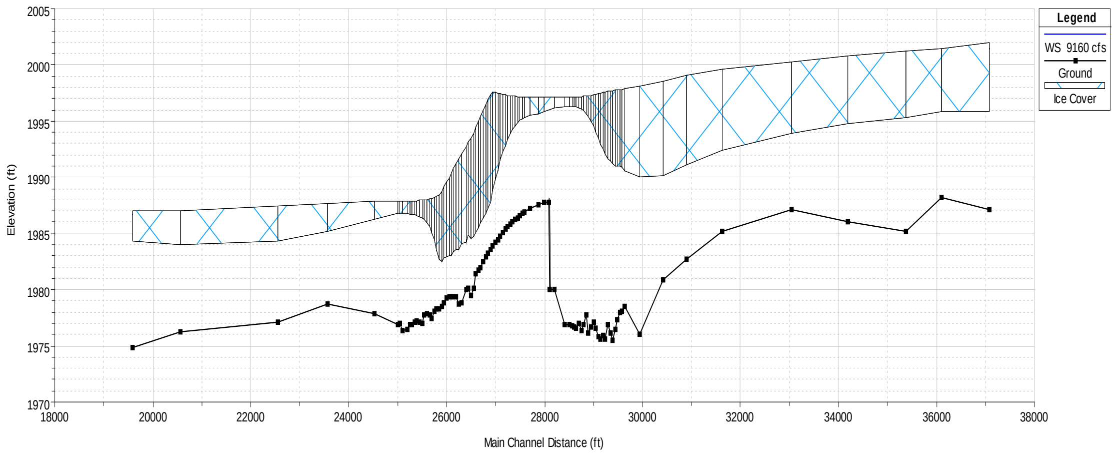



Figure 6.1.1. Ice jam profile. Q=9160 cfs

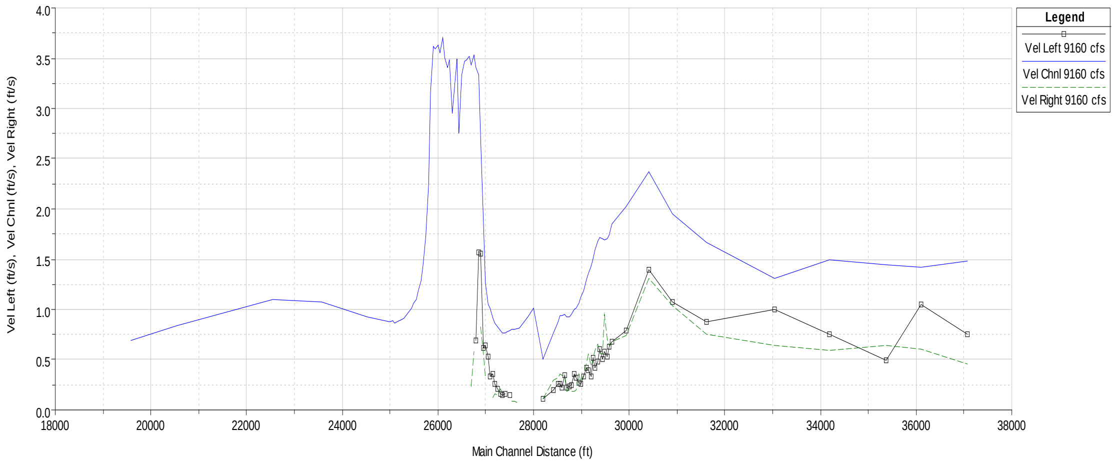



Figure 6.1.2. Water velocity beneath ice jam. Q=9160 cfs.



Return to TOC

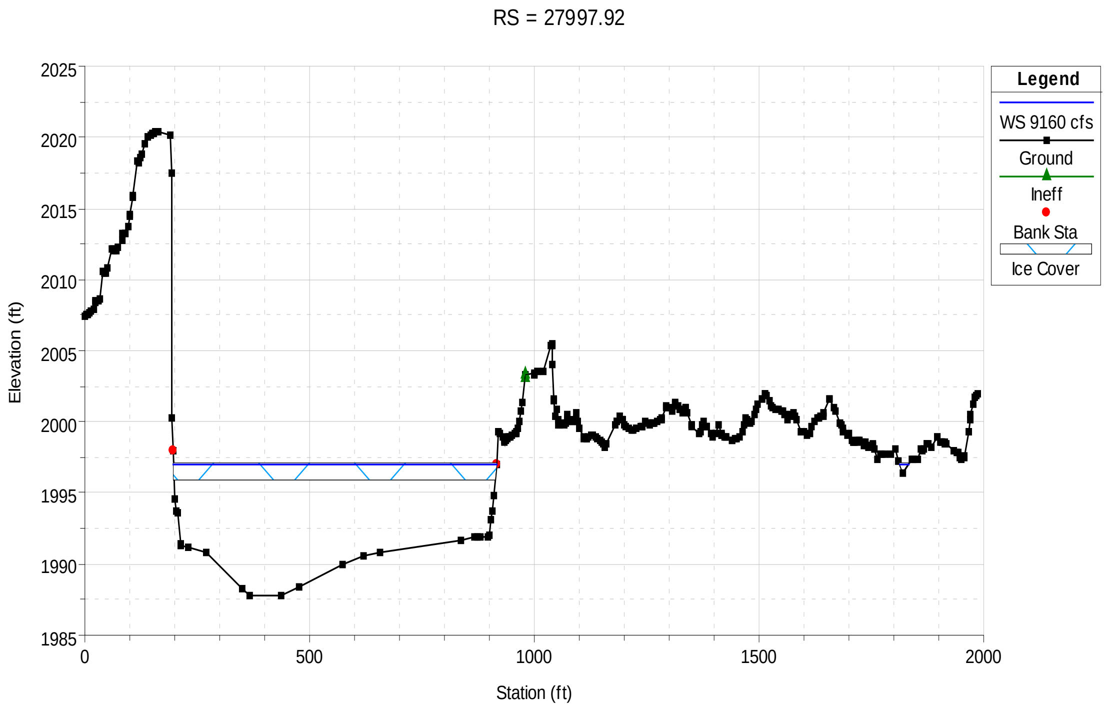



Figure 6.1.3. Cross section of ramp 110 ft below crest with ice jam. Q=9160 .

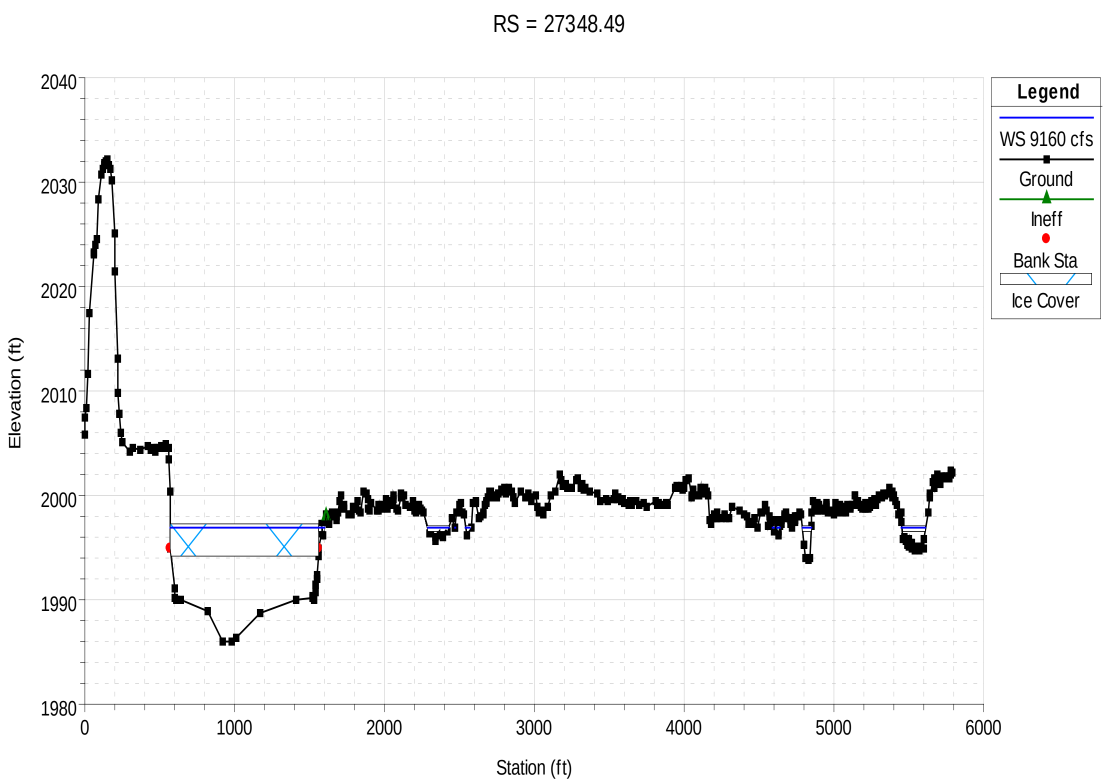



Figure 6.1.4. Cross section of ramp 744 ft below crest with ice jam. Q = 9160.



Return to TOC

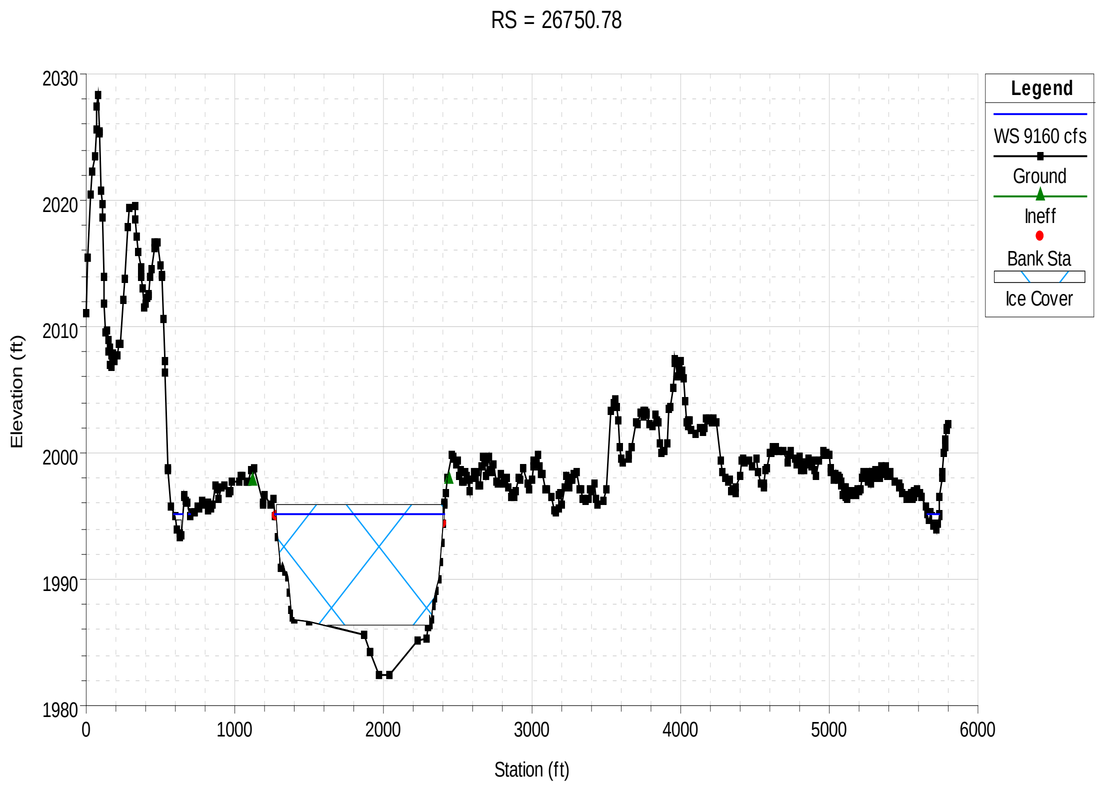



Figure 6.1.5. Cross section of ramp 1340 ft below crest with ice jam. Q = 9160 cfs.

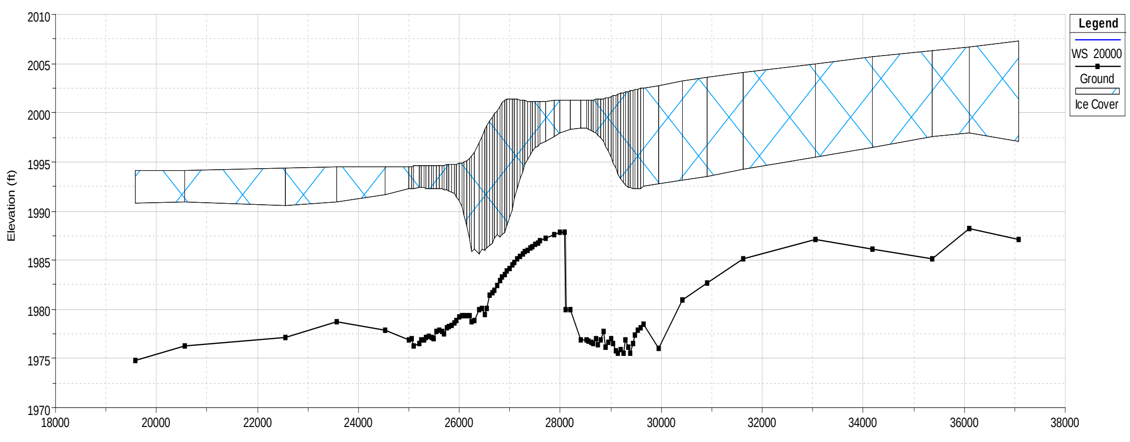



Figure 6.1.6. Ice jam profile. Q=20,000 cfs



Return to TOC

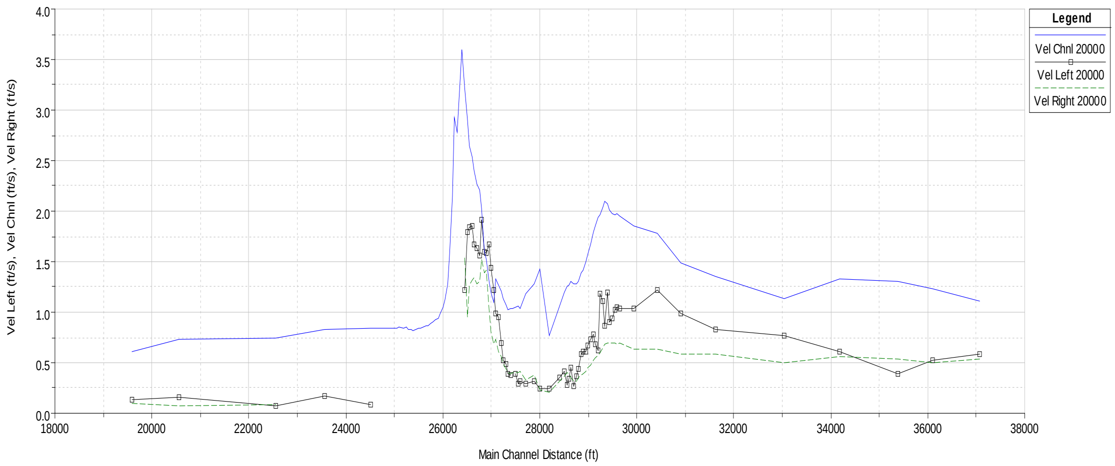



Figure 6.1.7. Water velocity beneath ice jam. Q=20,000 cfs.

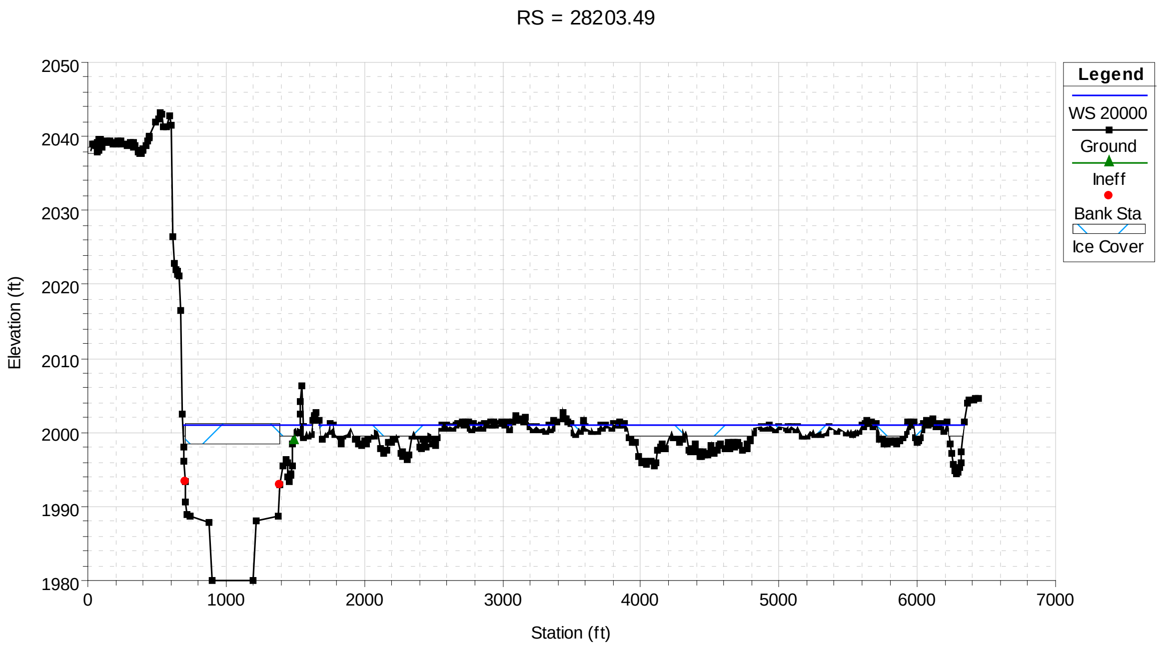



Figure 6.1.8. Cross section of ramp 110 ft below crest with ice jam. Q=20,000 .



Return to TOC

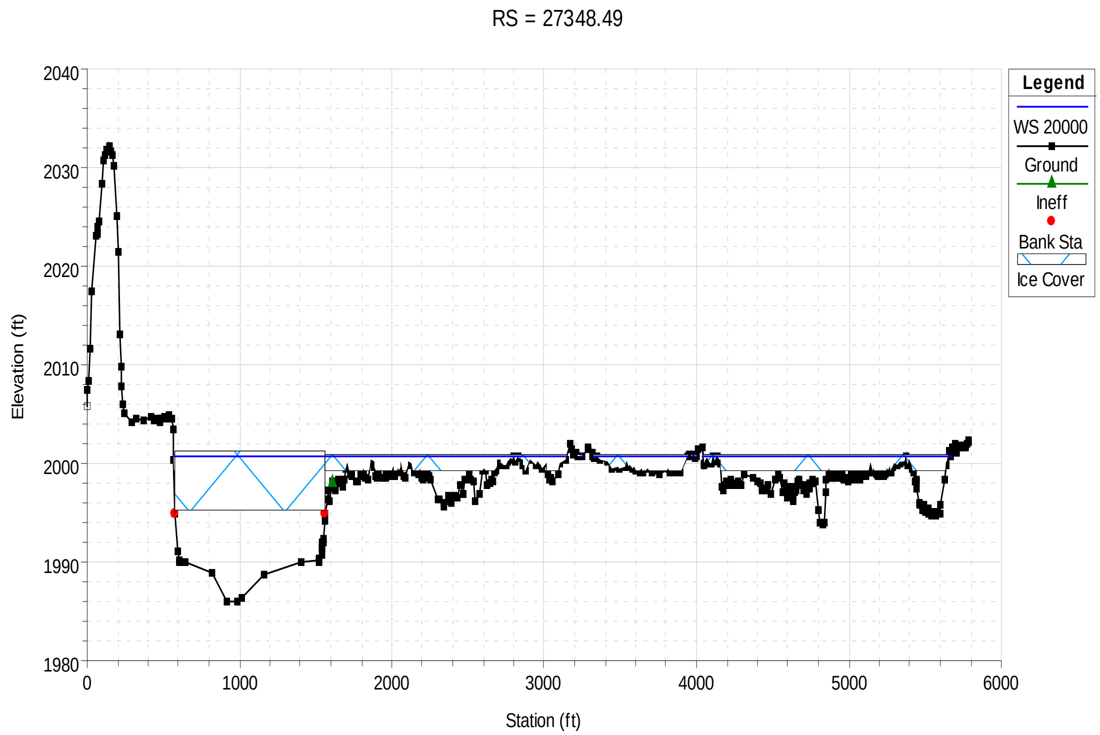



Figure 6.1.9. Cross section of ramp 744 ft below crest with ice jam. Q=20,000.

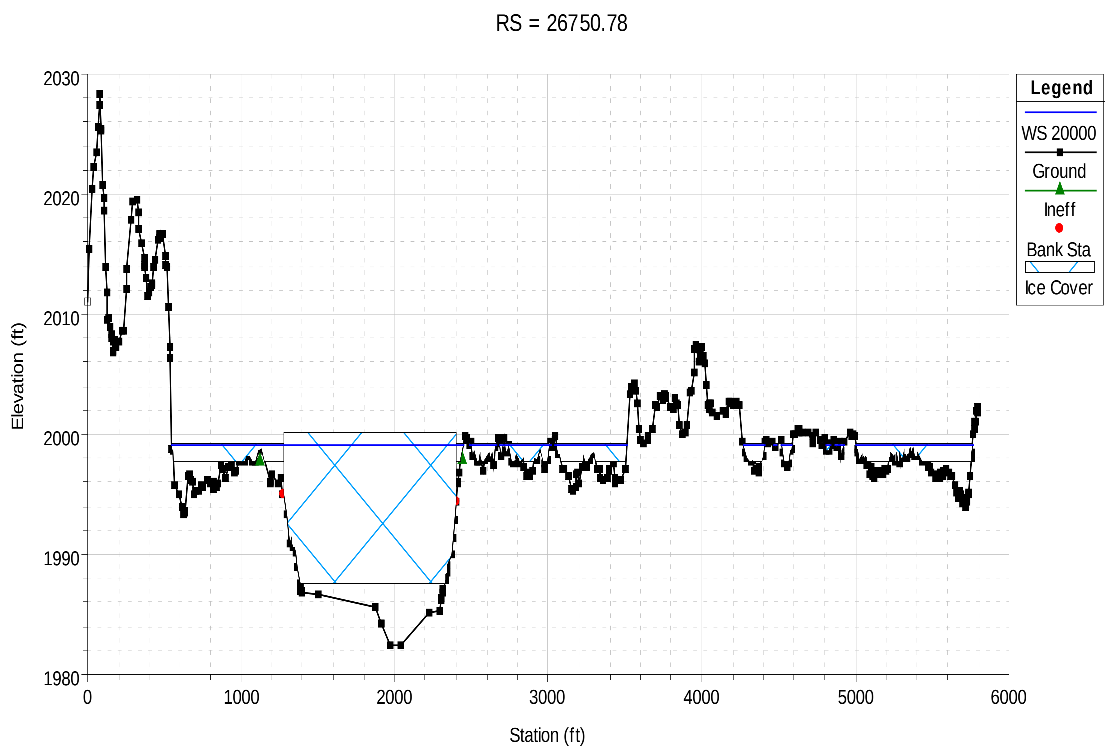



Figure 6.1.10. Cross section of ramp 1340 ft below crest with ice jam. Q=20,000.



Return to TOC

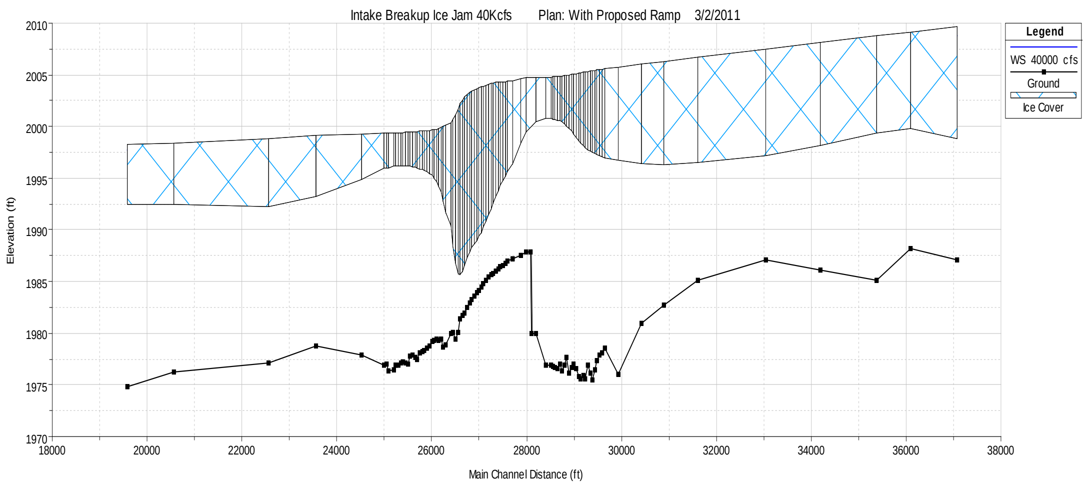



Figure 6.1.11. Ice jam profile. Q=40,000 cfs

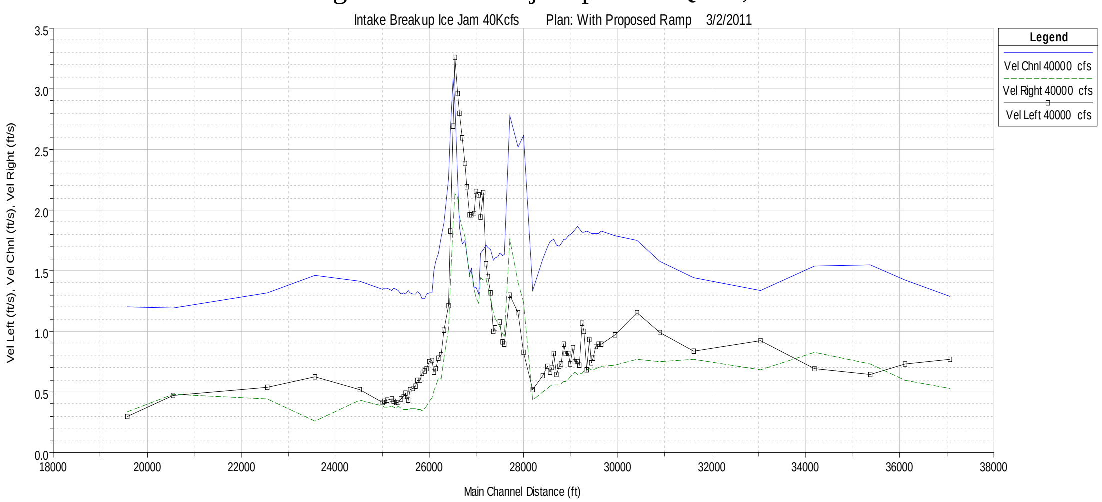



Figure 6.1.12. Water velocity beneath ice jam. Q=40,000 cfs.



Return to TOC

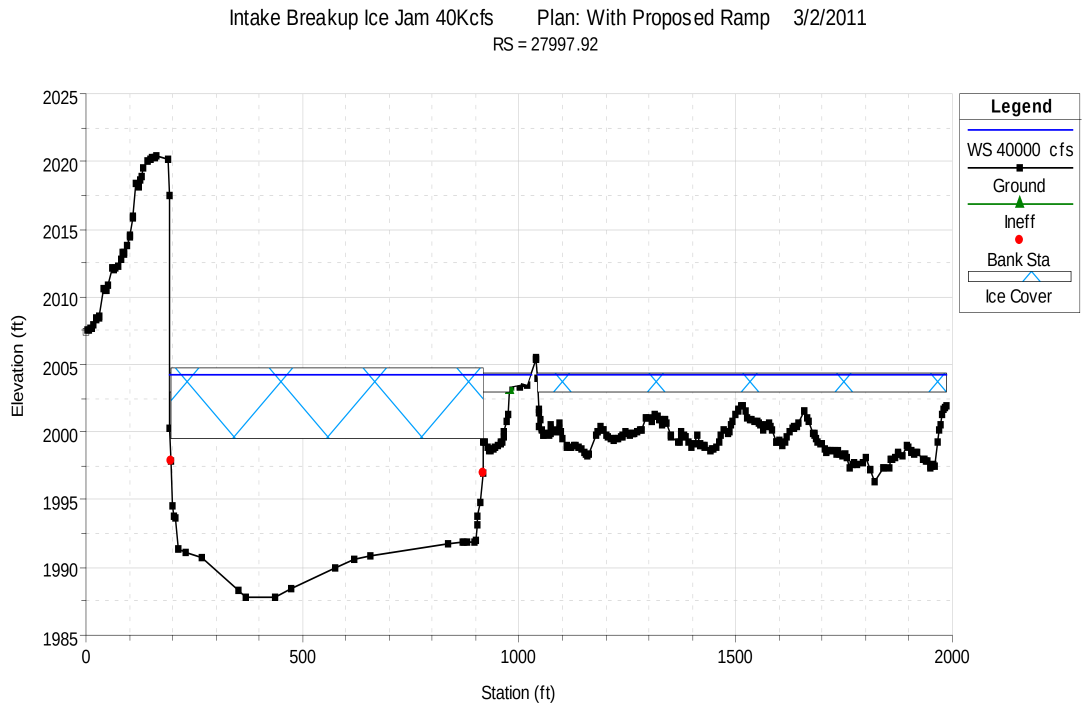



Figure 6.1.13. Cross section of ramp 110 ft below crest with ice jam. Q=40,000 .



Return to TOC

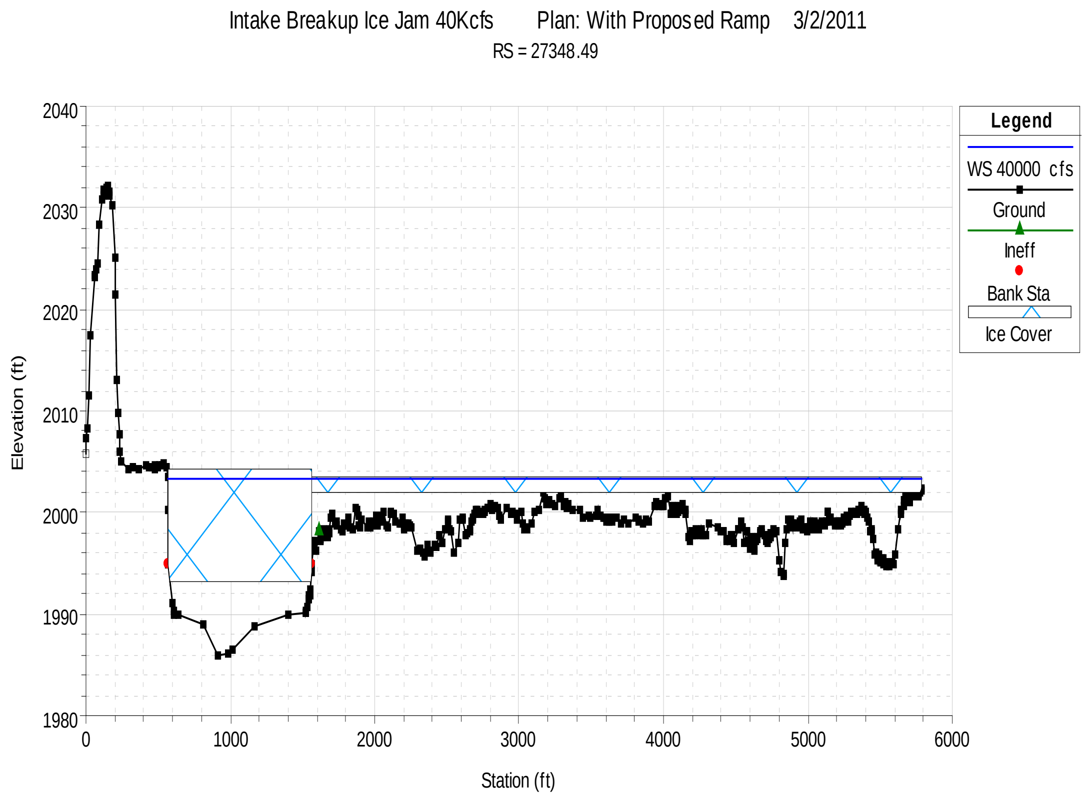



Figure 6.1.14. Cross section of ramp 744 ft below crest with ice jam. Q=40,000 .

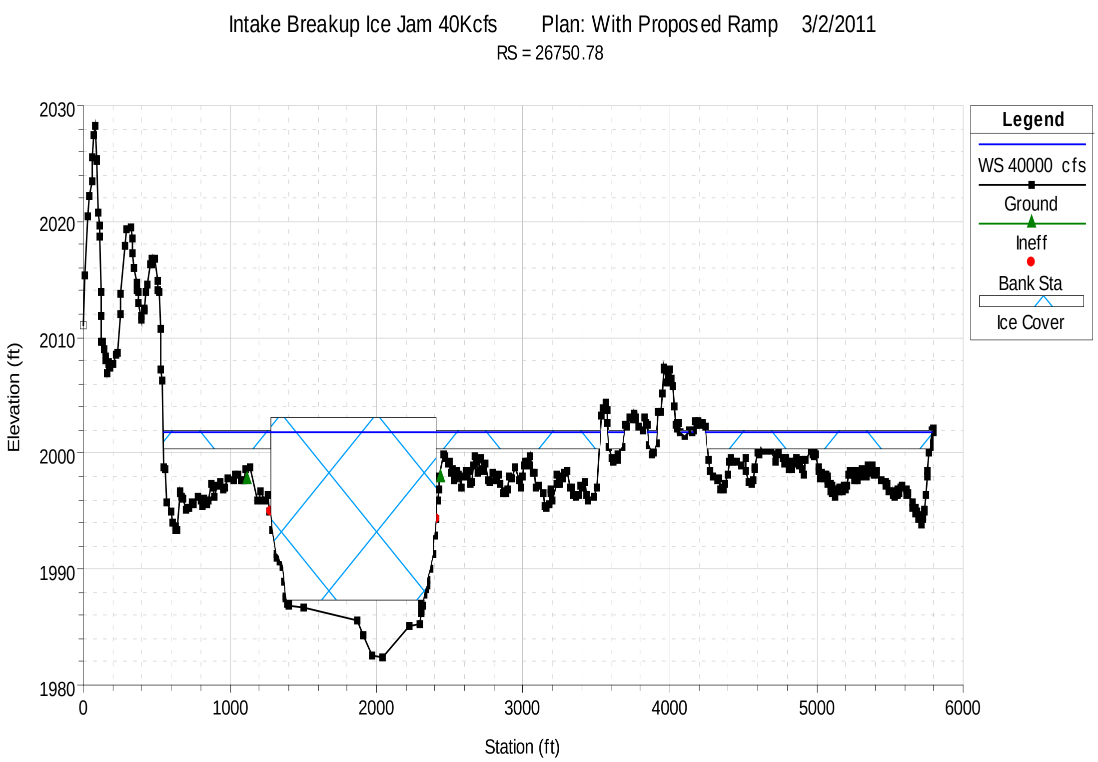



Figure 6.1.15. Cross section of ramp 1340 ft below crest with ice jam. Q=40,000 .



Return to TOC

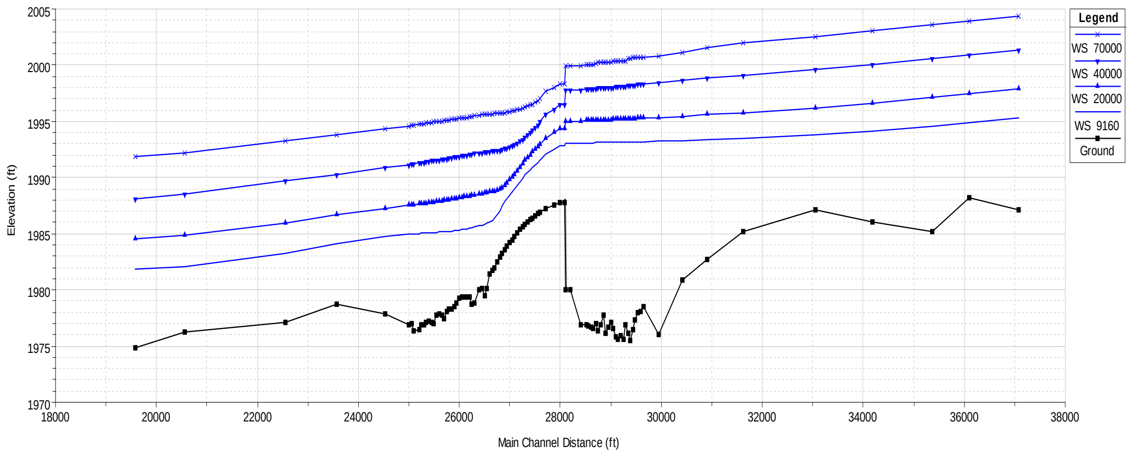



Figure 6.1.16. Open water profiles for Q= 9160, 20,000, 40,000 and 70,000 cfs.

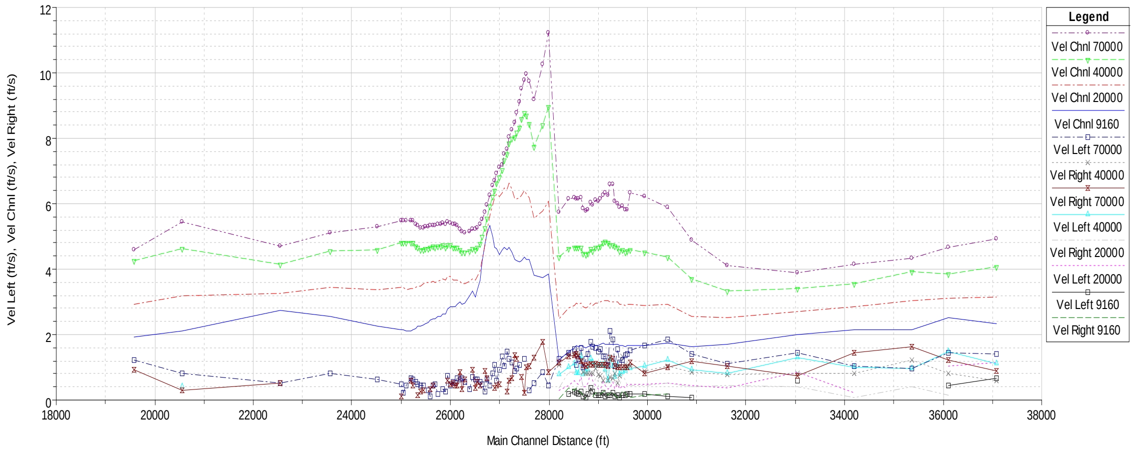



Figure 6.1.17. Average water velocity for Q= 9160, 20,000, 40,000 and 70,000 cfs.



Return to TOC

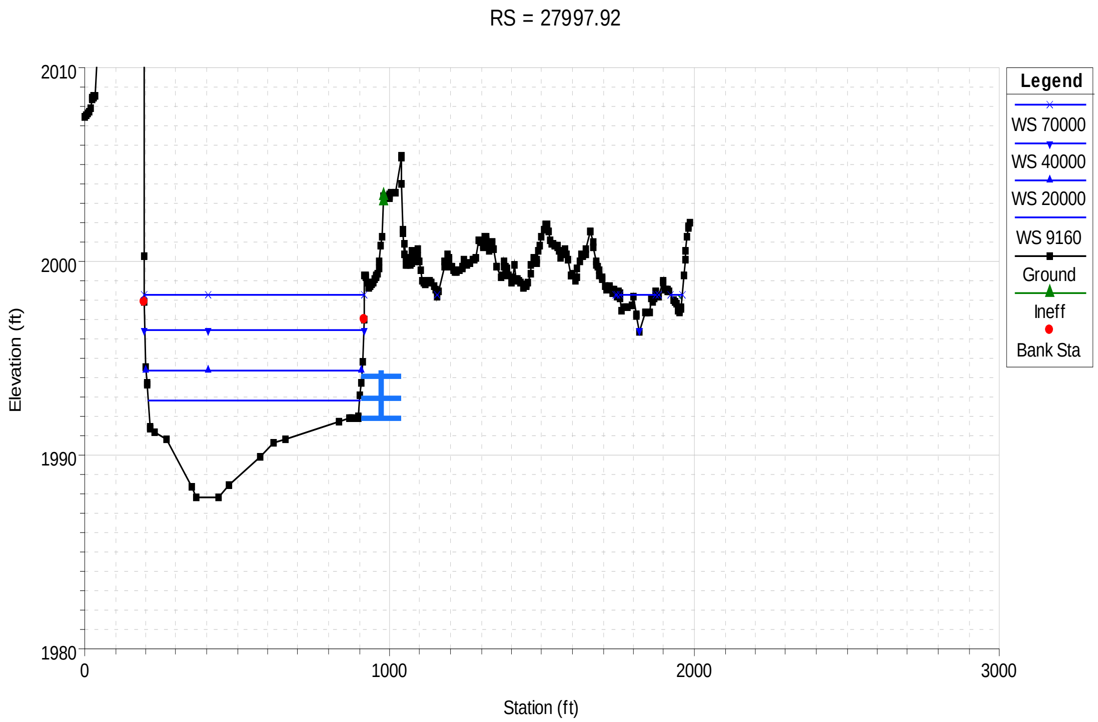



Figure 6.1.18. Cross section 92 ft below crest showing open water levels and 2-ft-thick ice floe.



Return to TOC

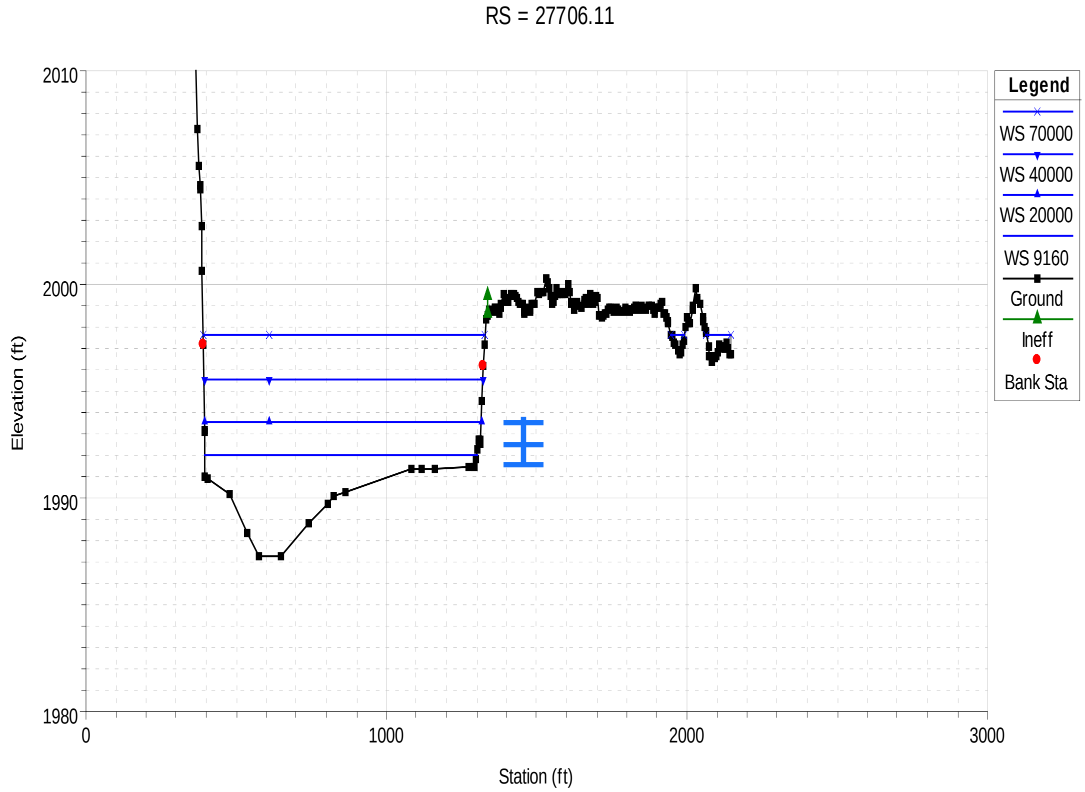



Figure 6.1.19. Cross section 386 ft below crest showing open water levels and 2-ft-thick ice floe.

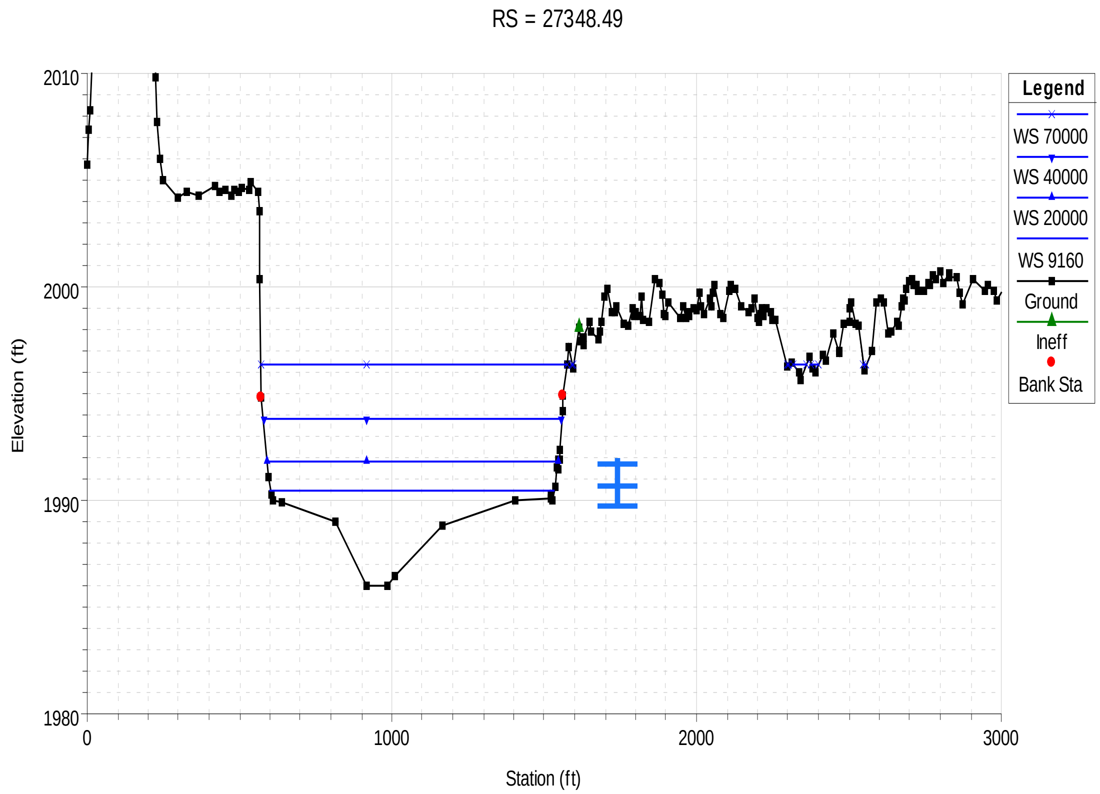



Figure 6.1.20. Cross section 744 ft below crest showing open water levels and 2-ft-thick ice floe.



Return to TOC

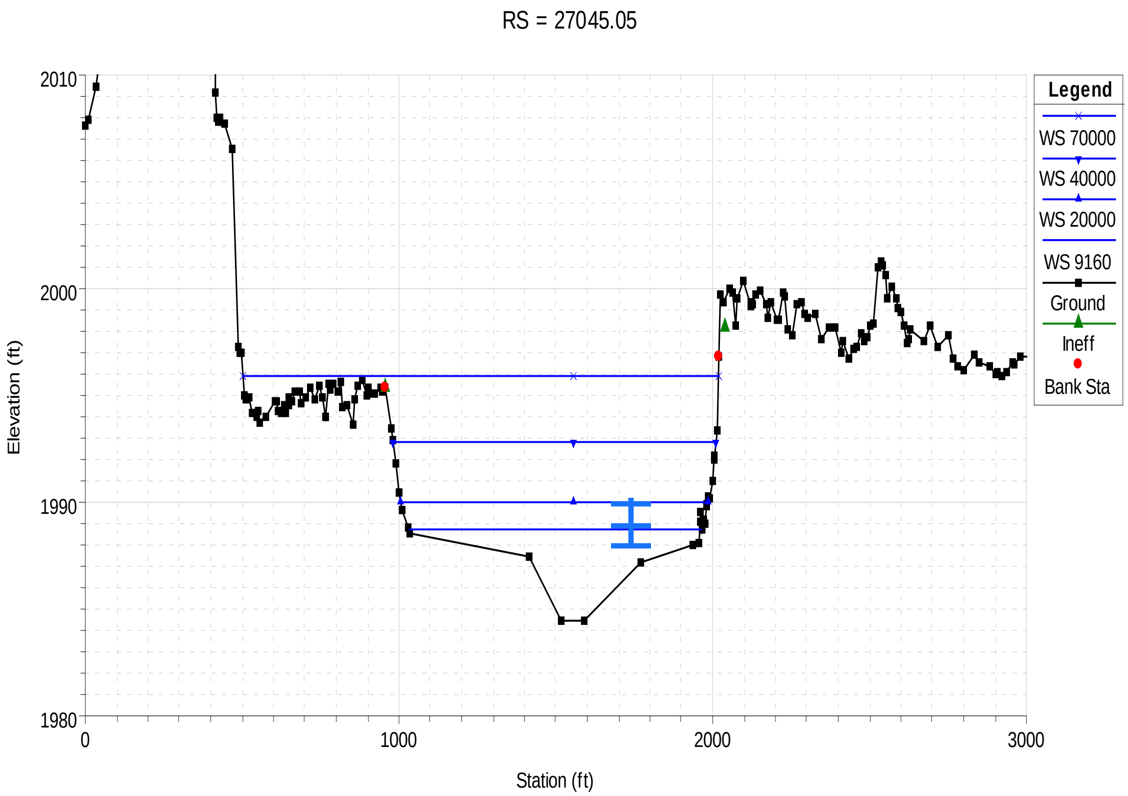



Figure 6.1.21. Cross section 1047 ft below crest showing open water levels and 2-ft-thick ice floe.

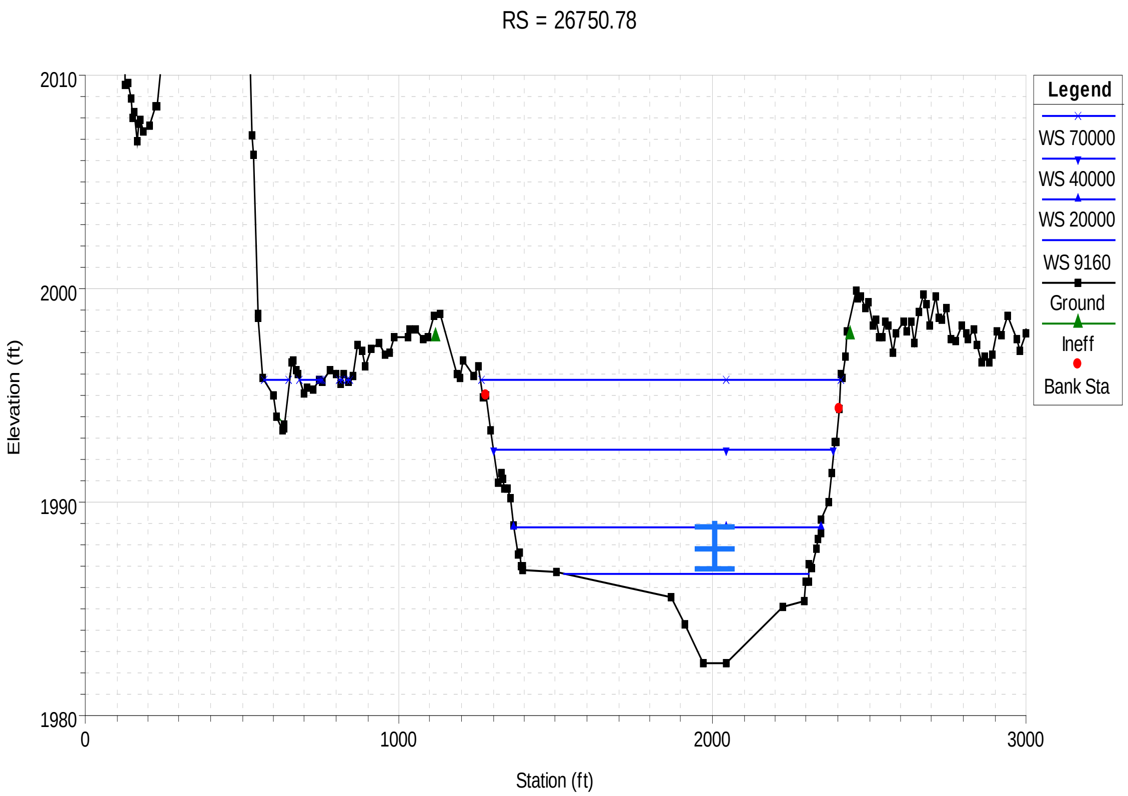



Figure 6.1.22. Cross section 1340 ft below crest showing open water levels and 2-ft-thick ice floe.

**Appendix A January 14, 2011 Site Visit to Intake and Findings**



Return to TOC

On the morning of Jan, 14, 2011, Andy Tuthill of CRREL met Justin Kuchera, Brad Coutant and Rick Hanson of Reclamation in Glendive, MT. We drove to Intake where Bruce Anderson of USACE, NWO showed us the dam from the north side. (Figure A1). A narrow lead came down the center of the upstream channel widening at the dam crest. In the apron section was several hundred ft of rapids that ran into deeper water below. Armor stone of sizes ranging from 1 to 3 ft were visible along the dam crest and in the rapids. A layer of ice, about 1.5 ft thick, covered portions of the rapids section. The wooden crest of the dam was barely visible under 1-2 ft of water and the downstream ogee section and wooden apron were completely rock covered. Justin remarked that, during a visit to the site last winter, the ice cover had been complete with no open water visible at the dam.

From Intake we drove to the offices of the Lower Yellowstone Irrigation Project in Sidney office at Sidney to meet with Jerry Nypen who has overseen operation at Intake for the last 15 years. Jerry described breakup on the lower Yellowstone as an extremely dynamic and often destructive process. The ice runs result from snowmelt driven runoff and can occur anytime between mid-February and mid-April, but more commonly in the mid-to-late March timeframe. Breakups vary in nature from fairly benign to extremely violent, with discharges ranging from 15,000 to 160,000 cfs.

The ice run he said can at times gouge the rock protection from the apron in a manner similar to driving a D-8 bulldozer downstream along the bed. The moving ice accumulation is not uniform in thickness and ice floes can pile up to scour sections of the dam and apron. Large floes can tilt on end and at times even launch in to the air. Following a large ice run, 30-ft-high shear walls may be left behind along the channel banks and it is not uncommon to see car-sized ice floes stranded on the floodplains.

On an average year, about two weeks are spent placing 300 to 1200 cubic yards (CY) of locally quarried sandstone along the dam crest using the 99-year old cableway (Figure A2). Assuming an average of 700 CY of solid rock are added per year over a period of 98 years, with 40 % voids, this represents a fill volume of about 115,000 CY of fill.

Subsequent passage of ice and floods serve to move much of this material including very large rocks downstream for distances as far as 2 miles. The original shape of the downstream ogee crest and wooden apron are hidden by this riprap whose average diameter is on the order of 1-2 ft. The largest rocks are 5-6 ft in diameter and smaller size fractions also included to provide infill material. The surface of the rock layer was non-uniform with the larger rocks protruding higher than the smaller ones.

Jerry said that the wooden crest of the dam and the downstream apron have been substantially rebuilt at least three times in the last century. Several of the major repairs have followed partial destruction by ice events. He remarked that the aftermath of a large ice event extends valley-wide at that the roar of the ice run can be heard from a mile away from the river. Jerry is not confident that any rock structure can withstand a severe ice run on the lower Yellowstone River without substantial damage.

Jerry provided reports and photographs from the construction of the dam and its first three years of operation from 1910 to 1912. These three years all experienced severe ice runs with the breakup of 1911 causing extensive damage to the project. These ice events and their impacts on the project are summarized below. Much of this information comes from Reclamation Services report “Lower Yellowstone Dam Feature History; March 4, 1910 to May 1, 1912”



Return to TOC

The 1910 ice run over the newly-completed dam which occurred on March 4 was quite severe. (Figure A3). The dam designers had assumed that ice would start passing the dam once the depth at the crest exceeded about 3 ft. and that the 9 ft-depth immediately downstream would provide a protective cushion for ice floes moving over the apron and downstream armor stone. Daily average flow at Glendive on 3/4/1910 was 30,000 cfs and the ice above the dam began to move at the expected depth of 3 ft at the crest. Observers noted that "crowding and jamming" of the ice as it moved over the dam and apron which raised concerns about potential damage to the structure. Soundings the following October found no damages however.

The 1911 ice broke up locally at the dam on March 9 with a depth of 3 ft at the dam crest. General breakup began on March 12 with a depth of 8.6 ft at the dam crest due to a downstream jam which released at 3:30 am. The ice run continued until 9 am with "much pounding of the apron". The release of a large jam from 50 miles upstream at Fallon reached Intake at 6 pm and continued until late in the night. Depth at the dam crest was 11.6 ft and "Much pounding of the apron was observed and heard". No gage records exist for Glendive but daily average flow at Sidney for the March 98-12 is listed at only 9000 cfs.

Soundings taken that April showed serious erosion along and below the lower sheet pile cutoff wall and that much of the loose stone below the sheet piling had been moved downstream. A survey on November 1, 1911 found 500 ft of the wooden apron destroyed with much of the stone filling gone. A 500 ft length of the lower wooden sheet piling had also been broken down and scour "had progressed to such an extent as to render the dam unsafe". Emergency repairs during the winter of 1911-12 included driving a row of steel sheet piling and placing 3800 CY of large rock above and below the new sheet piling. The rock was quarried locally from both sides of the river and drawn by horse and wagon out a trestle to be placed in the river using a floating derrick. A major part of the operation was cutting the 3-4-ft-thick ice cover to allow movement of the derrick (Figure A4). The cableway was also installed in the winter of 1912 to provide a more efficient means of adding rock to the apron in the future. The cost of repairs was $65,000, a sizeable sum considering the total cost of the dam had been $190,000.

The 1912 ice run was again severe, starting on March 28 at a daily average flow at Sidney of 83,200 cfs. A jam on a downstream bar (Figure A5) delayed the upstream ice release until depth at the dam crest had reached 4.8 ft. During the run, depth at the crest fluctuated between 9 and 14 ft, with ice velocities were estimated at 10-11 ft/s, peaking as high as 15 ft/s, "large cakes of ice were seen to strike the apron and sometimes…jump 10 ft above the water". Similar to the previous year, a late night lull preceded the arrival of a second large ice run from Fallon that "pitched the ice on end as it passed over the dam" and caused "great pounding" to the apron (Figure A6).

Soundings taken in April 1913 found little serious damage to the structure. Engineers credited this in part to the higher discharges and water levels over the dam and apron. The ice did erode the crest timbers to a depth of 3-4 inches and the new steel sheet piling reportedly withstood the ice pretty well.

Review of these early reports indicates that the impact of ice was initially underestimated in the design of the Intake Dam. Following the events of 1910-1912, ice became the dominant issue in terms of engineering and construction activities to protect the dam.

It appears that discharge and water depth are major factors in terms of potential damage to the dam and apron during breakup. Of these three well documented events the 1911 event had the lowest flows and water levels and by far the greatest damages to the structure.

Respectfully Submitted:

Andrew M. Tuthill, P. E.
U S Army Cold Regions Research and Engineering Laboratory
72 Lyme Rd.
Hanover, NH 03755
603-646-4225 office
603-643-3354 home
603-306-6699 cell



Return to TOC

Figure A1. View of Intake Dam from the north on January 14, 2011. Flow is right to left.



Return to TOC

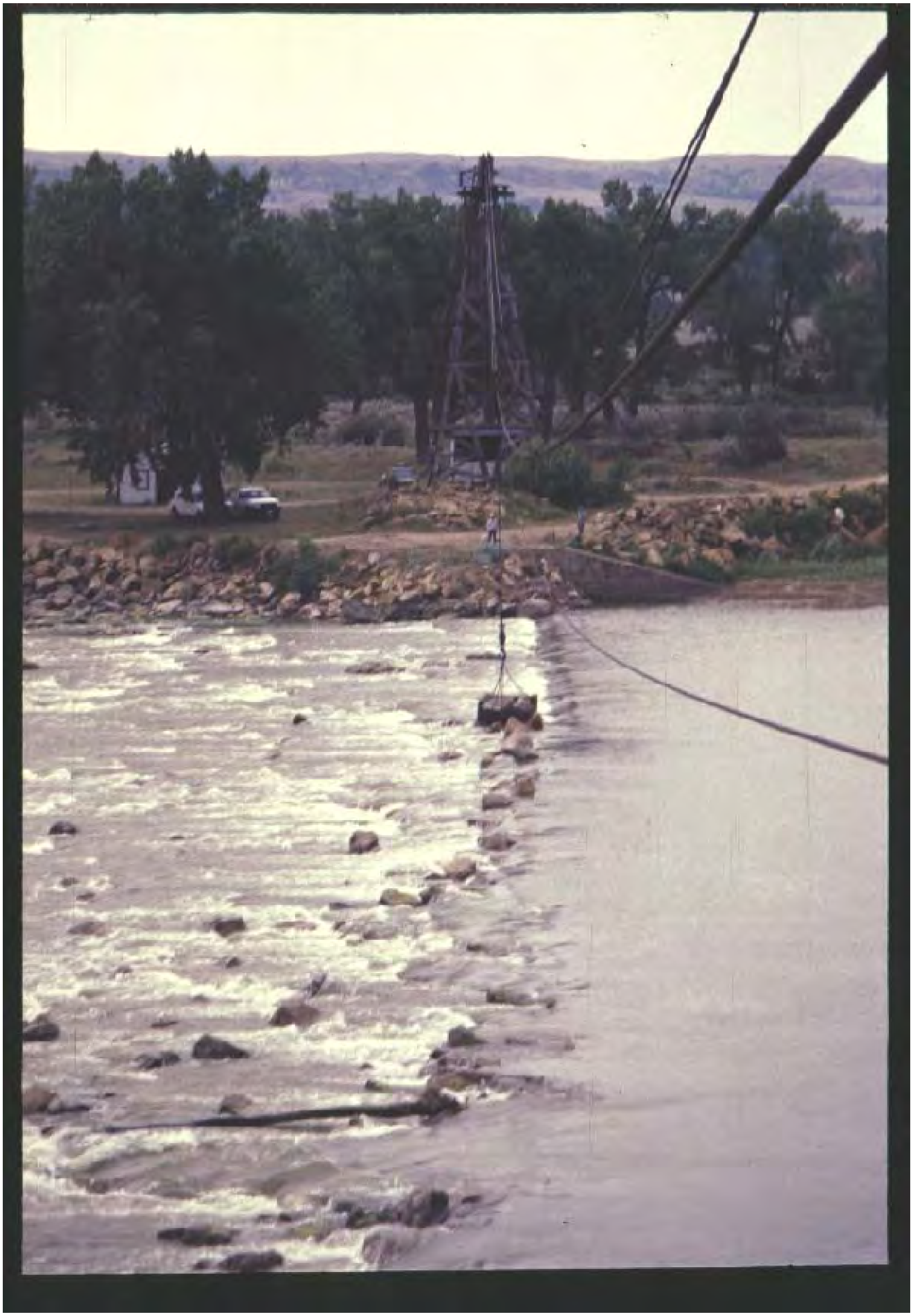


Figure A2.  Adding armor stone to the dam apron using the cableway



Return to TOC


Figure A3. Ice moving over the newly completed dam on March 4, 1910.

New No LY-230 View showing channel being cut out for the purpose of bringing floating derrick into harbor, taken from point on N. side of river below dam. L. Y. Dam. JHN 2/10/12

Figure A4. Clearing ice from the river to repair the apron Feb. 1912.



Return to TOC

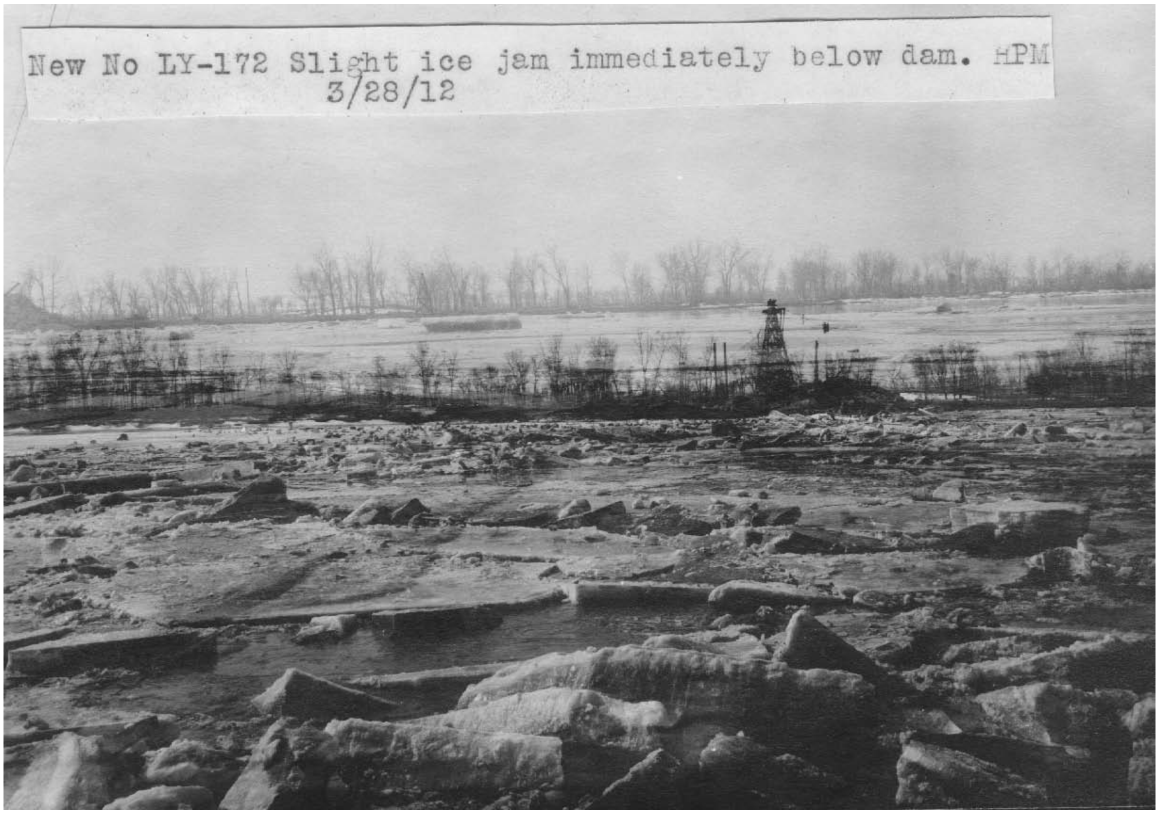


Figure A5. Jam below the Intake Dam at the onset of the March 28, 1912 breakup.

Figure A6. Second ice run during March 28, 1912.



Return to TOC

**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Intake Fish Passage Option Evaluation Summary**
**May 2012**

**Attachment 1b**

# Ice Forces-Intake Bypass Channel
# Lower Yellowstone River, 30% Design

**Prepared by:**
**Andrew Tuthill, Cold Regions Research and Engineering Laboratory (CRREL)**



Return to TOC

**Evaluation of Ice Impacts on Fish Bypass Channel at Intake Dam, Lower Yellowstone River**

Andrew M. Tuthill
Meredith L. Carr

US Army Corps of Engineers
Cold Regions Research and Engineering Laboratory
72 Lyme Road, Hanover, NH 03755

February 12, 2012

## 1. Introduction

The Lower Yellowstone Project at Intake is a Bureau of Reclamation irrigation project located on the Yellowstone River approximately 70 miles upstream from the confluence with the Missouri River. The project consists of a low-head diversion dam, a diversion headworks structure, and an irrigation canal system to deliver water to approximately 53,000 acres in Eastern Montana and Western North Dakota.

The diversion dam is a known barrier to native fish migration including endangered pallid sturgeon. The canal has been documented to entrain many thousands of fish during diversion operations (April through September). Bureau of Reclamation has an obligation, under the Endangered Species Act, to modify the structure or the operation of this facility to address pallid sturgeon concerns raised by USFWS and the Montana Department of Fish, Wildlife, and Parks. The Corps has been working with the Bureau of Reclamation to develop plans to construct a new headworks with screens and also provide fish passage. Two fish passage alternatives under consideration consist of a full river width rock ramp at an average slope of 0.5 to 1% and a bypass channel of 10,000 to 15,000 feet in length that would provide habitat similar to existing natural chutes. Figure 1 shows the preferred alignment of the bypass channel and its structural components.

Omaha District requested ERDC/CRREL[1] to provide engineering design guidance related to ice on the bypass channel and associated structures. This effort follows previous work by CRREL in 2011 that estimated ice forces on the intake dam and the new headworks structure and provided ice related design guidance for the rock ramp.

## 2. Design Background

The new headworks structure is currently under construction and will be in service for the 2012 irrigation season. A preliminary diversion dam and rock ramp fish passage concept design was completed in spring 2010. The next engineering phase identified unacceptable cost escalation associated with the rock ramp design however. This led to consideration of additional fish passage alternatives during preparation of a Decision Document (USACE March 2011a). One alternative is the construction of a bypass channel. The preliminary design assessed performance based on bypass channel geometry and hydraulic conditions needed for fish passage (USACE March2011b). An updated design

[1]Engineer Research and Development Center/Cold Regions Research and Engineering Laboratory



Return to TOC

(USACE January 2012) provided greater detail on various project components with slight revisions to channel geometry. The ice design information presented in this report will be incorporated in a 30% concept level design due in April 2012.

The ice force design effort draws on previous ice analyses done in 10% and 30% designs of the intake headworks, new dam and rock ramp as well as HEC-RAS modeling of hydraulic and ice processes in the preferred bypass channel and adjacent river.

## 3. Approach

This study began with a review of previous design efforts for the bypass channel (USACE March 2011a) as well as earlier ice analyses associated the design of the headworks, diversion dam and rock ramp. (USACE, March 2011a and January 2012). The previous literature review of related ice issues will be updated to include information on ice processes associated with bypass channels and chutes.

Ice-interaction was analyzed for the following project components:

a. Upstream control structure at bypass channel inlet (referred to as "exit" from fish perspective)

b. Channel plug where bypass channel diverges from path of existing natural chute.

c. Riprap at bypass channel bends for lateral stability

d. Vertical grade control structures along bypass channel

e. Downstream vertical control structure (referred to as "entrance" from fish perspective) where bypass channel re-enters Yellowstone River below dam.

f. Lateral stability structure along Yellowstone R. below bypass channel outlet.

g. New dam

h. Flow augmentation weir parallel to the Yellowstone River right bank immediately upstream of the diversion dam. This weir would provide additional attractive flow to the bypass channel entrance downstream of the dam during high flow events.

These structures are shown on Figure 1 and described in USACE, March 2011a and USACE January 2012.

For the purpose of design for ice forces, a worst case ice formation, breakup, jam and release scenario was developed similar to the approach in previous ice design analyses. Figure 2 shows the hydrograph for the Yellowstone River at Miles City and Sidney for the winter of 1996 which had the most severe ice jamming in recent history. The ice scenario starts with a hydraulically thickened ice cover forming during the early winter at flows in the 8-10 Kcfs range that remains in place until mid-March-early April when flow increases to an assumed breakup level of about 20 Kcfs. A large ice jam is assumed to form downstream of the Intake Dam as it has historically. As discharge continues to increase the jam in the main river channel forces flow and ice into the right overbank and



Return to TOC

bypass channel. It is assumed that the ice cover breaks up and formas a smaller jam in the bypass channel. At about 40 Kcfs the jams are assumed to release and the flow impounded by the jam surges downstream in the river channel and floodplain area leaving behind high shear walls and large ice pieces in the right overbank area. Figure 3 shows the aftermath of such an event which occurred in March of 1912.

This process of ice formation, breakup and subsequent ice run was modeled using HEC-RAS and the resulting water surface and ice jam profiles used to evaluate ice-structure interaction. For concrete structures such as weirs, design ice forces and heights of ice structure interaction are estimated based on established bridge design codes such as AASHTO (1998) and ice loading guidance found in the Ice Engineering Manual (US Army, 1999). In this project, the main type of ice interaction will be with riprap structures where the lack of theoretical guidance relating ice forces to rock stability necessitates a more empirical approach such increasing the riprap layer thickness.

The design approach for the riprap structures followed an approach similar to the one used in the design of the rock ramp (USACE, 2011a). The rule of thumb taken from lab tests by Sodhi et al. (1996, 1997, and 1999) recommends the $D_{50}$ of the riprap should be 2-3 times the maximum ice thickness. This was not used in the design of the bypass channel for reasons as explained in the previous ice analysis (USACE, 2011a) . These included cost, difficulty of finding and placing rock that large and the fact that the Yellowstone situation is different from the ice ride-up tests upon which the guidance was based. The approach taken was to design the riprap structures based on hydraulic conditions of the 100-year open water flood and add 1.0 ft the layer thickness *T*, scaling up the rock size distribution proportionally.

## 4. Ice Processes Related to Chutes and Bypass Channels

The literature review of ice processes related to chutes and bypass channels is not yet complete. Based on experience with large ice-affected rivers, ice processes play a major role in terms of overbank flooding and the flow to and from the floodplain. A major difference between fluvial and ice-affected processes is that ice jams may cause flow in overbank areas at much lower discharges than in open water conditions. The HEC-RAS analysis done in this study proved this out. On the lower Yellowstone River, breakup typically progresses downstream from warmer to colder climate in a series ice jams and releases. Jams in the main channel often push flow and ice into side channels and chutes, leaving behind high shear walls and ice pieces in the overbank areas when the jam releases as shown in Figure. 3. As the hydrograph increases to the breakup level, one would expect flow in overbank chutes to increase, floating up the freezeup ice cover and possibly forming small jams. The main breakup ice action would be expected to occur in the main channel however due to the higher velocities and depths and much greater ice supply. When these jams form as they have historically at many locations between Glendive and Sidney, the wide floodplains and side channels serve as relief mechanism accepting and storing flow and ice. Under these conditions, the flow area is large and overbank water velocities relatively low (≤ ~2 ft/s by HEC-RAS calculations at 40 Kcfs)



Return to TOC

which turns out to be a mitigation factor in terms of the design of bypass channel structures.

## 5. Ice-Hydraulic Processes Related to ice Loads on the Project

The ice analyses for previous design efforts, diversion found the lower Yellowstone River to be subject to heavy ice formation, dynamic ice breakups and ice jams. Because the Yellowstone flows northeastward from warmer to colder climate, the ice breakup progresses downstream in a series of jams and releases, and ice jam severity tends to increase in the downstream direction as the breaking front encounters stronger thicker ice. These events force flow and ice out of bank, either in side channels and chutes or over the entire floodplain width. Numerous ice jams and ice jam floods have occurred upstream of Intake at Glendive and downstream at Sidney (Haehnel and Tuthill, 2006). Jams have also been reported at Intake in the vicinity of the Richland County Line, Elk Island and Savage. All this suggests that the project reach is subject to the dynamic formation and release of ice jams. The most recent severe ice jam event on the Yellowstone occurred in February 7-13, 1996. Figure 2 shows the Yellowstone River discharge and AFDD for that winter at Miles City and Sidney.

On faster flowing rivers such as the Yellowstone, the predominant ice type is frazil which forms as small particles in super-cooled open water reaches. The frazil crystals stick together (flocculate) to form floes that tend to increase in size with distance traveled. The floes may accumulate along the channel sides to form border ice or stall in slack areas or channel obstructions to build an ice cover in the upstream direction. Only where water currents are slow ($\leq$ 1 ft/s) can in situ thermal ice growth be expected. In the 1 to 1-1/4 ft/s velocity range, the frazil floes will accumulate edge-to-edge in a process known as juxtaposition. At higher water velocities, the floes will stack or "shove" into a thicker ice accumulation. The HEC-RAS model contains an ice routine that calculates ice accumulation thickness by these processes for both the freezeup and breakup cases.

Average December-January discharge at Sidney gage is 5800 cfs with a standard deviation of 1680 cfs for the 1910-2009 period (6900 cfs for post-Yellowtail Dam time frame). A higher freezeup discharge will cause a thicker freezeup ice accumulation, since the water velocities and shear forces on the ice underside will be greater. For the purposes of this study, an extreme case freezeup discharge is defined as the long term December-January average flow plus two standard deviations or 9160 cfs. Figures 4 and 5 show HEC-RAS simulated freezeup ice covers in the main river and bypass channel respectively for this flow level. Upstream of the bypass inlet, the shoved frazil ice accumulation in the main river is a much as 8 ft thick while in the bypass channel the simulated freezeup ice cover is hydraulically thickened to about 3 ft thick.

From review of past ice jam events, is estimated that a late-season ice cover such will release in the project reach at a discharge of about 20 Kcfs[2]. Figures 6 and 7 show this pre-release condition. Also, it is assumed that a breakup ice jam in the project area will

[2] Review of the early project reports indicates that the ice could release once depth at the dam crest exceeded 3 ft at river flows as low as 9,000 cfs.



Return to TOC

release at a discharge of about 40 Kcfs[3]. This is based on the Sidney Gage data that give the annual peak on 3/14/1996 of 19.48 ft (instantaneous peak Q = 30 Kcfs) as ice-affected while the 3/6/1994 peak of 24.03 ft (peak Q=75 Kcfs) is listed as open water. In 1994 ice jams were reported at many locations on the lower Yellowstone, but the river may have been clear of ice by the time of the instantaneous peak on 3/6. HEC-RAS was used to calculate breakup ice jam profiles in the vicinity of the project at discharges of 40 Kcfs (Figures 8 and 9 respectively).

Once the ice cover releases, it is assumed that the floes and thicker frazil ice masses travel downstream and impact the project at approximately open water surface elevations (WSE). Open water surface and velocity profiles were calculated for discharges of 20, 40, 60, 80 and 100 Kcfs (Figures 10 and 11). These elevations are used to estimate the height range that the ice floes and ice masses could impact bypass channel structural elements, as discussed in the next section.

## 6. Ice Forces and Design of Riprap

Most of the structural components affected by ice consist of riprap. The two concrete structures are the sill at the inlet to the bypass channel and the flow augmentation weir near the downstream end. The structures and their ice design issues are discussed below. Hydraulic and riprap design information is summarized in Table 1.

The 100-year event riprap size was calculated by the Isbash Equation which relies on water velocity, rock density and a stability coefficient (0.86 used in this case). The riprap was also sized by methods from USACE (2011a) which uses water velocity, flow depth and a number of empirical coefficients. This EM is one of the few design documents that considers ice, stating that in cases of heavy ice or debris loadings, the layer thickness should be increased 0.5 to 1.0 ft. Since conditions of heavy ice are expected in the bypass channel area, the open water design layer thickness $T$ was increased by 1.0 ft and the rock size scaled up proportionally. Finally the riprap designs by these two methods, factored for ice were compared to preliminary riprap designs provided by the Omaha District (USACE, 2011b and Table 1).

### *a. Upstream Control Structure at Bypass Inlet*

The plans for the upstream control structure call for a 15-ft long by 60-ft wide concrete sill surrounded by riprap. This is probably the most critical structure in terms of vulnerability to ice as its upstream approach lies on the outside of a bend and will be exposed to the full impact of ice runs on the main river. The Omaha District (NWO) design calls for Type C riprap ($D_{50}$ = 12 in) and a layer thickness $T$ of 3.5 ft for the 3.5:1 upstream and downstream slopes and 5:1 side slopes. The ice-factored Isbash and Corps EM methods give rock sizes and bed thicknesses quite similar to the NWO design. In terms of ice action, for the 20 Kcfs and greater flow range where breakup ice movement would be expected, the water depth and ice clearance over the 1990.3 ft elevation sill and

[3] These ice cover and breakup ice jam release discharges are very approximate and will vary greatly depending on ice thickness and ice strength.



Return to TOC

riprap blankets would be sufficient to avoid major ice impacts (Figures. 7a and 9a). Possible areas of vulnerability in terms of ice are 1.) The left hand side slope where the Yellowstone River transitions into the bypass, and 2.) The upstream interface between the concrete sill and the riprap bed. For the first case, one might consider increasing the average rock size to 16-24 in and the bed thickness to at least 4 ft. For the second case, should some of the riprap get scoured away exposing the front edge of the sill, the sill should be designed to withstand a horizontal ice loading of 10 kips/lineal ft.

*b. Channel Plug*

The channel plug being located off the alignment of the diversion channel will likely not experience many breakup ice impacts. By the time the assumed breakup flow of 20 Kcfs is reached, the bottom of the bypass ice cover would still be below the 2000 ft elevation of the plug crest so ice would not be expected to pass the structure (Figure 7a). At the 40 Kcfs assumed ice jam release discharge, the bottom of the bypass ice cover would be well above the crest of the adjacent channel plug (Figure 9a). Also, with overbank flow velocities on the order of 1 ft/s (Figure 9b), one would not expect rapid downstream movement of ice from the bypass channel to the location of the channel plug.

The preliminary riprap design proposed by the Omaha District is more than adequate to withstand conditions of severe ice based on the ice-factored Ishbash and EM 1110-2-1601 approaches (Table 1).

*c. Riprap at Bends for Lateral Stability*

The preliminary Omaha District plan calls for armoring the bypass channel bends with riprap with a $D_{100}$ of 16 inches and a layer thickness of 24 inches. This is based on a velocity of 8.75 ft/s. Assuming a rock unit weight of 165 pcf and an Ishbash coefficient of 0.86, the calculated $D_{50}$ would be about 12 in. In this case, the ice-factored Ishbash and EM 1110-2-1601 rock sizes and thicknesses are slightly greater than those calculated by NWO (Table 1).

The bend riprap protection is planned to extend up to the 10-year open water elevation. In the case of the assumed 20 Kcfs breakup discharge the top of the riprap would be at the mid-jam elevation (Figure 7a). For the assumed release discharge of 40 Kcfs, the bottom of an ice jam on the bypass channel, if it were still in place would be about 5 ft above the top of the riprap. Depending on how the ice jam release occurs, this process could result in ice impacts to the riprap.

*d. Vertical Control Structures in Bypass Channel and at Outlet*

The preliminary riprap design by the District gives comparable results to the ice-factored Ishbash and EM 1110-2-1601 approaches (Table 1). The tops of these vertical control structures will be



Return to TOC

1-2 ft below the channel invert as indicated in the HEC-RAS water surface and ice jam profiles. In the 20-40K breakup ice jam flow range, the channel invert and these structures will be well submerged with under ice clearances in the 12-20 ft range (Figures 7a and 9a). It is not expected that the bypass channel bed or vertical control structures will experience significant ice impacts.

*f. Downstream Lateral Stability Structure*

In the event of a large ice run or an ice jam and release sequence, this embankment will experience severe ice action comparable to existing conditions below the intake dam. The preliminary riprap design by the District is comparable to the results of the ice-factored Ishbash and EM 1110-2-1601 approaches (Table 1).

*g. New Dam Crest*

It is assumed that the new dam crest will be a horizontal weir with a crest elevation of about 1990.2 ft. In the ramp fish passage alternative, the dam crest was mildly trapezoidal with the invert at 1987 ft and the edges at 1991 ft. It is expected that ice will impact the level-crested dam in a similar way to the trapezoidal crest. In the previous 30 % design of the dam crest, it was anticipated that large ice floes could impact the dam crest over an elevation range of 1985 to 2000 ft. In terms of direct ice impacts to the upstream face of the dam, the design called for an ice loading of 15 kips/ lineal ft. For a thick frazil ice mass sliding horizontally over the top surface of the crest, the ice shear force was estimated to be 2 kips /ft$^2$. These ice loadings would apply to the revised level-crested dam design. . The 15 kips/ lineal ft loading on the dam face is conservative representing the high end found in the design literature. Although this design loading is applied to vertical concrete structures in rivers subject to heavy ice loadings, a sloped upstream face would be preferable since the ice would tend to ride up over the crest reducing the potential for damage to the concrete. Because the 15 kips/ft ice loading on the dam face is conservative, it would not need to be added to the 2 kips/ft$^2$ estimate for foe frazil ice masses ice shearing horizontally along the top surface of the dam.

*h. Flow Augmentation Weir*

A flow augmentation weir parallel to the Yellowstone River right bank immediately upstream of the diversion dam will add flow to the bypass channel fish entrance downstream of the dam during high flow events. The weir will be constructed of roller compacted concrete with compacted backfill along its upstream side.

The crest of the weir will be at the 7000 cfs water surface elevation of about 1991.0 ft based on HEC-RAS. This is only 0.8 ft higher than the dam crest 1990.2 ft shown in the current HEC-RAS model. Figure 6a shows a worst case ice cover profile at 20,000 cfs, the breakup discharge.



Return to TOC

These results indicate that the upstream ice will be sufficiently thick to impact the weir when it passes over. With increasing discharge under ice clearance increases and major ice impacts to the weir would be less likely (Figure 8a). Like the dam, the top surface of the flow augmentation weir will need to withstand horizontal forces due to ice sliding along its crest of 2 kips/$ft^2$. The upstream face of the weir will be vulnerable to severe ice action from ice runs in the main river. It is questionable whether the compacted backfill along the weir face shown in the preliminary plans will be adequate to withstand this type of ice action. A possibility is to eliminate the backfill and extend the concrete to the upstream face of the weir. This flow augmentation weir is a critical component of the main dam serving as the dam's right embankment.

The concrete wall on the upstream side of weir will experience heavy ice impacts and should be designed for an ice loading of 10 kips/lineal ft. This ice loading is conservative and need not be added to the estimated ice shear force of 2 kips/$ft^2$ on the top surface of the weir. The riprap on the where the concrete wall ties into the bank will also experience heavy ice action. Here, an average stone in the 1.5 -2.0 ft range and a layer thickness of about 4 ft is suggested.

## 7. Summary and Conclusions

1. This study analyzed ice-related design aspects of a proposed fish bypass channel at the Intake Diversion Dam on the Yellowstone River in Montana. Past ice related design efforts were reviewed and a HEC-RAS model used to develop a worst case ice formation, breakup and release scenario. HEC-RAS calculated results of depth, water velocity and ice thickness were used gage how ice will interact with the various structures making up the proposed bypass channel and size riprap which is the primary component of the these structures. Exceptions include two concrete weirs, one at the inlet and the other at the outlet of the bypass channel. The design ice forces for the concrete structures were estimated by conventional means as outlined in AASHTO (1998) the Ice Engineering Manual US Army (2008).

2. For the upstream concrete sill under a worst case scenario, an ice force of 5 kips/ft could act horizontally along the front edge. For the surface of the upstream sill and the downstream flow augmentation weir crests, a maximum horizontal ice force of 2 kips/$ft^2$ due to sliding ice is estimated. The concrete wall along the upstream edge of the flow augmentation weir is expected to experience high ice impacts. Here, an ice design load of 10 kips/ft is recommended.

3. Design of riprap to resist ice damage followed the approach taken in the earlier ice analysis of the riprap ramp (USACE 2011a). First an average riprap $D^{50}$ and $D^{30}$ were calculated by the Isbash and EM 1110-2-1601 methods respectively with velocity and depth inputs from a HEC-RAS simulated 100-year open water event. Following the guidance of the EM 1110-2-1601, the layer thickness was increased by 1.0 ft for heavy ice conditions and the rock size fractions scaled up proportionally. This approach



Return to TOC

produced riprap designs very similar to those provided in the Omaha District preliminary designs (USACE 2012 and Table 1).

4. Several areas where the preliminary riprap designs by the District could be scaled up are the left hand side of the transition from the Yellowstone River into the upstream control structure, and the right bank of the Yellowstone River immediately upstream of the flow augmentation weir. Here the rock size could be increased to 1.5-2.0 ft and the layer thickness to 4.0 ft.



Return to TOC

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Return to TOC

**Table 1. Hydraulic Conditions for 100-year Open Water Event and Riprap Design for Sturctrual Components**

| | | | | | | | | | $D_{50}$ (inches) | | | $D_{100}$ (inches) | | | Layer Thickness (inches) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Structure | HEC-RAS River Station (ft) | Hydraulic Depth (ft) | Average Velocity (ft/s) | Water Surface Slope | Channel Width (ft) | Bed Shear ($lb/ft^2$) | Bend Radius (ft) | Side Slope (H:V) | Omaha District | Factored Isbash | Factored EM | Omaha District | Factored Isbash | Factored EM | Omaha District | Factored Isbash | Factored EM |
| Bypass Inlet Weir | 15,530 | 13.0 | 5.0 | 0.00026 | 185 | 0.21 | 500 | 5:1 | Type C 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Channel Plug | 9,586 | 11.6 | 6.2 | 0.00053 | 230 | 0.38 | | | 20 | 12 | 8 | 30 | 24 | 16 | 45 | 36 | 24 |
| Bypass Bends | 6300 & 2900 | 13.0 | 7.0 | 0.00032 | 230 | 0.26 | 400-1400 | 7:1 | | 12 | 10 | 16 | 24 | 18 | 24-36 | 36 | 28 |
| Vertical Grade Control | 9300 & 4800 | 13.0 | 6.0 | 0.0003 | 230 | 0.24 | | 5:1 | Type C 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Bypass Outlet Weir | 136 | 13.0 | 5.2 | 0.00075 | 240 | 0.61 | | 5:1 | Type C 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Downstream Lateral Stability Structure | 27,575 | 17.8 | 6.5 | 0.00032 | 800 | 0.36 | | 3:1 | 12 | 10 | 7 | 24 | 20 | 12 | 36 | 30 | 34 |
| Flow Augmentation Weir | 28,203 | 16.8 | 6.8 | 0.0006 | 150 | 0.63 | | | Recommend 1.5-2.0-ft riprap where concrete wall ties into bank. | | | | | | | | |



Return to TOC

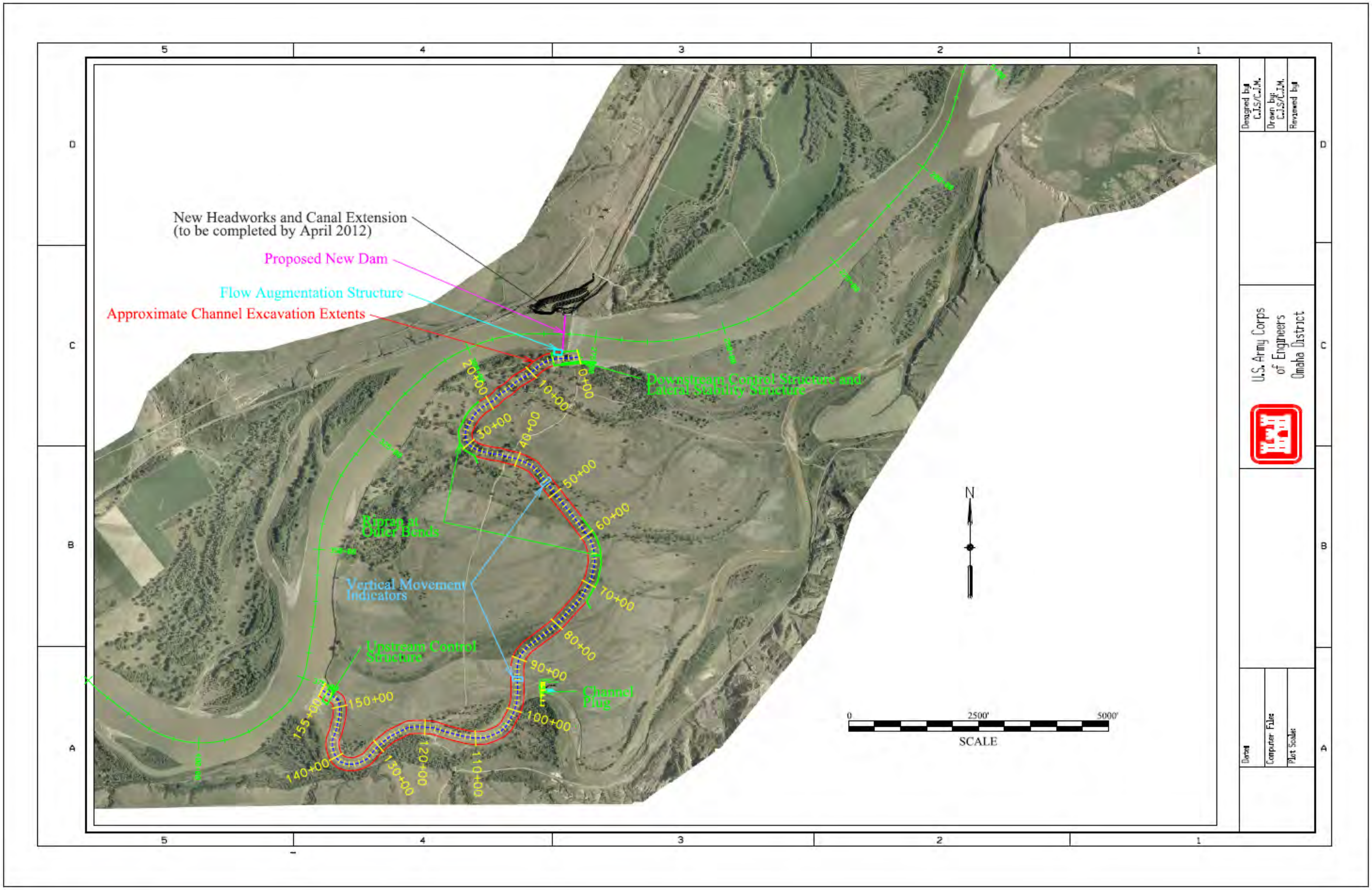



Figure 1. Map of preferred Intake Dam bypass plan as of Jan. 5, 2012 showing structural components.



Return to TOC

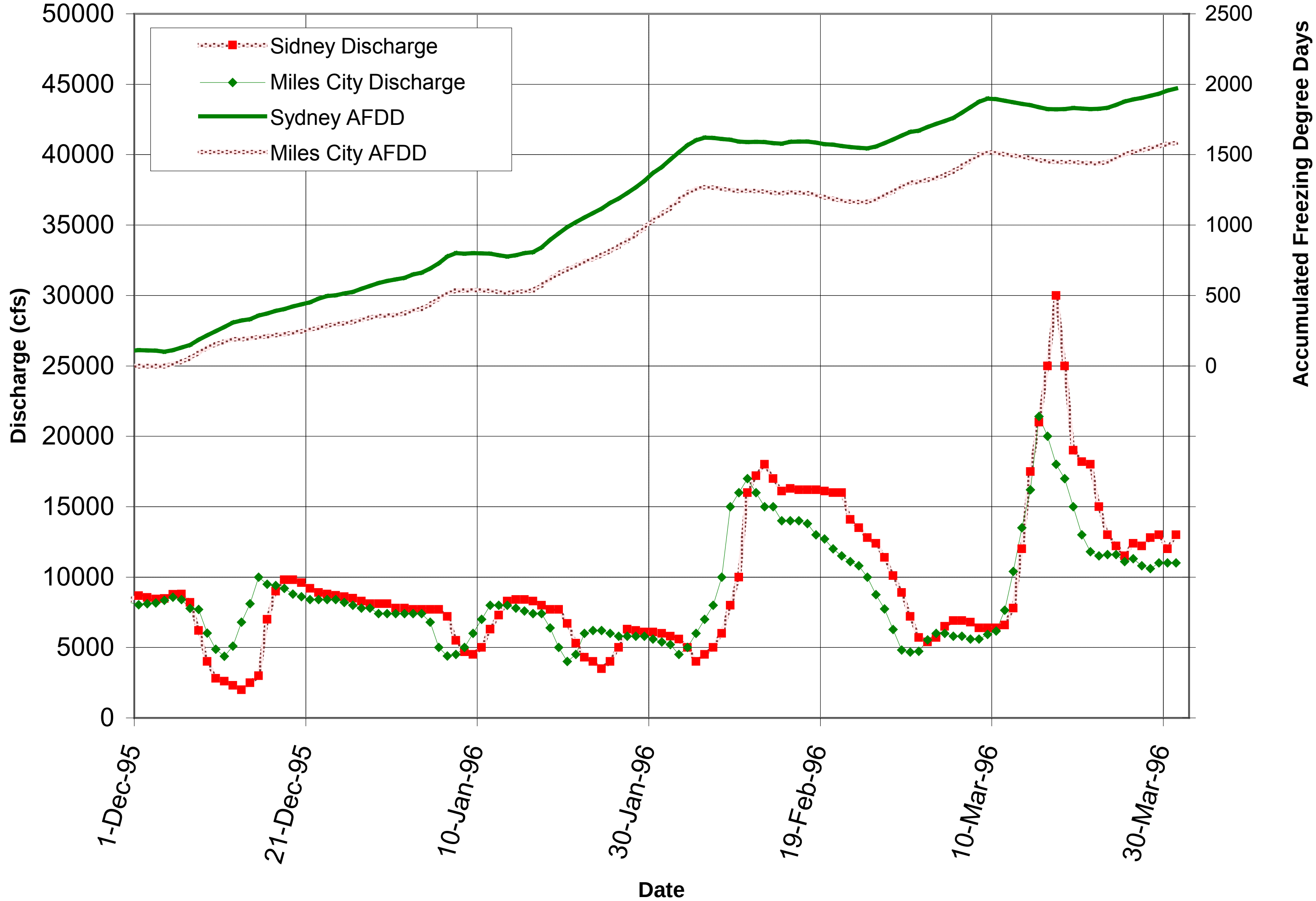



Fig. 2. Yellowstone River discharge and AFDD for the winter of 1996



Return to TOC

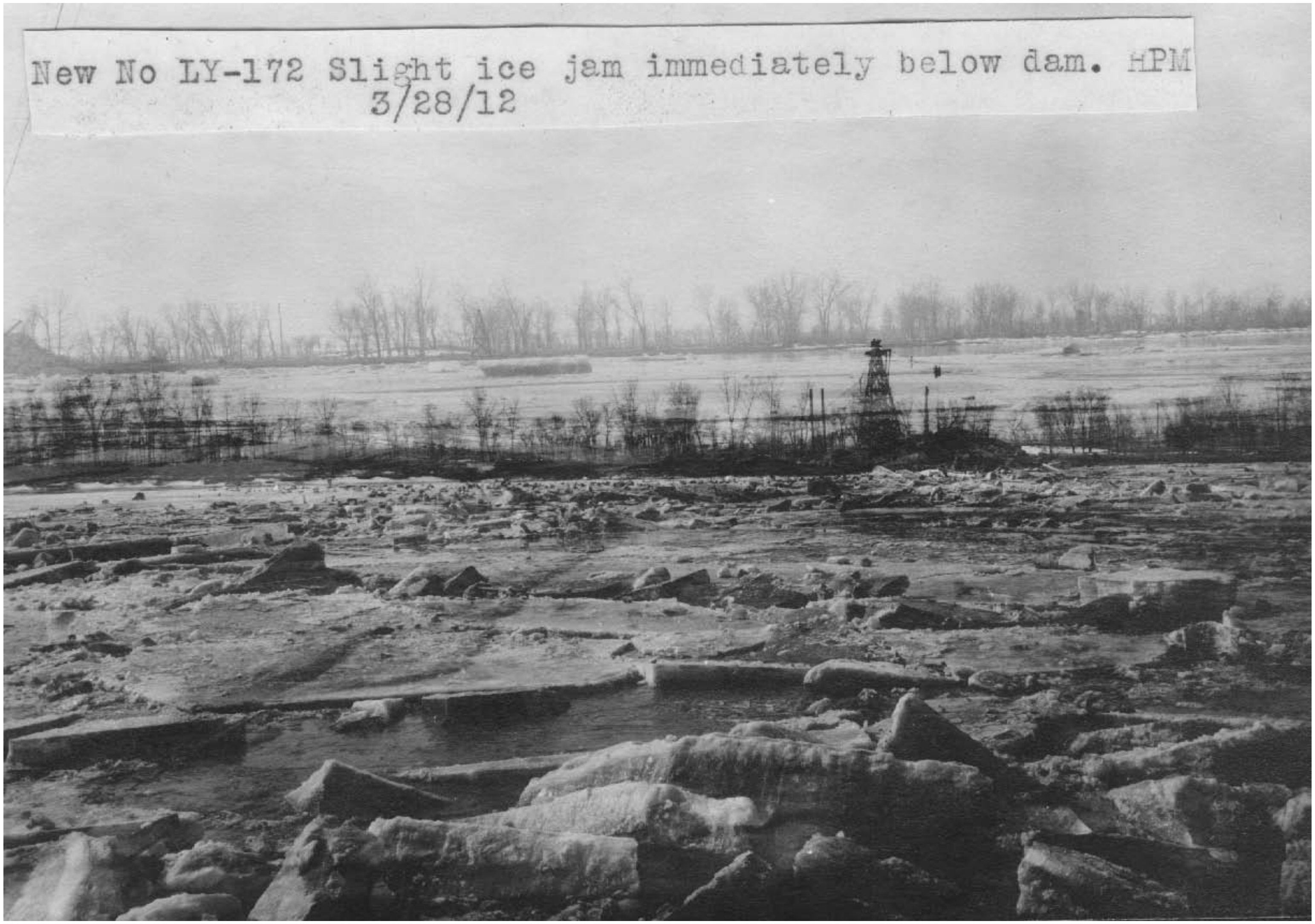



Fig. 3. Ice jam on the Yellowstone River at the Intake in 1912 forcing flow and ice into the right overbank area.



Return to TOC

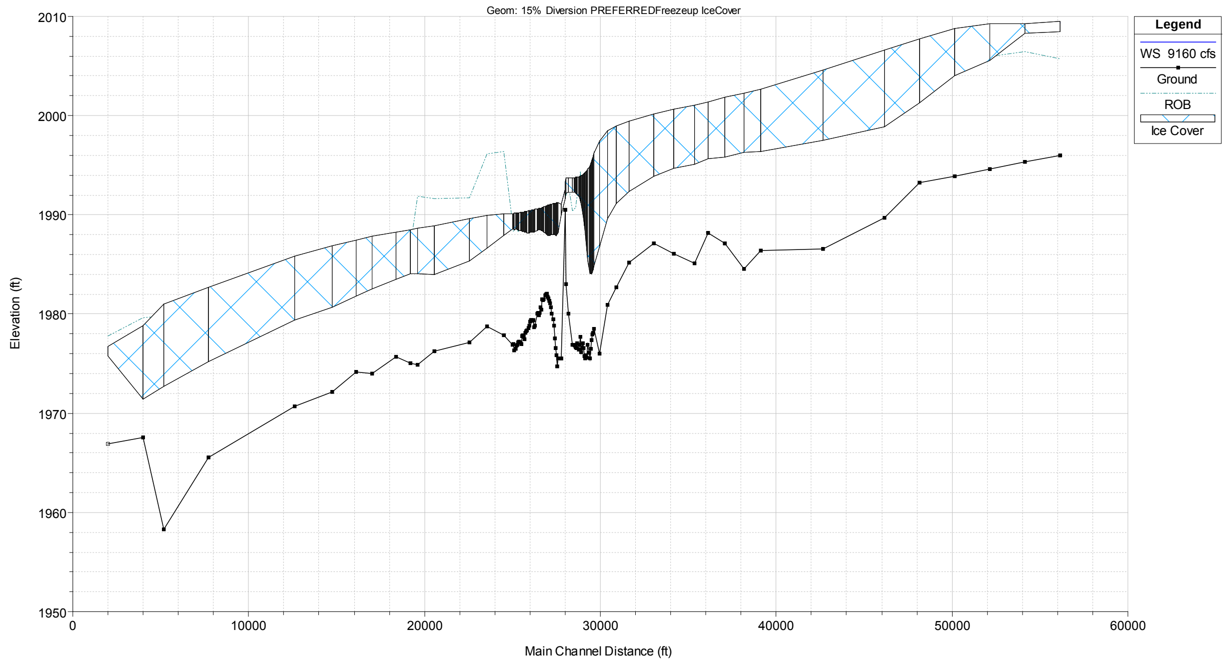



Fig. 4a. Freezeup ice accumulation on main river. $Q_{river}$ = 9160 cfs with 15% passing the bypass channel. $n_{ice}$ = 0.04, porosity = 0.4, $V_{eros}$ = 5 ft/s.

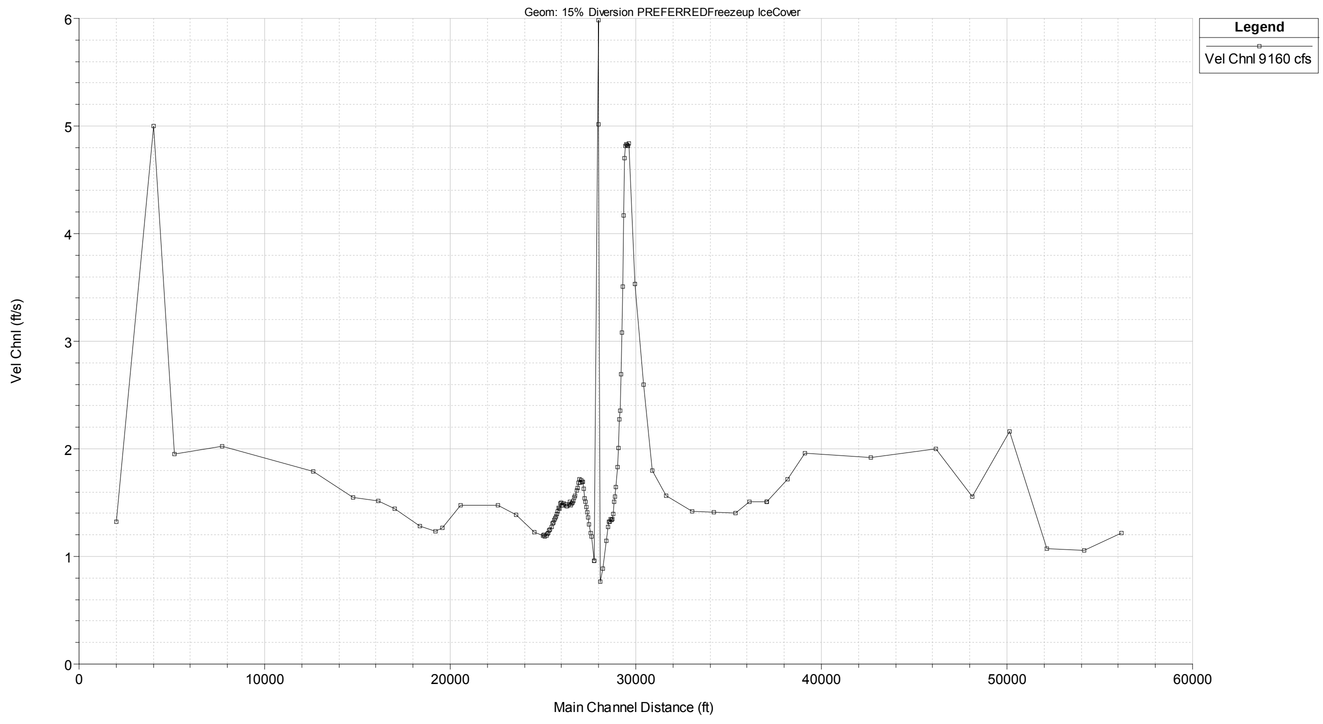



Fig. 4b. Average channel velocity in main river with freezeup ice accumulation. $Q_{river}$ = 9160 cfs with 15% in the bypass channel



Return to TOC

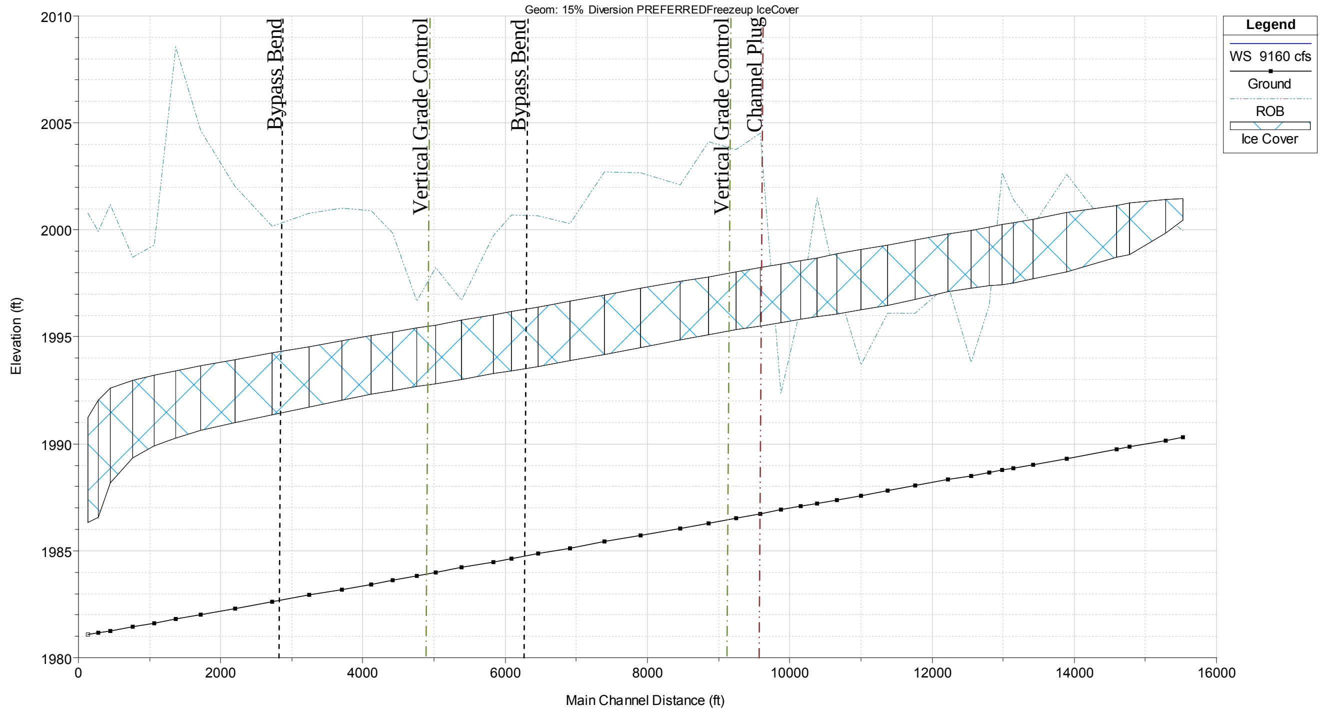



Fig. 5a. Freezeup ice accumulation on bypass channel with 15% diversion. $Q_{river}$ = 9160 cfs with 15% passing the bypass channel.
$n_{ice}$ = 0.04, porosity = 0.4, $V_{eros}$ = 5 ft/s

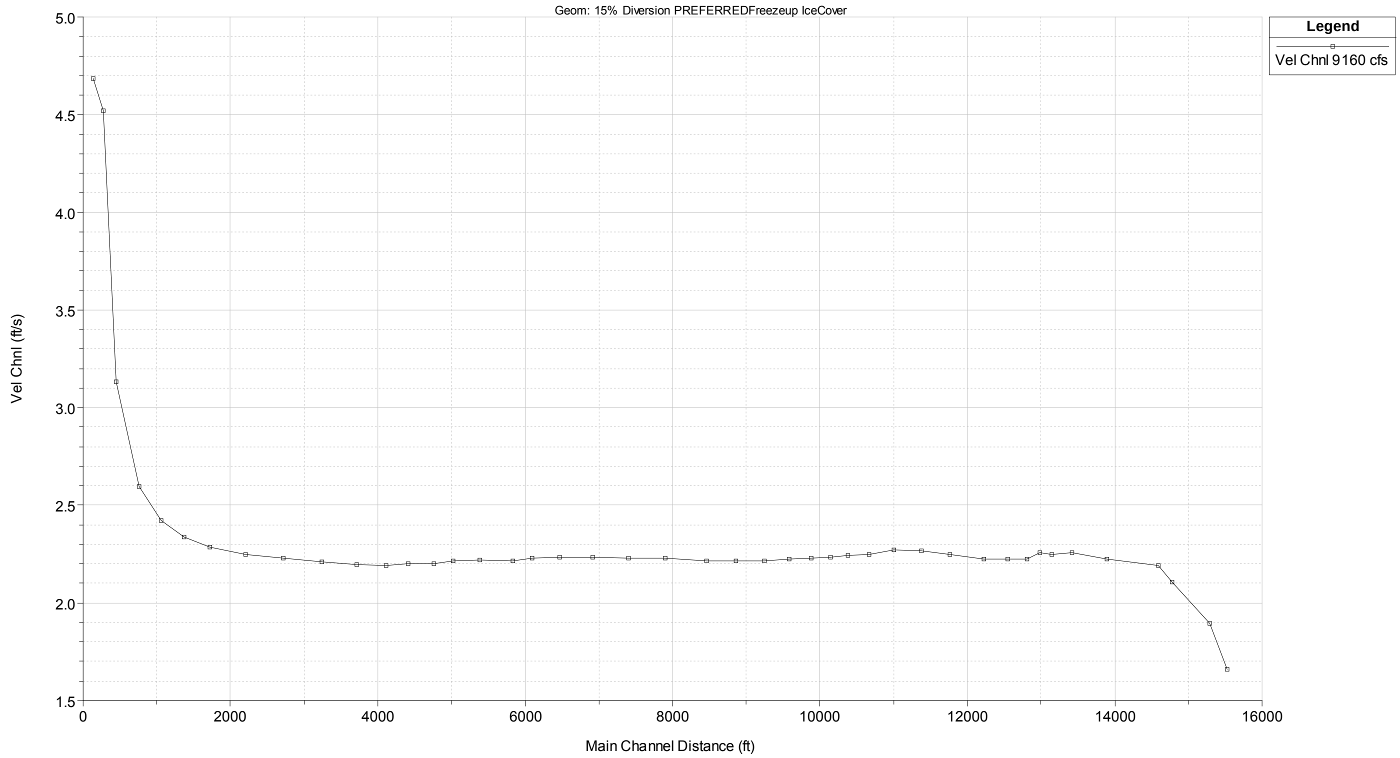



Fig. 5b. Average channel velocity in bypass channel freezeup with ice accumulation. $Q_{river}$ = 9160 cfs with 15% passing the bypass channel.



Return to TOC

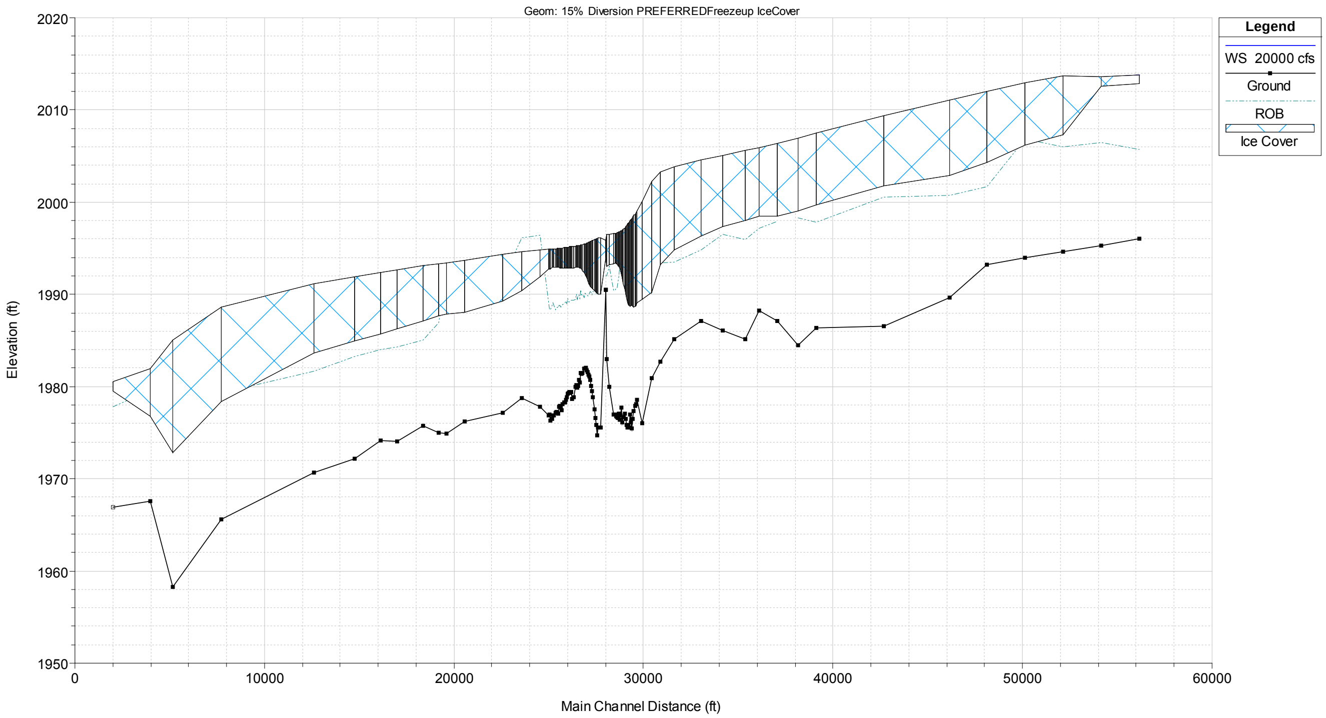



Fig. 6a.. Pre-breakup ice accumulation on main river. $Q_{river}$ = 20,000 cfs with 15% diversion ($Q_{bypass}$=2600 cfs). $n_{ice}$ = 0.04, porosity = 0.4, $V_{eros}$ = 5 ft/s.

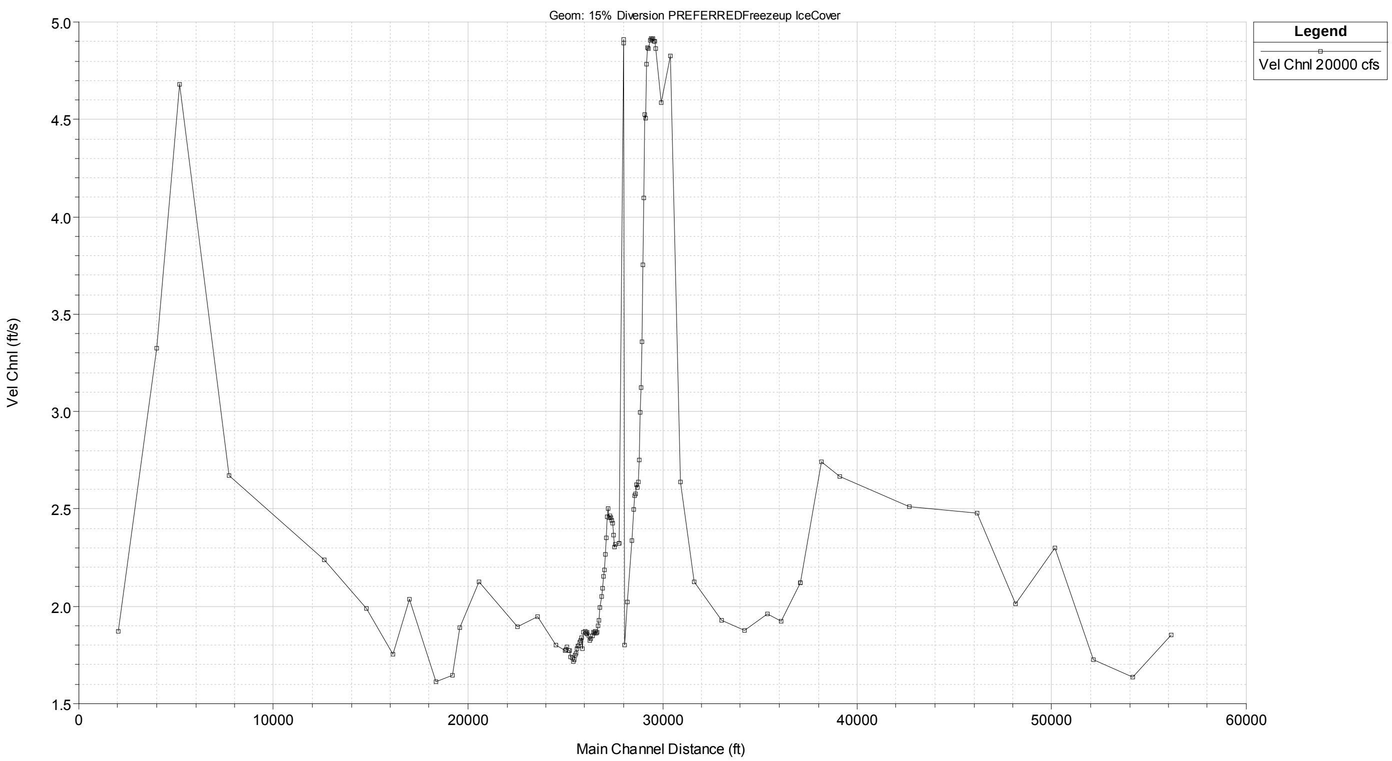



Fig. 6b. Average channel velocity in main river with pre-breakup ice accumulation. $Q_{river}$ = 20,000 cfs with 15% diversion ($Q_{bypass}$=2600 cfs).



Return to TOC

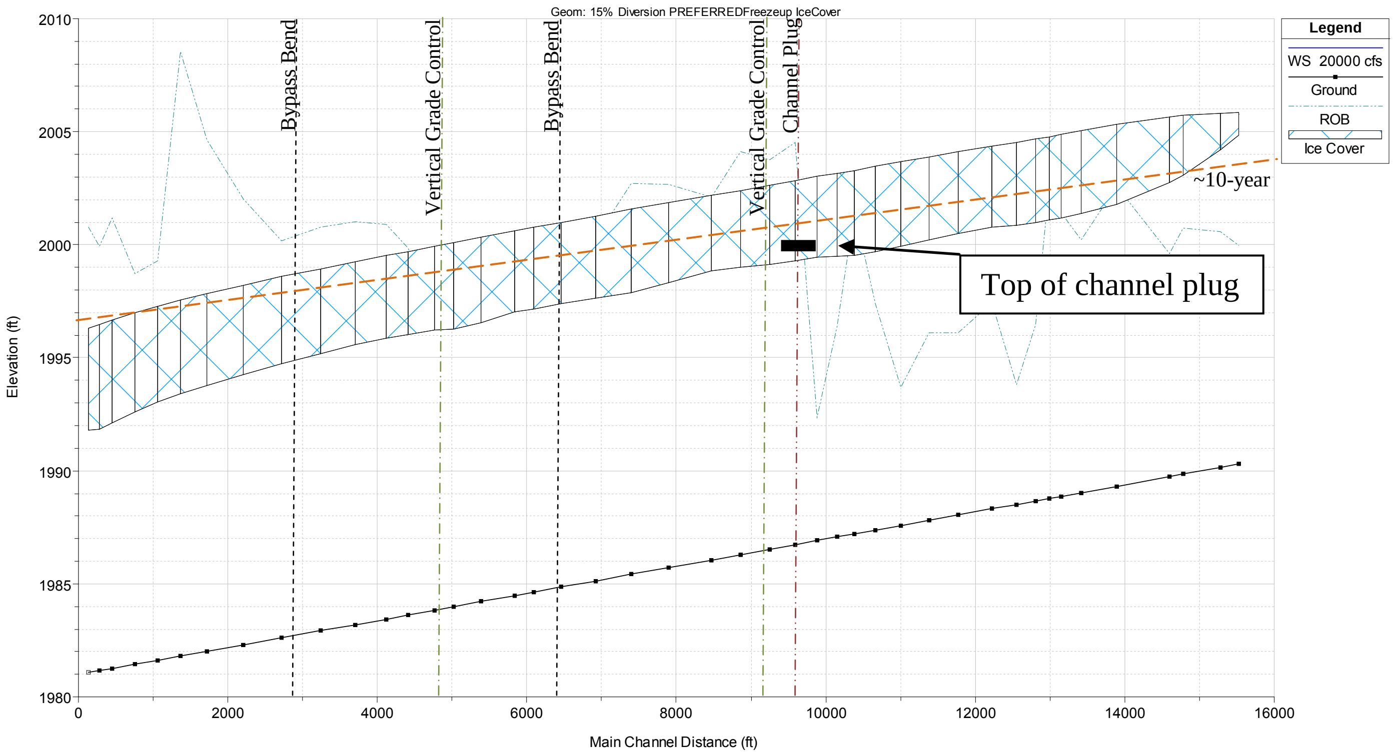



Fig. 7a. Pre-breakup ice accumulation on bypass channel. $Q_{river}$ = 20,000 cfs with 15% diversion ($Q_{bypass}$=2600 cfs) $n_{ice}$ = 0.04, porosity = 0.4, $V_{eros}$ = 5 ft/s. 10-year elevation indicated by orange dashed line.

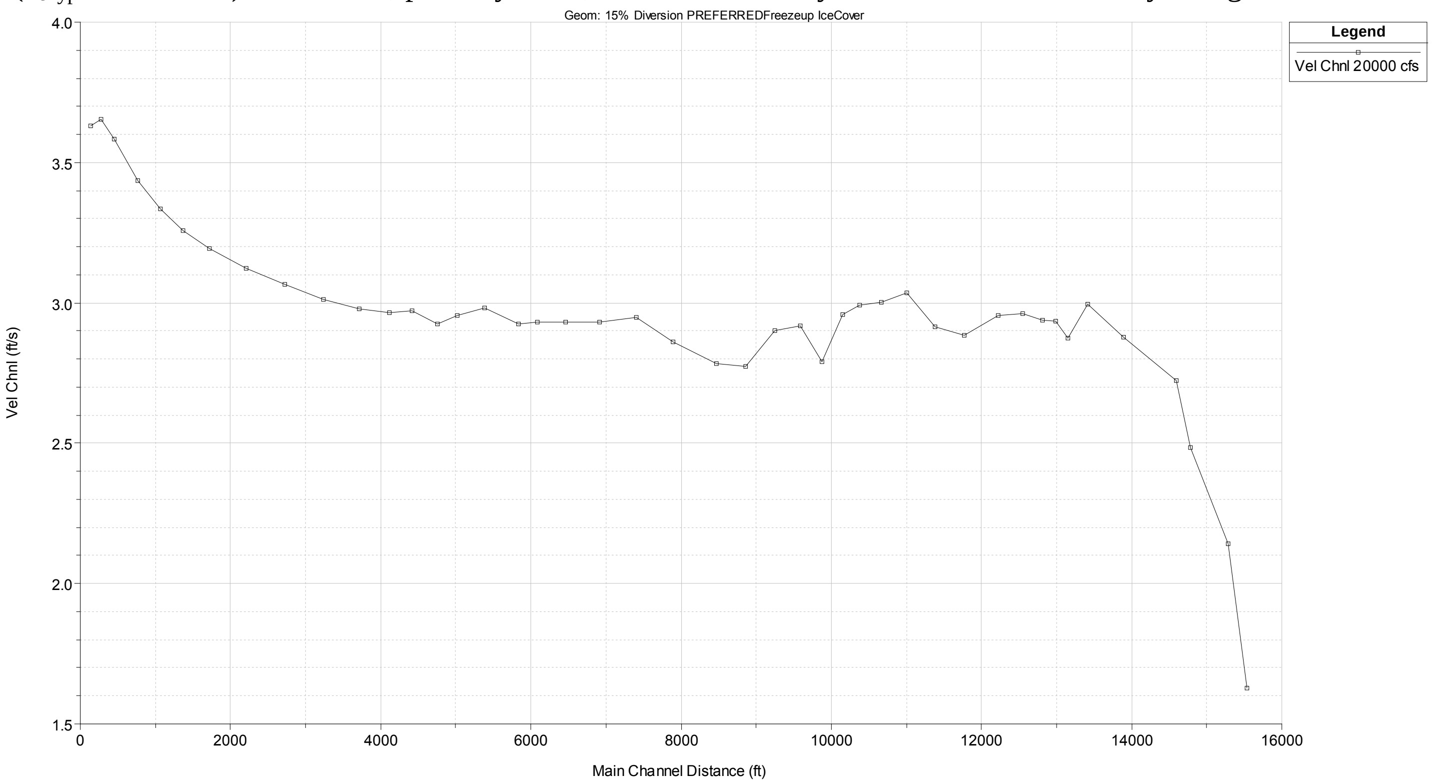



Fig. 7b. Average channel velocity in bypass channel with pre-breakup ice accumulation. $Q_{river}$ = 20,000 cfs with 15% diversion ($Q_{bypass}$=2600 cfs).



Return to TOC

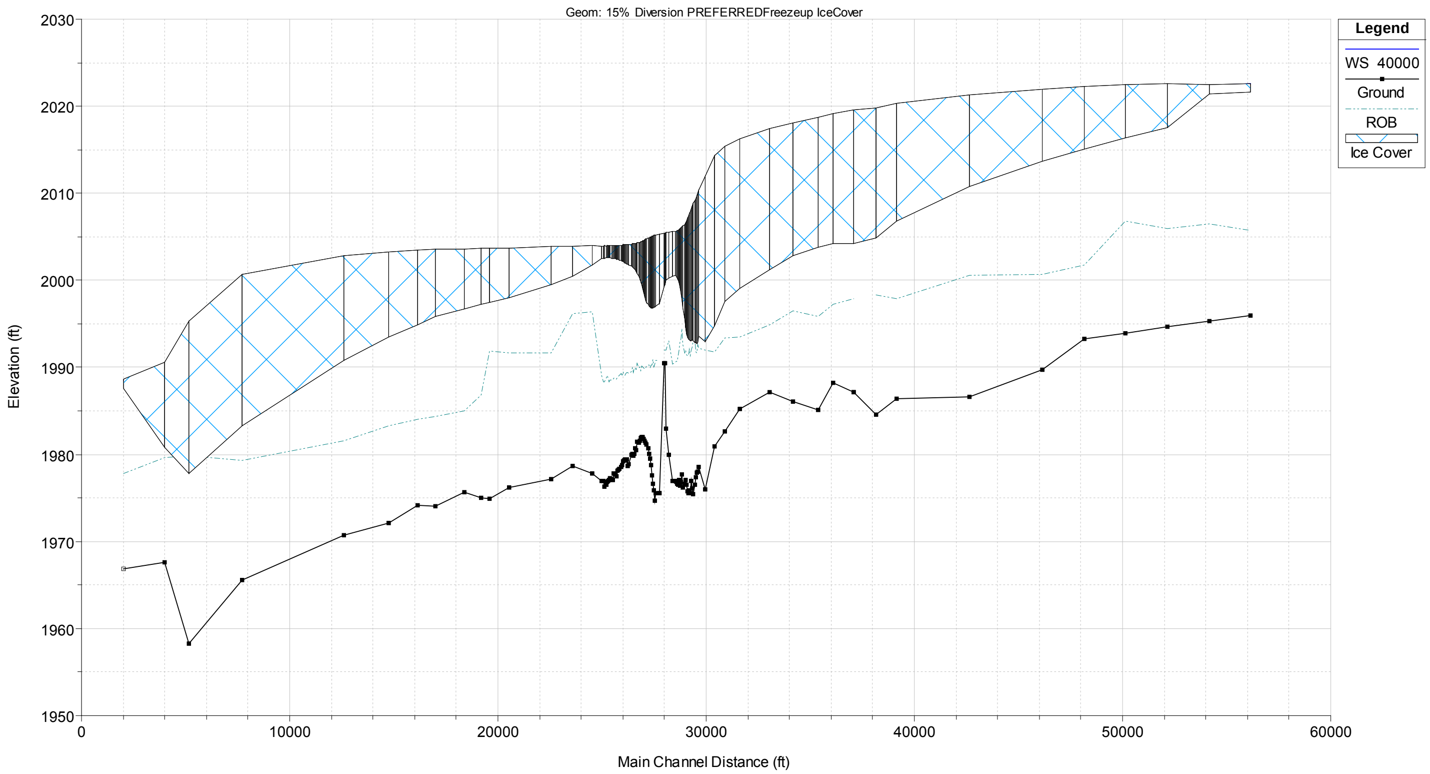



Fig. 8a.. Breakup ice jam on main river. $Q_{river}$ = 40,000 cfs with 15% diversion ($Q_{bypass}$=5200 cfs). $n_{ice}$ = 0.08, porosity = 0.4, $V_{eros}$ = 5 ft/s.

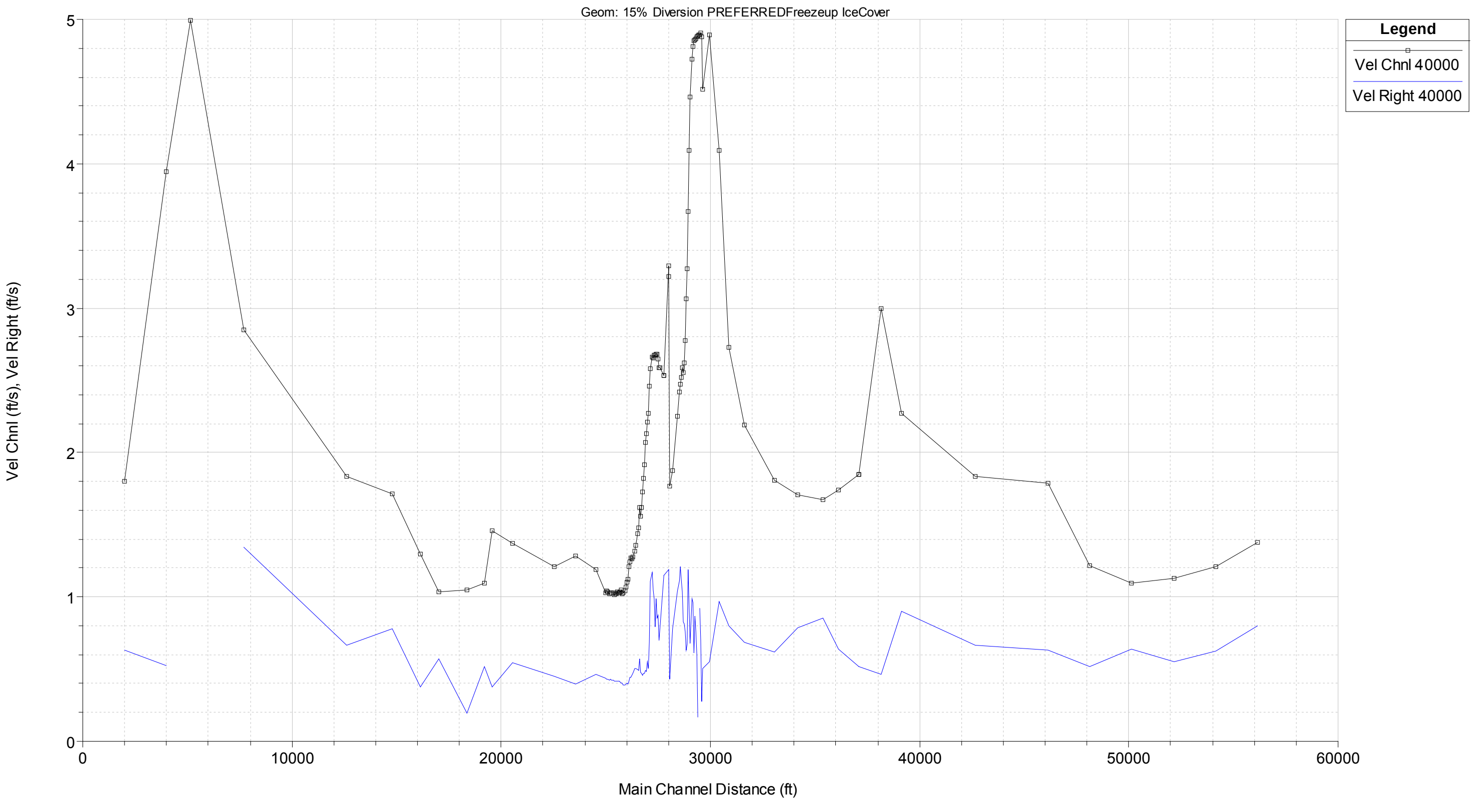



Fig. 8b. Average channel velocity in main river and right overbank with breakup ice jam. $Q_{river}$ = 40,000 cfs with 15% diversion ($Q_{bypass}$=5200 cfs).



Return to TOC

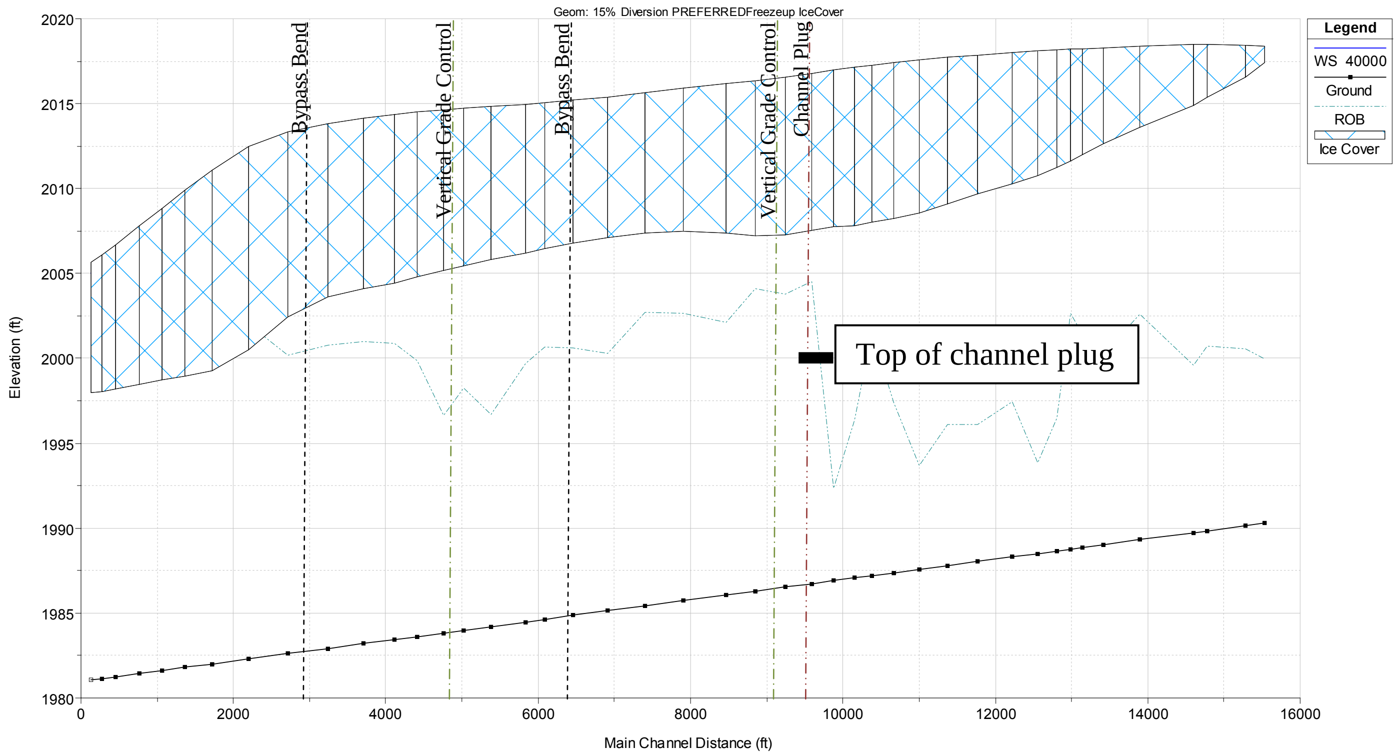



Fig. 9a. Breakup ice jam on bypass channel. $Q_{river}$ = 40,000 cfs with 15% diversion ($Q_{bypass}$=5200 cfs). $n_{ice}$ = 0.08, porosity = 0.4, $V_{eros}$ = 5 ft/s.

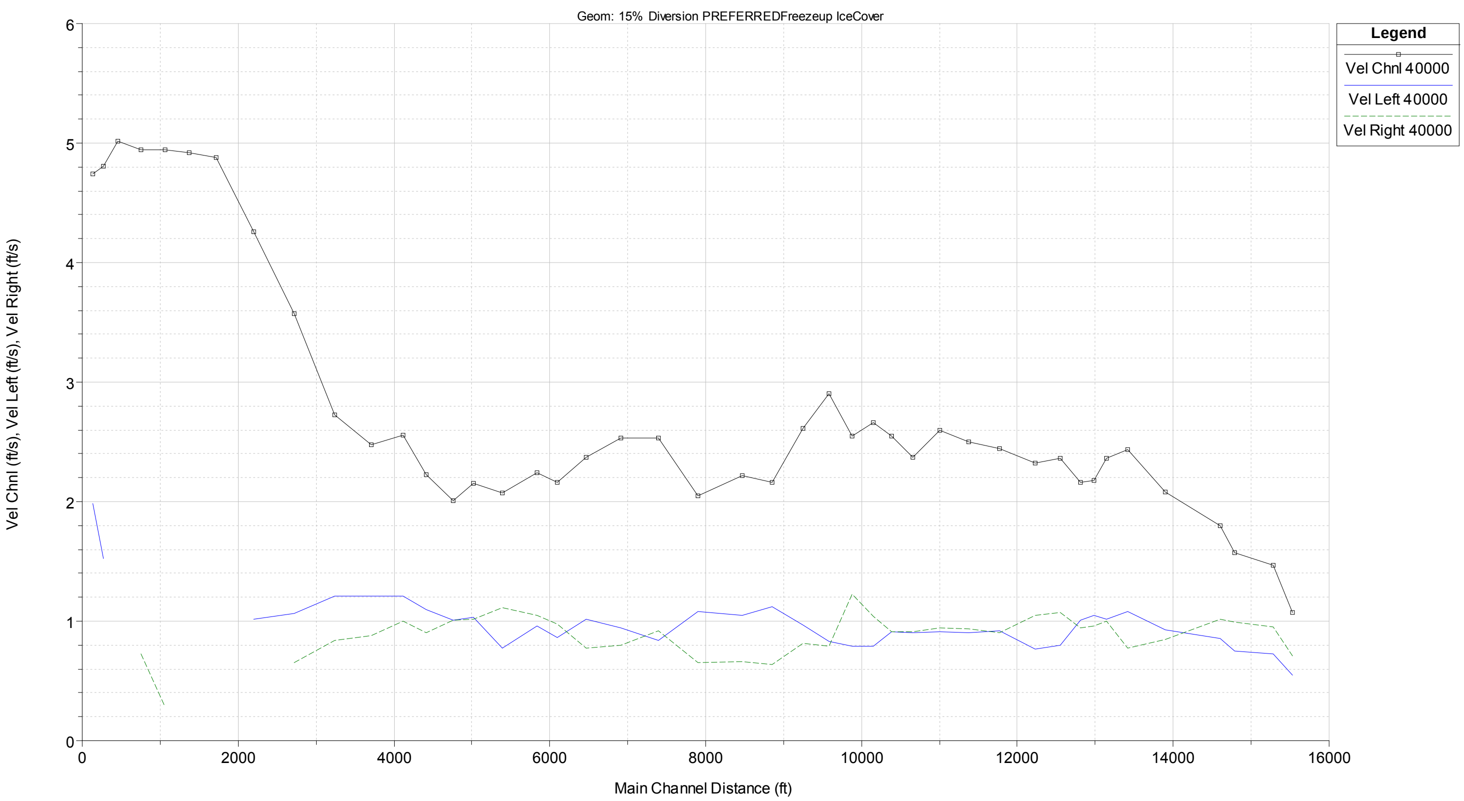



Fig. 9b. Average channel velocity bypass channel and overbanks with breakup ice jam. $Q_{river}$ = 40,000 cfs with 15% diversion ($Q_{bypass}$=5200 cfs).



Return to TOC

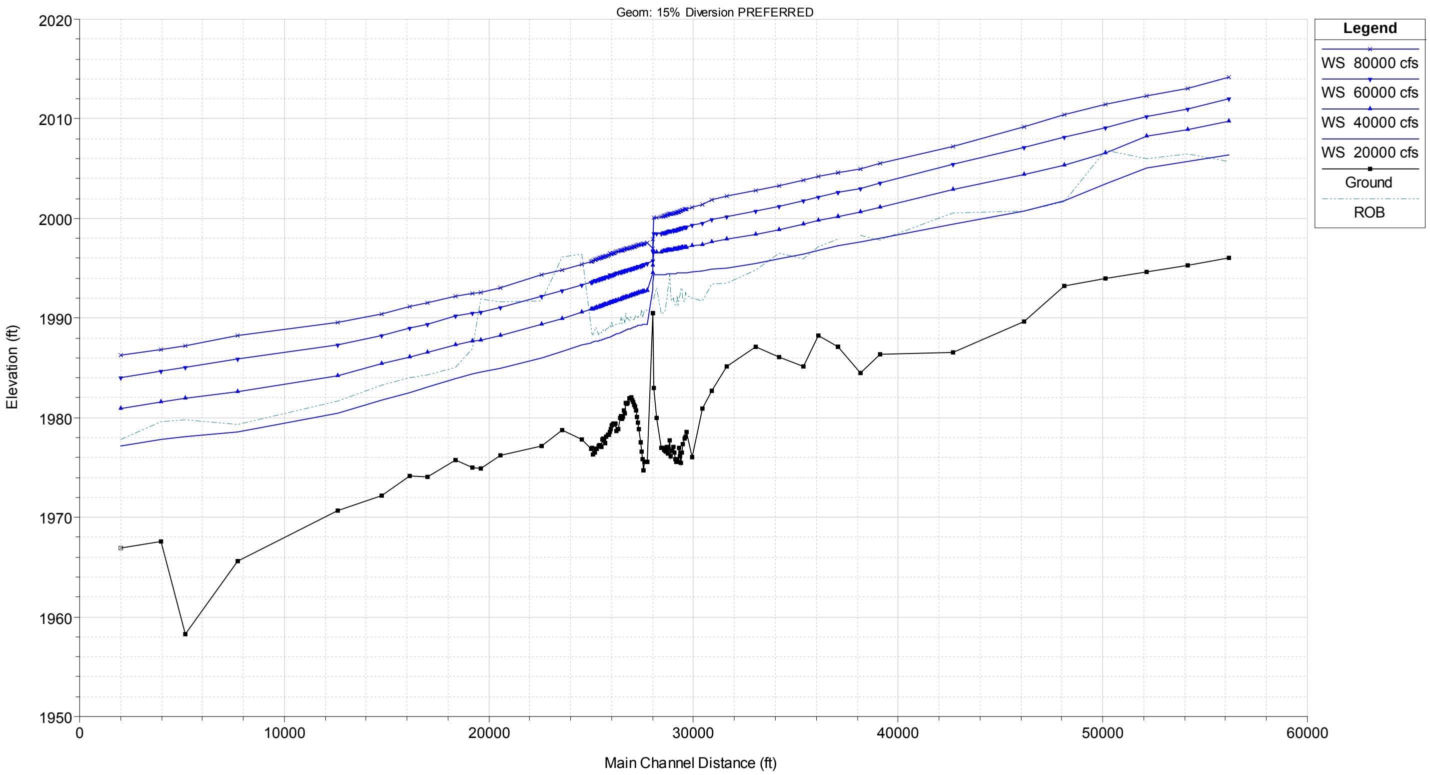



Fig. 10a. Open water surface profiles for river flows of 20, 40, 60 and 80 Kcfs with 15 % diversions.

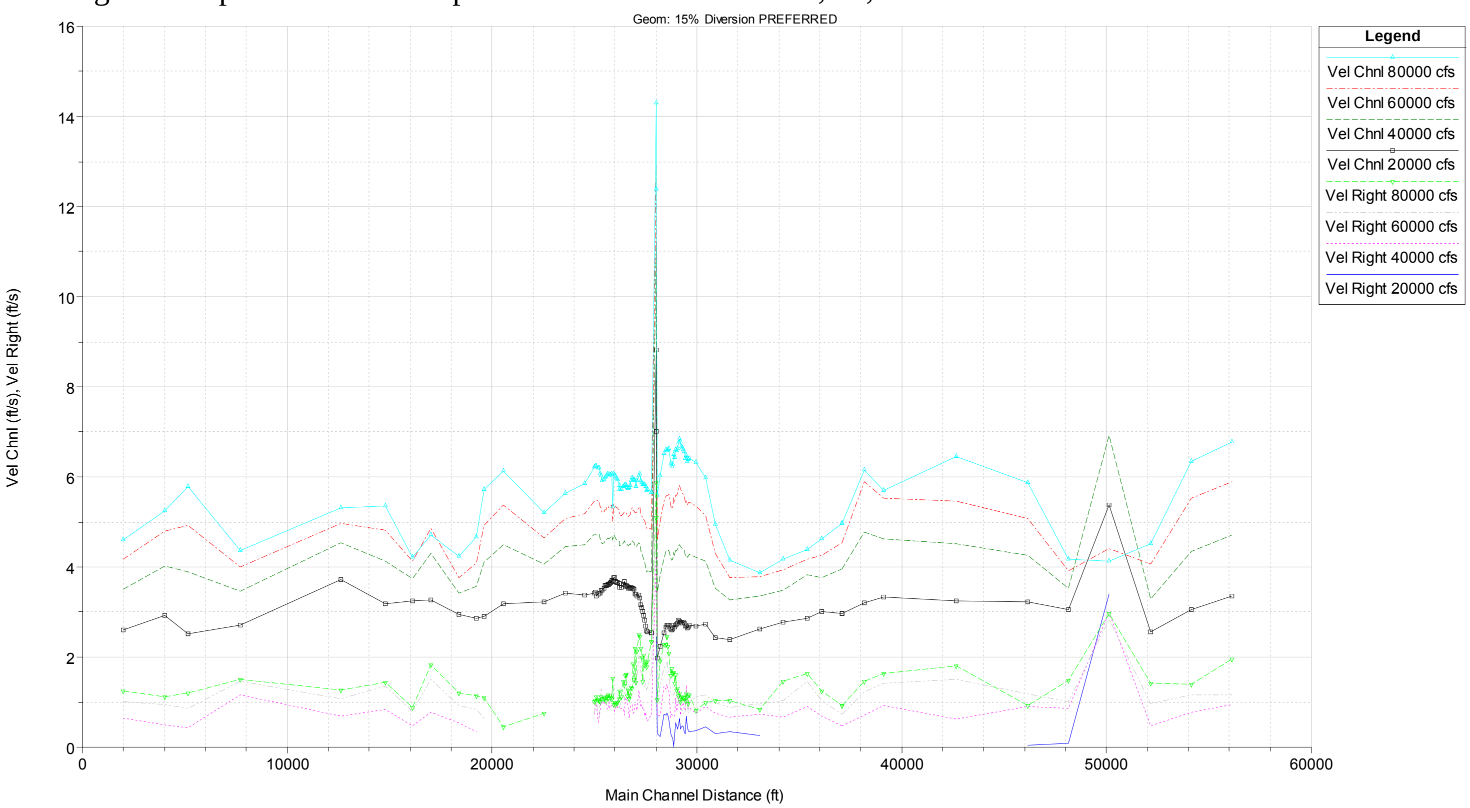



Fig. 10b. Average water velocity in the river channel and right overbank for river flows of 20, 40, 60 and 80 Kcfs with 15 % diversions.



Return to TOC

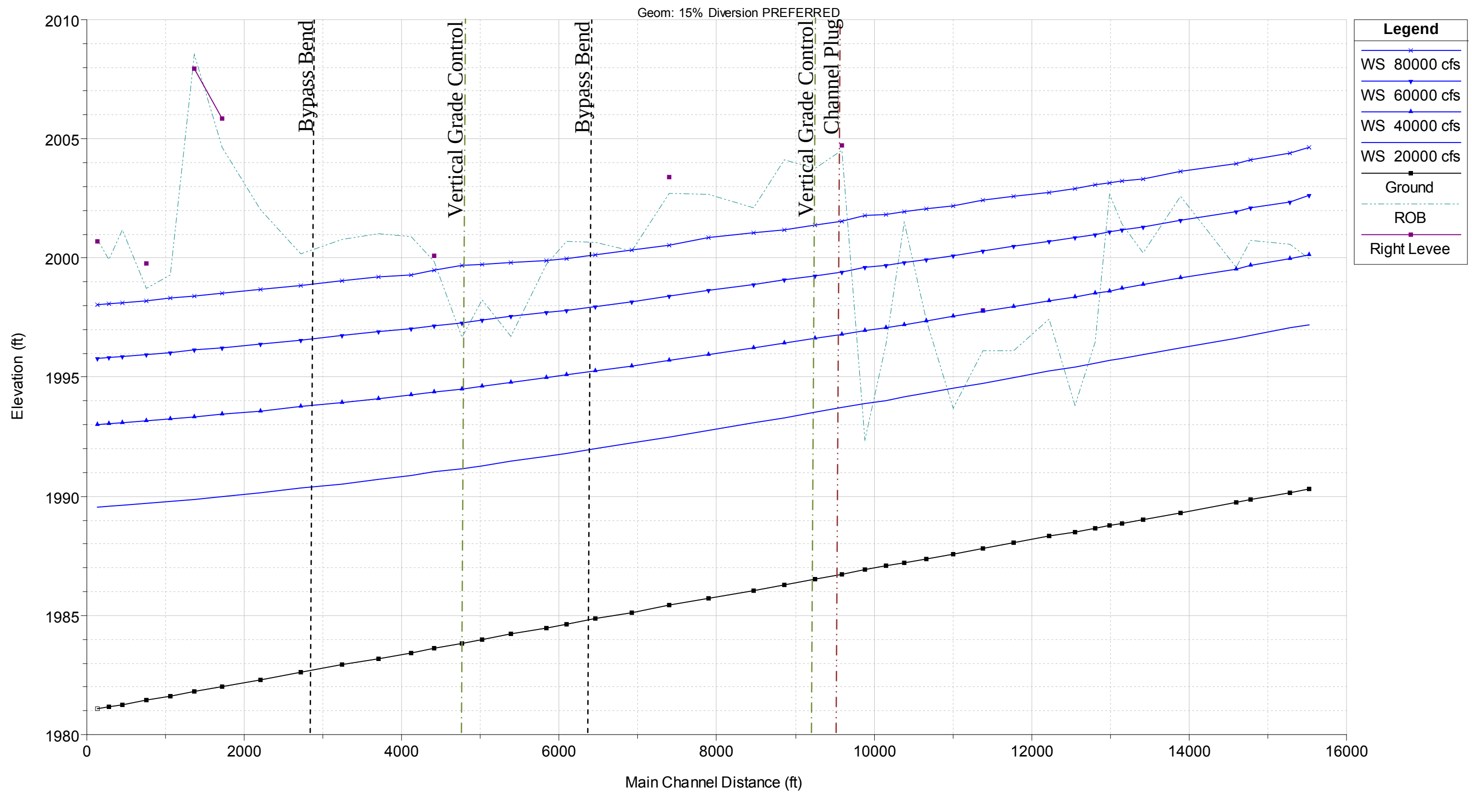



Fig. 111a. Bypass water surface profiles for river flows of 20, 40, 60 and 80 Kcfs with 15 % diversions.

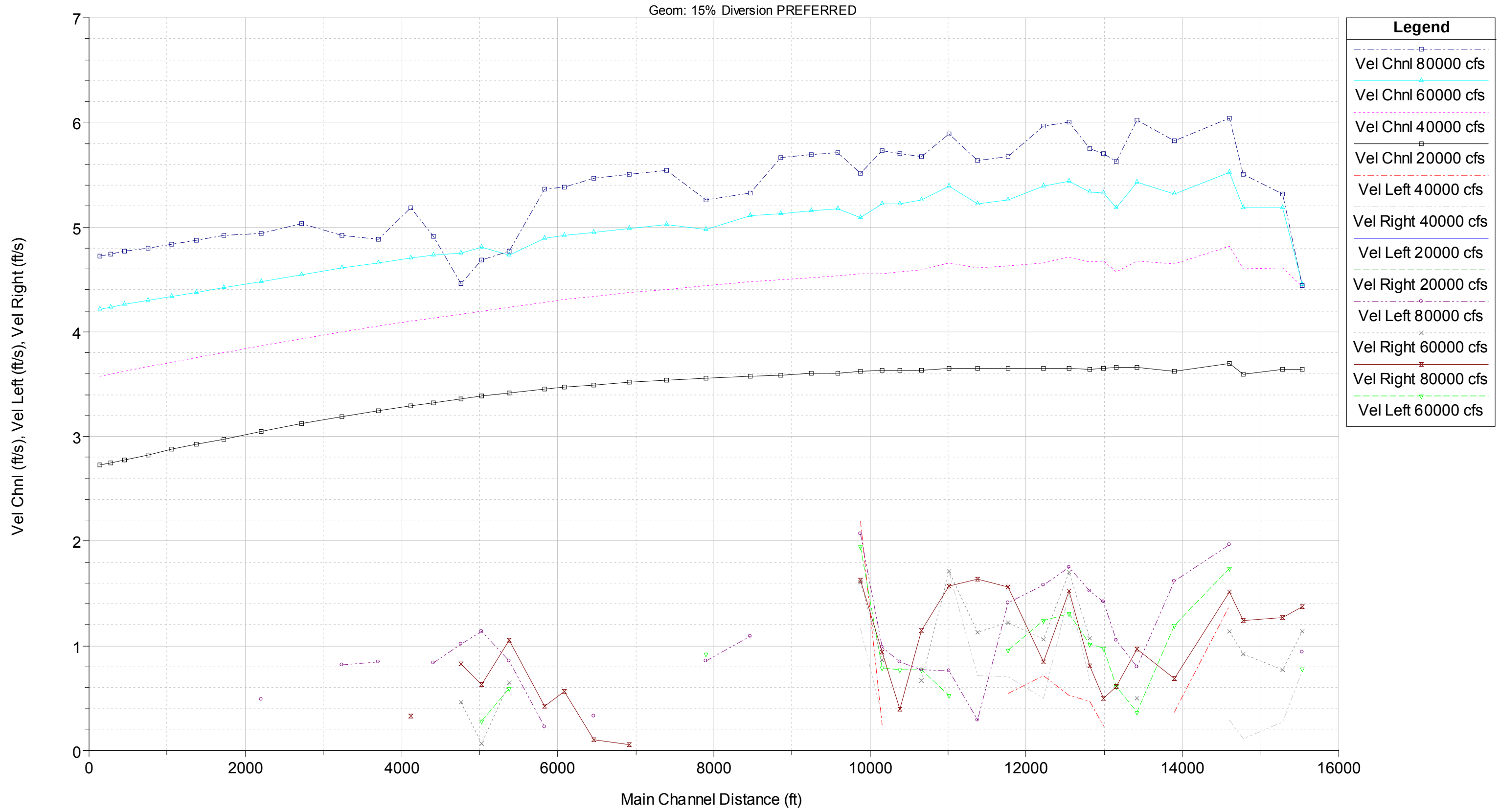



Fig. 11b. Average water velocity in the bypass and overbanks for river flows of 20, 40, 60 and 80 Kcfs with 15 % diversions.



Return to TOC

# Intake Diversion Dam Modification
# Lower Yellowstone Project, Montana

## Intake Fish Passage Option Evaluation Summary
## May 2012

## Attachment 2

## Fish Transport Overview



Return to TOC

# Fish Transport Overview
# May 2012

## 1. Introduction.

This document provides an overview of the potential application of fish transport at the Intake Diversion Dam Modification project. Prior to the Missouri River Basin Interagency Roundtable (MRBIR) meeting in Denver on Jan 10, 2011 COE leadership expressed interest in the potential for physically relocating fish above the dam as a short term method of preventing near term extirpation of the Yellowstone wild pallid sturgeon. Leadership of both USFWS and Reclamation responded positively to the idea at MRBIR.

In order to provide agency leadership with the information necessary to make an informed decision on whether to initiate trap and haul at Yellowstone project team members were solicited for information. Informal discussions held between the COE PM and some members of the Yellowstone Intake Project Delivery Team and members of the Biological Review Team suggest that there may be some usefulness for the idea as an efficacy test but as a management tool, especially long term, fish transport is of limited to no value. Development of written responses by staff level personnel pertaining to trap and haul was limited as many non-COE team members felt that the response to the question needed to be generated at an agency policy level. To date Montana Fish Wildlife and Parks (MtFWP) is the only agency providing official comments with an official response from USFWS currently under development.

In summary:

- Fish transport options were evaluated as a possible cost effective solution
- Project Delivery Team, Biologic Review Team, and stakeholder agency input was solicited
- Consensus is that fish transport is not recommended as either a short term or long term option
- There may be some value in fish transport as short term ramp effectiveness evaluation, however, any test would need a detailed implementation plan to examine all population issues of both hatchery and wild pallid sturgeon

The specific questions posed by John Hartley, the COE PM, related to catch and haul can be found below with summaries of responses, official and unofficial, received to date.

## 2. General Response

The Yellowstone Intake project was formulated to achieve multiple goals including providing volitional passage for pallid sturgeon and other aquatic species. Providing this passage would address both Reclamation's responsibilities at Yellowstone as well as COE BiOp requirements associated with the Missouri River, could provide for curtailing the yearly action of dumping rock on the dam and could provide for downstream recreational boat passage and possibly upstream jet boat passage (boat passage was a big issue during the Lewis and Clark bicentennial but has not been a design consideration to date {Mefford Reclamation personal comm.}). Trap and haul fails to meet any of these goals as a short term or long term proposal.

Among fish passage experts, trap and haul carries a stigma worldwide largely because it interrupts and can alter volitional movement of the species. Other notable concerns include the handling process imparts stress to the fish that can result in direct or delayed mortality and every step of the process requires considerable skilled labor. Well designed trap and haul facilities can be a very effective, but always carry a significant risk of problems arising that can result in fish mortality. This is of particular concern for long lived species where spawning adults are few and highly valued.

A more politically oriented concern addressed the issue that if management groups studying either wild populations or hatchery fish have to staff up to conduct a temporary trap and haul program the newly created jobs would then be on the line should the temporary program be discontinued. That could result in temporary programs becoming quasi-permanent.

## 3. Specific Questions.

Specific questions discussed and are summary of agency response are provided in the following sections.

1) **Is transporting pallid sturgeon over Intake Dam a viable long/short term management tool for the species at this location. Why or why not?**

General responses to the question indicated that pallids can be caught and physically transported, potentially without disrupting reproductive behavior. Limited numbers of wild population pallids in the lower Yellowstone and the sexual immaturity of the hatchery fish in the river limit the effectiveness of the project.

Specific reasons documenting that transport of pallid over the dam as a management action for this project is not considered viable are as follows:

A) The passage objective requiring that pallid sturgeon can move unimpeded upstream of Intake Dam will not be achieved using Catch and Haul.

B) The population recovery objective showing that the population is on track to becoming self-sustaining will not be achieved using Catch and Haul.

C) Evaluation of the conservation stocking program utilizing a captive broodstock indicates that age-specific survival rates, population abundances and stocking rates are adequate to prevent near term extirpation of the species in the reaches of the Missouri and Yellowstone rivers impacted by this project. Additional management strategies involving Trap and Haul are not considered necessary.

D) Biologically catch and haul would be introducing stress and potentially causing direct and indirect impacts to the pallid life history that may reduce the fitness of the population overall. It was noted that fish behavior in response to stressors can vary widely by individual and may differ by sex, age class, spawning condition and probably many other factors. Experience with physically handling pallids described by scientists at the COE Gavins Point Project is that pallids can be captured and tagged and spawning is still seen within a couple of weeks. In addition pallid sturgeon were relocated hundreds of miles to hatcheries where they have a fairly high success rate of spawning after transport. The COE Gavins Point scientists do not think transporting fish short distances would adversely affect their ability to spawn in the river, but they also admit there are uncertainties associated with the proposed action that will not be understood until this approach is further evaluated. Other studies show where in tagging studies of white and green sturgeon caught on the Sacramento as part of the GCID rock ramp evaluation study, over 50 percent of the sturgeon caught during their migratory period, tagged and then released some distance downstream of the rock ramp failed to move upstream. How much their movement behavior



Return to TOC

following restocking was due to handling was uncertain (Mefford, Reclamation, personal communication).

E) The logistics of trap and haul may be complicated and costly considering numbers of the native population are low and pallid behavior is not well understood and is far from predictable. Conducting a viable trap and haul operation for wild adult pallid would be challenging and involve considerable risk to the small population of wild adults remaining. For trap and haul operations conducted on other rivers a facility similar to the entrance to a fishway that provides adequate attraction conditions to guide fish into the trap area is built close to the barrier. Attraction requirements for a trap are likely to be very similar to those required for a bypass channel. A trap facility could require infrastructure including a deep structural channel with numerous gates that allow flow to pass through or around the trap, a hoist, trunk loading area, pumps for water supply, lighting, and good access, all protected for floods and ice. Trap facilities are typically manned seven days a week during the spawning season. Therefore, onsite provisions for personnel are probably necessary. Following trapping, fish must be removed from the trap and loaded into a transport truck for transport to restocking sites which must allow good access under all river and weather conditions, lighting and possibly a pumped non-potable water supply. The minimum infrastructure alternative is to hunt for individuals in the river and capture them which works for tagging experiments but probably will not be efficient enough of a process to be used as a spawning relocation management tool.

F) Ecologically, transporting pallid over the dam regularly (without allowing passage of the rest of the biological community) may affect the balance of the aquatic environment above Intake Dam.

2) **Is transporting reproductively ready pallid sturgeon over Intake Dam a worthwhile efficacy test of larval drift and the need to provide fish access above the existing Yellowstone structure? Why or why not?**

Results from efficacy tests utilizing trap and haul need to be considered in light of potential effects the relocation process had on the fish. Information about how the pallids will respond when naturally negotiating an implemented passage option will not be derived from a catch and haul program.
Gavins Point Project scientists have responded that a well designed short-term research effort could provide the information to alleviate many of the uncertainties that exist with passage at Intake including:

- Will pallid stay above the structure
- Will pallid sturgeon spawn successfully above the Intake structure?
- Will eggs be fertilized and develop?
- Will eggs hatch?
- Will larvae begin to drift?
- Is drift distance sufficient to support recruitment?

A summary of several studies evaluating the impact of increased larval drift and provision of pallid passage above Yellowstone intake was provided by MtFWP. The summary conclusion of the studies was that provision of passage and access to the spawning habitat above the structure is likely to be the best and most viable alternative for restoring a self-sustaining pallid population in the Great Plains Management unit. An Independent Review of the Science panel contracted for by Reclamation (Nov 2009, Jan 2010) has already addressed a number of the questions raised by the Gavins scientists and concluded that "additional analysis or research may marginally reduce



Return to TOC

uncertainties regarding the probability of success but is not likely to lead to fundamentally different conclusions, the true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response."
Additional considerations related to the difficulty in getting useful data from an efficacy test using trap and haul include:

a) it will likely take significant numbers of spawning surgeon above the dam to produce enough larvae in a large river to be able to identify impacts on juvenile sturgeon recruitment.
b) what is the impact of the existing dam on larval drift and larval mortality due to turbulence, direct impact of larvae on rocks and predation?
c) How is the impact of the backroller at the toe of the dam on drift accessed?

**3) Pallid sturgeon has been stocked above intake in the past. What is the status of that population and do/will the activities of that population provide the spawning and larval drift information that would be obtained by a new fish relocation plan thus negating the need for an additional phase of relocation.**

The pallid sturgeon were stocked in the Yellowstone River between 2004-2010. These fish would not be able to provide information in regards to spawning and larval drift until they have reached sexual maturity (2016-2020)

The following information on pallid stocking comes from an email from George Jordan of the USFWS:

50 yearling pallid sturgeon equipped with radio transmitters were released near Forsyth in 2004. Some remained in this reach while others dropped down to below Intake.

The most relevant fish in relation to the discussion about possible reproductive condition fish above Intake are: the 2006 and 2007 year class fish.

-10,800 fingerlings were stocked in 2007 at two locations; Fallon and Forsyth.

-983 yearlings (2006 year class fish) were stocked in 2007 at Fallon and Forsyth.

-16,282 fingerlings were stocked in 2008 at three locations; Fallon, Miles City and Forsyth.

-2797 yearlings (2007 year class fish) were stocked in 2008 at Fallon and Forsyth.

Monitoring has established that many of the pallid sturgeon stocked in the Yellowstone move downstream into the Missouri River below the Yellowstone River confluence (where they are recaptured as juveniles). Stocked pallid sturgeons have been found to utilize both the lower Yellowstone and Missouri Rivers to some degree, regardless of their stocking location in.

**Notes from Feb. 10, 2011 conversation between Tim Welker (Fish Biologist COE Gavins Point Project) and Ryan Wilson, (field biologist lead for sampling Segment 4 of the Corps' Pallid Sturgeon Population Assessment Program, USFWS-Bismarck) regarding Yellowstone River stockings and pallid captures in (Yellowstone River confluence to headwaters of Lake Sakakawea)**

77% of all recaptures below the confluence(Segment 4) are from YR river stocking sites. The recapture rates in Segment 4 for each stocking site are as follows: Intake=45%; Sidney=19.4%; Fallon=15%; Forsythe=13%; Fairview=6%; Big Sky=<1%; Cartersville=<1% (a few telemetered fish without PIT tags were captured, so these were assumed to be fish stocked at Cartersville).
In 2008, a number (100) of telemetered fish were stocked in the Bighorn River near Billings. These fish have been recaptured in Segment 4.



Return to TOC

The last MTFWP survey report above Intake that Ryan had in his files was for 2008. They sampled above Intake at RM 97 and RM 92. Only 7 pallids were collected and they were fish stocked in 2007. Most of MTFWP sampling is conducted downstream of Intake. The thinking is that most of these juvenile fish eventually move downstream to the lower YR or the Missouri River below the confluence. It is not known if these fish try to move back above Intake, but, of course, there is no way for these fish to access this area once they pass downstream of the dam. The general pattern for adult pallid sturgeon is that they move out of the YR sometime in late June or early July into the MR below the confluence (and headwaters of Lake Sak.; Segment 4) with some fish moving into the MR above the confluence (Dave Fuller MTFWP- Ft. Peck has 6+ years of telemetry data on adult PDSG). MTFWP sampling in the summer focuses on the Sidney and Fairview areas. MTFWP doesn't catch many adults during this time, mainly recently stocked fish. It is not entirely clear if the younger juvenile fish exhibit this same pattern, or they stay in the lower YR or in the MR below the confluence (which is where many of these fish are captured).

**4) Is physical relocation a potential Adaptive Management (AM) tool that could be used to relocate fish congregating at whatever passage structure we come up with but which are refusing to pass?**

No. If we are uncertain about the success of our action, then we should move forward using AM as our management strategy to re-address the passage issue at Intake (assess, design, implement, monitor, evaluate and adjust) to ensure we achieve our project objectives. If we are confident in our action's ability to achieve the desired outcomes, then we should implement our actions within an AM framework until objectives are achieved. The accurate evaluation of passage success criteria (see below) would be adversely impacted by utilization of trap and haul as an AM tool since the long term criteria require documentation for naturally produced juvenile pallids in the lower Yellowstone and trap and haul would introduce a factor of uncertainty in that assessment.

*Success Criteria* USFWS October 23, 2009

Within 4 years after completion of the fish passage and entrainment projects at Intake Dam:

- Document that adult and stocked juvenile pallid sturgeon can move unimpeded upstream of Intake Dam.
- Document that adult and stocked juvenile pallid sturgeon can pass downstream of Intake Dam without being entrained into the irrigation canal.

Within 8 years after completion of the fish passage and entrainment projects at Intake Dam:

- Document the presence of naturally produced juvenile pallid sturgeon in the lower Yellowstone and Missouri rivers between Fort Peck Dam and Lake Sakakawea.
- Document that pallid sturgeon ($\geq$ 40 mm total length) can pass downstream of Intake Dam without being entrained.
- Indicate that naturally produced juvenile pallid sturgeon survival rates can be estimated and modeled to show that the population is on track to becoming self-sustaining.

**5) If we get yes answers to either of the first 2 questions we need an implementation plan.**

Currently, the Integrated Science Program has funded research for 2011 to track reproductively-ready pallid sturgeon on the Yellowstone River. It is anticipated that this research will provide insight and rigor to our lower Missouri River research activities



Return to TOC

regarding pallid spawning, egg success, and larval drift. This effort could easily be modified to incorporate transport of reproductively-ready pallid sturgeon above Intake. We could expand our current research scope (with input from the upper basin entities) to directly address specific uncertainties that are important to passage success at Intake Dam.

**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Intake Fish Passage Option Evaluation Summary**
**May 2012**

**Attachment 3**

# Performance Evaluation of Ramp Alternatives

Return to TOC

# Table of Contents





Return to TOC

## Table of Figures





Return to TOC

# 1 Introduction

This document is a collection of figures detailing hydraulic modeling results from evaluation of various ramp options investigated for the fish passage efforts at Intake Dam.

## 1.1 Passage Criteria

A set of criteria was established through consultation with the Biological Review Team in order to identify target velocities and depths suitable for Pallid Sturgeon passage. A list of key targets was established.

- **Velocity:** Allow some degree of passage under variable flow conditions to be experienced during spring and summer
    - **Fishery Flow Criteria**: Design target flow 6 ft/s max, 3-4 ft/sec max for longer ramp lengths. Pallid burst speed 7.5-8 ft/s max, best swimmers. Sustained swim speed 6 ft/sec for short distance
    - **BRT** Optimum adult velocity less than 4 ft/sec, juvenile 1-2 ft/sec
- **Depth:** Maintain minimum depth throughout passage season. Optimum depth >1 m, 0.5 m minimum
- **Attractive Flow:** Pallid sturgeon orient into the dominant current so acceptable options must provide sufficient attractive flow for locating and navigating the structure
- **Turbulence:** Minimize high turbulence \ hydraulic shear zones, and avoid excessive steep vertical drops which are not negotiable by pallid sturgeon
- **Connectivity**: Maintain a passage corridor from upstream to downstream

For sake of simplicity, in addition to depth and velocity one foot contours, hydraulic model results are presented using passage corridor figures. These figures display model results where depth and velocity results meet criteria as prescribed by the BRT.

Ideal conditions for passage are represented by velocities two to four feet per second with depths greater than one meter; however passage may be feasible at depths of half a meter. Passage likelihood is considered to be marginal at velocities greater than 4 feet per second with an upper threshold of 6 feet per second for sustained swimming speeds of the target species.

## 1.2 Project Features.

Primary project features are replacing the existing rock and timber fill Intake Diversion Dam with a concrete weir and rock ramp. This would maintain the existing surface elevation of the river upstream of the weir for diversion into the main canal, while improving fish passage and contributing to ecosystem restoration. A new main canal headworks structure with screens to minimize canal entrainment was awarded for construction in fall 2010. The rock ramp would be constructed downstream of the new weir by placing large angular rock sized for stability. The large rock would be backfilled with a granular choke stone to provide suitable substrate for passage.

## 1.3 Ramp Modeling.

Results presented in this report are derived from a 2D numerical model of the project. Computations were performed using the ADaptive Hydraulics (ADH) modeling utility. A rock ramp physical model was also constructed at the

Reclamation Technical Services Center in Denver, Colorado. Results from the physical model generally confirmed ADH model results with the exception of near crest flow conditions.

The ADH model is a finite element code capable of modeling two-dimensional, depth-averaged, shallow water equations. This tool is developed and maintained at the U.S. Army Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) and the work is funded primarily through the System Wide Water Resources Program (SWWRP).

The shallow water equations are applicable for situations in which the water depth is much less than the wavelength and therefore useful for estuarine and riverine modeling as well as other applications in which vertical velocity effects are not important aspects of the problem being solved.

Flow rates selected for analysis were 7,000, 15,000, 30,000, and 40,000 cfs. These flows cover the range of flows that would likely be encountered during pallid sturgeon migration. Design and analysis focused on the 15,000 and 30,000 cfs flows as the most important during the pallid migration period.

| 50% Exceedance by Month |
|---|
| April-8,470 |
| May-14,800 |
| June-30,700 |
| July-17,100 |
| August-7,080 |
| September-6,660 cfs |

Figure 1 - 50% Exceedance Flows by Month, April thru September

# 2 Ramp Rock Stability.

Evaluation of suitable rock size and layer thickness to provide ramp stability was performed for both hydraulic and ice forces. Analysis of ice forces on both the headworks and ramp structure was performed by the USACE Cold Regions Research and Experimentation Lab (CRREL) and is summarized in a separate document.

## 2.1 Hydraulic Stability.

For hydraulic stability, current USACE criteria was consulted with respect to determining the minimum rock size and layer thickness using computed flow depths and velocities. The concept design efforts utilized the Ishbash equation to determine minimum rock size throughout the ramp. Rock sizes were based on a 20-year peak flow rate and a layer thickness based on 1.5 times $D_{100}$. Using ADH model results, the maximum rock size varied from a $D_{100}$ of 30 to 48 inches across the ramp.

Current USACE criteria were consulted with respect to determining the minimum rock size and layer thickness using computed flow depths and velocities. EM 1110-2-1601 provides guidance for a layer thickness of 1 times $D_{100}$ or 1.5 times $D_{50}$. For greater flow turbulent areas, the HDC Sheet 712-1 provides rock sizing guidance based on flow velocity with a minimum layer thickness of 1.5 times $D_{100}$ or 2 times $D_{50}$. The ETL 1110-2-120 also recommends a layer thickness of 1.5 times $D_{100}$ for turbulent flow areas. Final determination of rock size and layer thickness for hydraulic stability will be required using computation results.

Final determination of rock size and layer thickness for hydraulic stability will be required using computation results.



Return to TOC

- Rock size based on ADH model computed velocities and the Ishbash equation, 20-year event peak Yellowstone River flow
- Ramp $D_{100}$ varies from 30 to 48 inches
- Rock layer thickness of 1.5 times $D_{100}$

## 2.2 Ice Forces

CRREL has provided evaluations of ice impacts on the structure at the initial concept design stage for the ramp in 2008 and 2009 as well as additional analysis provided early 2011.

While initial efforts suggested that the maximum rock size and the layer thickness could be adjusted across the ramp to address differences in hydraulic stress in different parts of the design, which would result in reduced rock cost, the CRREL ice analysis (see attachment 1) showed that much of the ice impact would be on the lower flow sides of the ramps. While there may still be possibility for some optimization near the toe of the ramp a more uniform rock gradation and layer thickness appears likely.

Previous ice analysis studies conducted in 2008 and 2009 indicated that an average diameter of 6 feet or more is necessary using guidance based on the maximum ice thickness. In the most recent analysis, the ice report indicates that the required rock size is smaller than that dictated by hydraulic analysis.

The CRREL evaluation included a review of the ice impact history at the site. Several times over the life of the structure ice has significantly damaged to nearly destroyed the crest structure. While crest hydraulic conditions are significantly different than the ramp, severe ice events should be expected to move ramp rock. Given the low construction tolerances for the uppermost ramp slope and the potential for ice induced rock movement, it is likely that ramp performance could be systematically degraded over time, especially near the crest. To mitigate this possibility to some extent it has been suggested that the uppermost portion of the crest be grouted. Costs for construction and maintenance of a grouted section have not been developed.

The ice evaluation results indicated that analysis of ice impacts on a full width, aerially extensive rock ramp has not been done before and that there is a significant amount of uncertainty in the results. Detailed analysis during final design more result in the recommendation for larger rock to provide ice stability. In addition, there is significant risk that the ramp could suffer repetitive damage during annual ice out events with a higher risk for greater damage during extreme ice events.

- Ice impact likely higher to lower ramp portion and side slopes
- Preliminary sizing of 6 foot $D_{100}$ for ice forces, reduced to similar size to hydraulic force computation results
- Significant amount of uncertainty in analysis
- Ramp likely to experience damage during severe ice events that will require rock repositioning to meet passage objectives
- May need to grout a portion of the ramp below the crest for stability
- Ramp may suffer repetitive damage during annual ice out with higher risk for extreme events

# 3 Ramp Alternatives Considered

Several alternatives were formulated with the goal of balancing hydraulic performance necessary to achieve fish passage and total project costs.  Results were presented to the BRT for review and a minimum threshold for ramp extents was established. Ramp alternatives evaluated are summarized in the table below.



Return to TOC

| Alternative Name | Description |
|---|---|
| Base Ramp | Full river width ramp |
| | 0.4% average slope, includes 70 ft wide thalweg, average length of 1600 ft, river area of 32 acres |
| | Evaluated with both physical and numerical modeling |
| | Most suitable for BRT fish passage criteria |
| Tripled Slope Ramp | Tripled slope for entire ramp to reduce ramp extents |
| | Average length of 900 ft with 17 acre footprint |
| | Evaluated with numerical modeling only |
| | Eliminated from further consideration due to failure to meet BRT fish passage criteria |
| Full River Width TPC Ramp | Steepened ramp to a point where cost estimate approximately meets allowable TPC |
| | Average length of 550 ft with 9 acre footprint |
| | Evaluated with numerical modeling only |
| | Eliminated from further consideration due to failure to meet BRT fish passage criteria |
| Partial River Width TPC Ramp | Provided 300 ft wide passage corridor on right bank and set length to approximately meet TPC |
| | Evaluated with numerical modeling only |
| | Eliminated from further consideration due to failure to meet BRT fish passage criteria |
| Steepened Toe Ramp | Doubled slope on left bank for downstream portion of ramp |
| | Incorporated steepened toe to reduce ramp extents |
| | Average length of 1300 ft with 25 acre footprint |
| | Evaluated with both physical and numerical modeling |
| | Marginally meets BRT fish passage criteria |
| Double Slope Ramp | Doubled Sslope for entire ramp to reduce ramp extents |
| | Average length of 1000 ft with 19 acre footprint |
| | Evaluated with numerical modeling only |
| | Minimally meets BRT fish passage criteria |
| High Flow Bench Ramp | Modification of Double Slope Ramp |
| | Incorporates 100 ft top width widening on right bank |
| | Evaluated with numerical modeling only |
| | Improves passage at all flows |
| | Further refinement required if carried forward |

**Figure 2 - Ramp Alternatives Summary Table**

## 3.1 Considered But Eliminated

### 3.1.1 Original Ramp Design

Following guidance provided by the BRT for hydraulic targets for depth and velocities necessary for Pallid Sturgeon migration through the project area, a base ramp geometry was developed for the project. The proposed ramp configuration includes a variable elevation crest combined with a variable slope rock ramp with features that mimic the natural thalweg of the river in plan form.

A 70' channel inverted at elevation 1988.1 concentrates flows through the ramp. The invert elevation was selected to maintain water levels upstream of the dam sufficient for diversion of irrigation water through the headworks at 3000 cfs. The 70' wide channel was selected to maintain depths of 3' through the ramp at that 3000 cfs flow rate. The invert of the ramp traverses from the left bank to right as the ramp proceeds downstream, mimicking natural thalweg conditions in the area. The channel invert is at a 0% slope in the lateral direction. The remainder of the crest is sloped from 3.0% to 0.5% to eliminate areas where passing fish may be stranded. Lateral slopes are maintained throughout the ramp.

In order to lessen spikes in velocities experienced at the crest the ramp is variably sloped from the crest to the downstream toe. Upstream of the ramp, a 3:1 concrete crest slopes up to the proposed invert of the ramp. The concrete crest is completed with a 10' flat section. The 3:1 crest serves to divert ice flows over the crest. Following the 10' flat section, the remainder of the ramp would be constructed of rip-rap stone material. The first 500' slopes at a rate of 0.002 ft/ft, followed by 400' at 0.004 ft/ft, 400' at 0.006 ft/ft, to ground at 0.008 ft/ft. The averaged slope of the ramp is approximately 0.0045 ft/ft.

The current configuration results in an overall ramp length of approximately 1600'. The layout occupies 32 acres of the river.

A physical model of this ramp geometry was constructed at the Reclamation Lab in Denver, Colorado. While in the majority of the model the results correlated with and confirmed the results of numerical modeling of the design, the physical model revealed higher velocities near the crest that were not apparent in numerical models. In order to maximize potential pallid passage modelers installed a rock boulder field downstream of the crest on the south side (right bank side) of the channel. The boulder field served to divert additional flow to the thalweg and towards the left bank of the channel which reduced crest velocities on the right side of the channel. One outcome of CRREL ice impact analysis was to show that such a boulder field could be subject to regular destruction by ice effects. Furthermore the movement of the boulders by the ice could result in a bulldozer effect which could cause damage to other parts of the ramp structure. Further consideration of a boulder field was retained as a potential adaptive management tool rather than as a design component.

This ramp geometry option was the most desirable to the BRT based the degree to which it met fish passage criteria, but it is currently considered infeasible due to excessive project costs.

### 3.1.2 Tripled Slope Ramp

In an effort to find a balance between an acceptable level of fish passage and total project costs, modifications were made to the original ramp geometry. To determine the minimal acceptable passage limits the ramp gradient was steepened to three times the original slope. Crest geometry remained the same, as did the thalweg configuration of the ramp.

The Tripled Slope geometry shortens the ramp length by 675', reducing the total length from the crest to nearly 900'. The total area of this grading plan is 17 acres which represents a 47% reduction from the original design.

This option failed to provide suitable passage corridors for the range of flows studied and was eliminated on the basis of failing to provide adequate passage for the target species based on consultation with the BRT.

### 3.1.3 Total Project Cost Ramp (Full River Width)

In an effort to evaluate the flow conditions and possibility for fish passage resulting from a geometry that met the initial total project costs for a full river width ramp, a geometry was modeled that limited total riprap costs to approximately



Return to TOC

ten million dollars. The result was a total ramp length of 550', a reduction of over 1000' from the original proposal. The grading plan occupied 9 acres of river, a 72% reduction from the original plan.

This option failed to provide suitable passage corridors for the range of flows studied and was eliminated on the basis of failing to provide adequate passage for the target species based on consultation with the BRT.

#### 3.1.4 Total Project Cost (Partial River Width)

In an effort to reduce ramp extent and evaluate hydraulic performance for a geometry that met total project costs, a partial river width ramp geometry was modeled that limited total riprap costs to approximately ten million dollars.

The result was a ramp that provided a 300' passage corridor on the right bank of the river with a 1.5% gradient. The remainder of the ramp was modeled as a 10% gradient.

This option was eliminated due to undesirable hydraulic performance and due to failure to meet BRT fish passage criteria. There was potential for scour along the steeper left side of the structure which would require substantial amounts of bank and bed protection to prevent erosive forces from damaging adjacent lands and the structure itself. The cost of this added protection would substantially offset the cost savings gained through construction of a partial channel width ramp.

### 3.2 Considered and Carried Forward

#### 3.2.1 Steepened Toe Ramp

As an initial step in reducing riprap two facets of the original ramp geometry were modified. Analysis of the original rock ramp geometry indicated that most passage corridors were aligned along the right bank side of the proposed structure. In order to reduce the extents of the ramp, slopes along the left bank were approximately doubled. In addition, the toe of the ramp was adjusted to a steeper gradient of 2%. These changes were made without significant impacts to the hydraulic performance of the ramp as it relates to fish passage criteria.

The result was a ramp shortened in length relative to the original ramp design by 300' with a reduction in aerial extent of 22%.

Upon review by the BRT, this option was deemed a suitable alternative for Pallid Sturgeon passage, though less preferable than the originally proposed geometry.

#### 3.2.2 Doubled Slope Ramp

To identify the threshold where increases in ramp slope resulted in insufficient passage, the original ramp was gradually steepened. The steepest configuration deemed biologically suitable comprised a geometry with a nominal slope approximately double that of the original design (0.9%).

The Doubled Slope geometry reduces ramp length relative to the original design by 600' with a reduction in aerial extent of 40%.

BRT review considers this option minimally acceptable as it relates to Pallid Sturgeon passage. All steeper gradient ramp options are considered unsuitable.

#### 3.2.3 High Flow Bench Ramp

Following a late January meeting with the BRT to discuss passage criteria and progress status, a recommendation was made to include a “high flow bench” as a possible ramp feature. The ramp would serve to provide lower velocities in times of high flow on the fringes of the ramp as well as to provide additional passage potential around the crest.



Return to TOC

This feature was initially incorporated into the “Doubled Slope Ramp” by adding a 100’ wide bench along the right bank of the structure. Inclusion of this feature requires removal of the existing dam right bank abutment. While widening reduces depths across the crest, it also serves to alleviate some velocity concerns. The bench area is designed to become suitable for passage at flows upward of 30,000 cfs and is approximately 2’ higher than the adjacent portions of the ramp. The high flow bench would serve to provide an area of lower velocities during periods of flows exceeding 15,000 – 20,000 cfs

Initial USACE analysis indicates that inclusion of the bench could require a similar level and size of riprap as the rest of the ramp compared to other geometries evaluated. Since the bench is located at the margins of the channel near the crest it would be subject to significant yearly ice impact and could required significant maintenance. The BRT envisions such a bench to be constructed of mostly native granular material and to resemble point bars found near natural riffles on the Yellowstone. It may be possible that most of this section of the ramp could be filled with granular material similar to natural substrate present in the area, however, to maintain stability, larger sized riprap would need to be placed at the crest and as sills of larger riprap every 150-200’ as the bench proceeds downstream along the ramp. Since it the bench is located at the margins of the channel near the crest it would be subject to significant yearly ice impact and could required significant maintenance. Additional design is required to determine what level of protection will be required.

Initial ADH modeling of this option indicates improvements to the passage corridors at all flows. At lower flows the bench serves to maintain sufficient depths along the fringes of the ramp. Once inundated, the increased top width augments the area of suitable velocities for passage when compared with the currently proposed geometry. Presentations of the results to the BRT were met with mixed reactions. The utility of the high flow bench was acknowledged, however it was requested that the design be modified so the bench becomes functional at lower flow thresholds than currently configured. If a ramp alternative is ultimately selected for pallid pasage at Yellowstone intake modeling of the highflow bench alternative will take these recommendations into account. If BRT recommendations to lower the bench elevation are followed, it should be noted that material removal volume would be increased. In addition, bench erosion and stability risks would be higher. As a result, an increase in iniital project cost and O&M would be expected.

The cost estimate for the ramp only portion of this option will be similar to the cost of the double slope ramp plus added excavation costs for the bench. Rock protection costs are dependent on the final design for the feature, and could be significant.

# 4 Original Ramp Hydraulic Summary

The depth and velocity contours in this section display ADH results for the initial version ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white). The ramp as proposed extends over 1600’ feet downstream of the crest.

A 70’ channel inverted at elevation 1988.1 concentrates flows through the ramp. The invert elevation was selected to maintain water levels upstream of the dam sufficient for diversion at 3000 cfs. The 70’ wide channel was selected to maintain depths of 3’ through the ramp at that 3000 cfs flow rate. The invert of the ramp traverses from the left bank to right as the ramp proceeds downstream, mimicking natural thalweg conditions in the area. The channel invert is at a 0% slope in the lateral direction. The remainder of the crest is sloped from 3.0% to 0.5% to eliminate areas where passing fish may be stranded. Lateral slopes are maintained throughout the ramp.

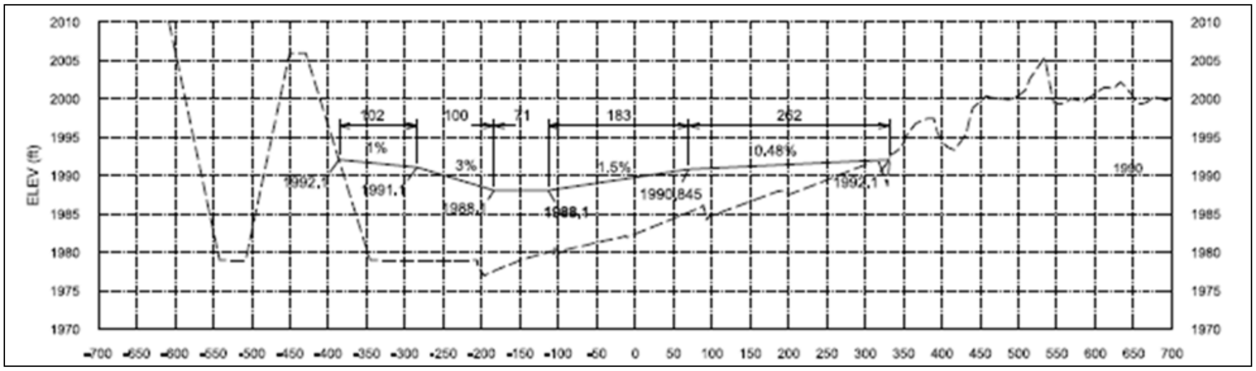


Figure 3 - Original Ramp Weir Crest Section

In order to lessen spikes in velocities experienced at the crest the ramp is variably sloped from the crest to the downstream toe. Upstream of the ramp, a 3:1 concrete crest slopes up to the proposed invert of the ramp. The concrete crest is completed with a 10’ flat section. The 3:1 crest serves to divert ice flows over the crest. Following the 10’ flat section, the remainder of the ramp will be constructed of rip-rap stone material. The first 500’ slopes at a rate of 0.002 ft/ft, followed by 400’ at 0.004 ft/ft, 400’ at 0.006 ft/ft, to ground at 0.008 ft/ft. The averaged slope of the ramp is approximately .0045 ft/ft. The current configuration results in an overall ramp length of approximately 1600’. The layout occupies 32 acres of the river.

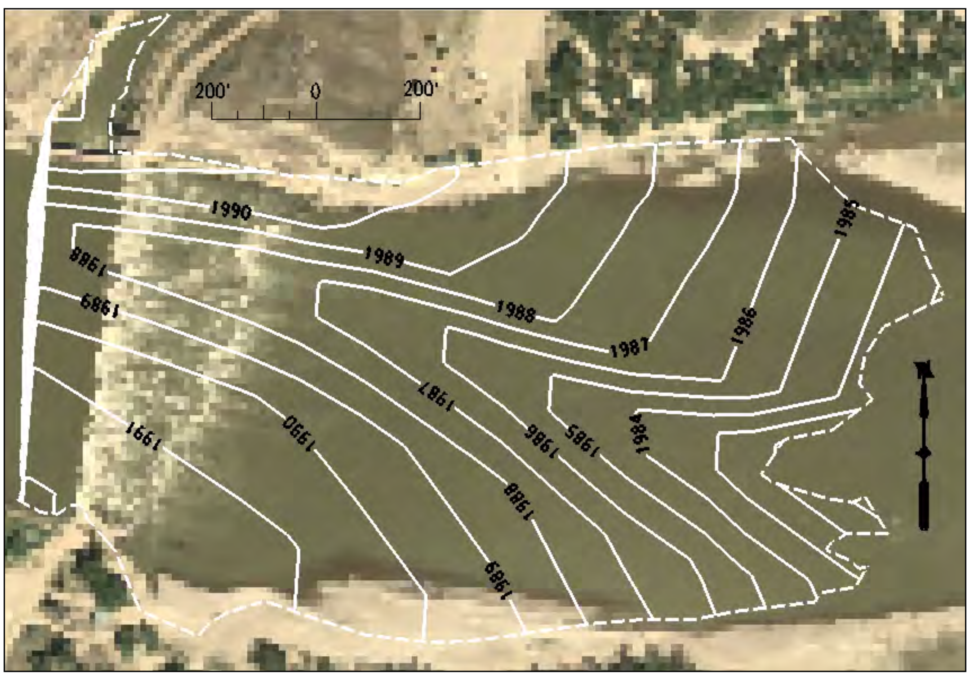


Figure 4 - Original Ramp 1' Contours



Return to TOC


**Figure 5 - Original Ramp Depth Contours (presented in feet).**

Depths throughout the ramp are greater than 1m at both 30 and 40 Kcfs. At 7 and 15 Kcfs, sufficient depths are only found through the low point of the ramp and diminish as the left and right edges of the ramp are approached. For all flows, a majority of the ramp is above depths of 0.5m.


**Figure 6 - Original Ramp Velocity Contours (presented in feet/second).**

Velocities throughout the ramp are greater than 6 fps at 40,000 cfs, excluding the fringe areas. At 30,000 cfs, pathways are available through the crest at the 5-6 fps range. At 15,000 and 7,000 cfs, velocities meet the 4 fps criteria throughout, but are not necessarily accompanied with sufficient depths.

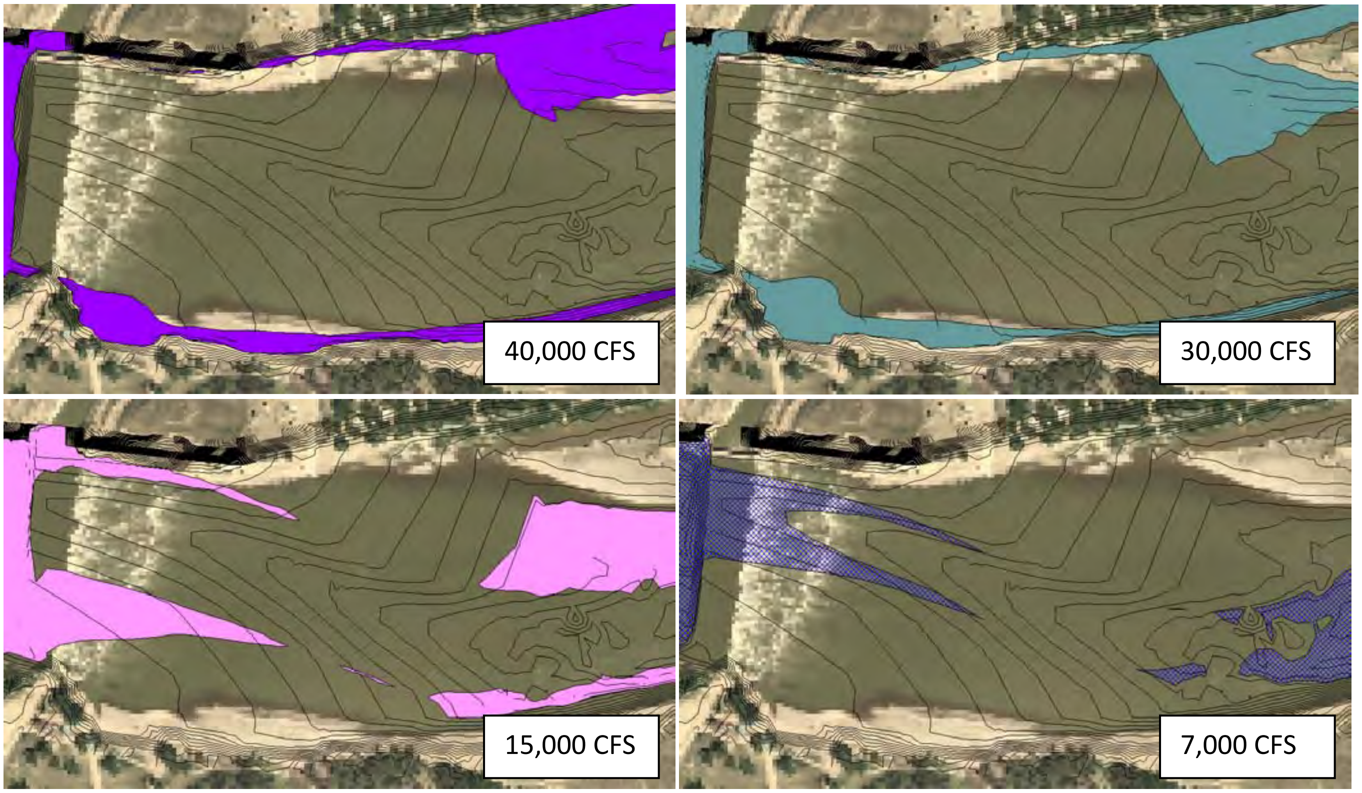



Figure 7 - Original Ramp passage delineations.

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria of at least 1 m in depth and less than 4 feet per second velocities. The black lines indicate 1’ contours of the proposed grading. At the two lower flows, insufficient depths prevent a passage corridor from extending the entire length of the ramp. At higher flows, the 4 fps velocity criteria is only met on the fringe areas of the ramp. Note the amount of area downstream of the ramp not meeting the specified criteria for all simulations.



Return to TOC

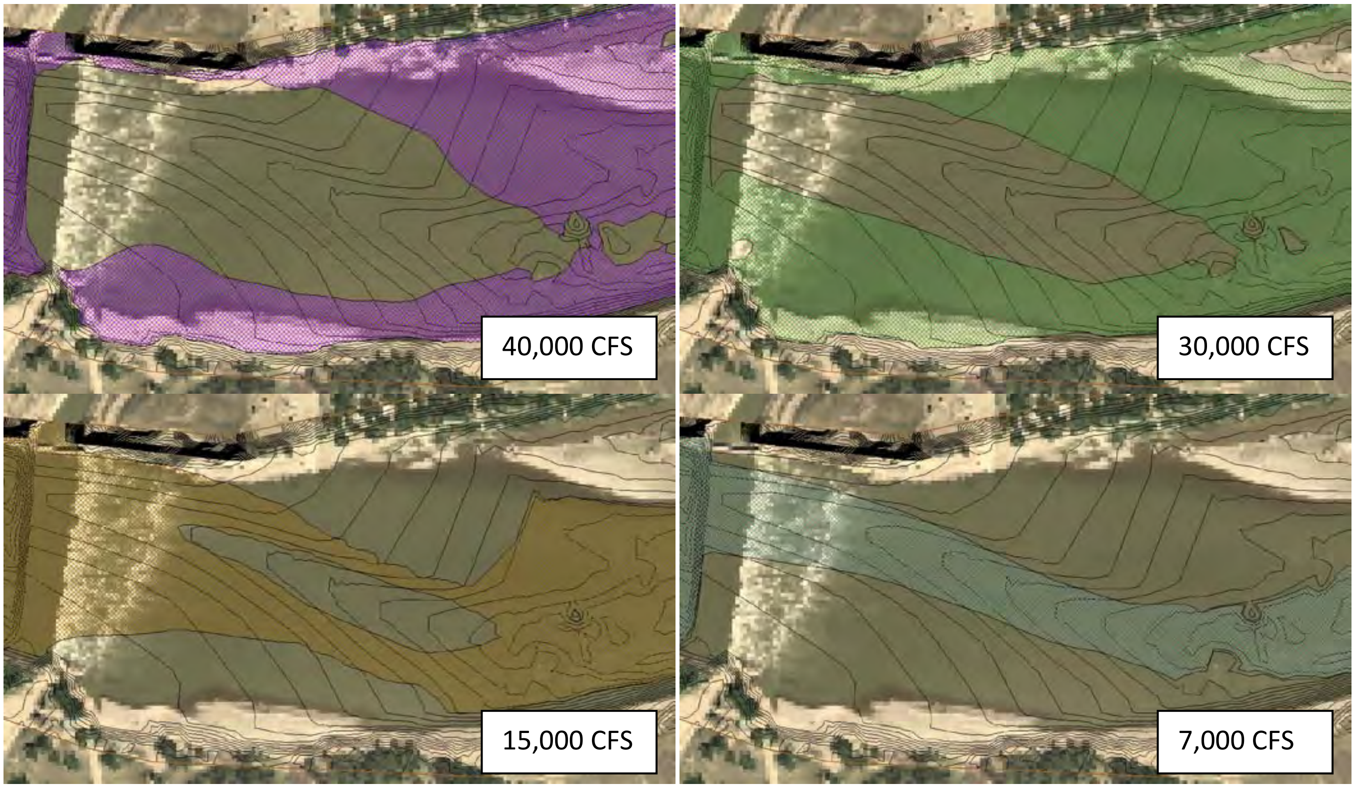
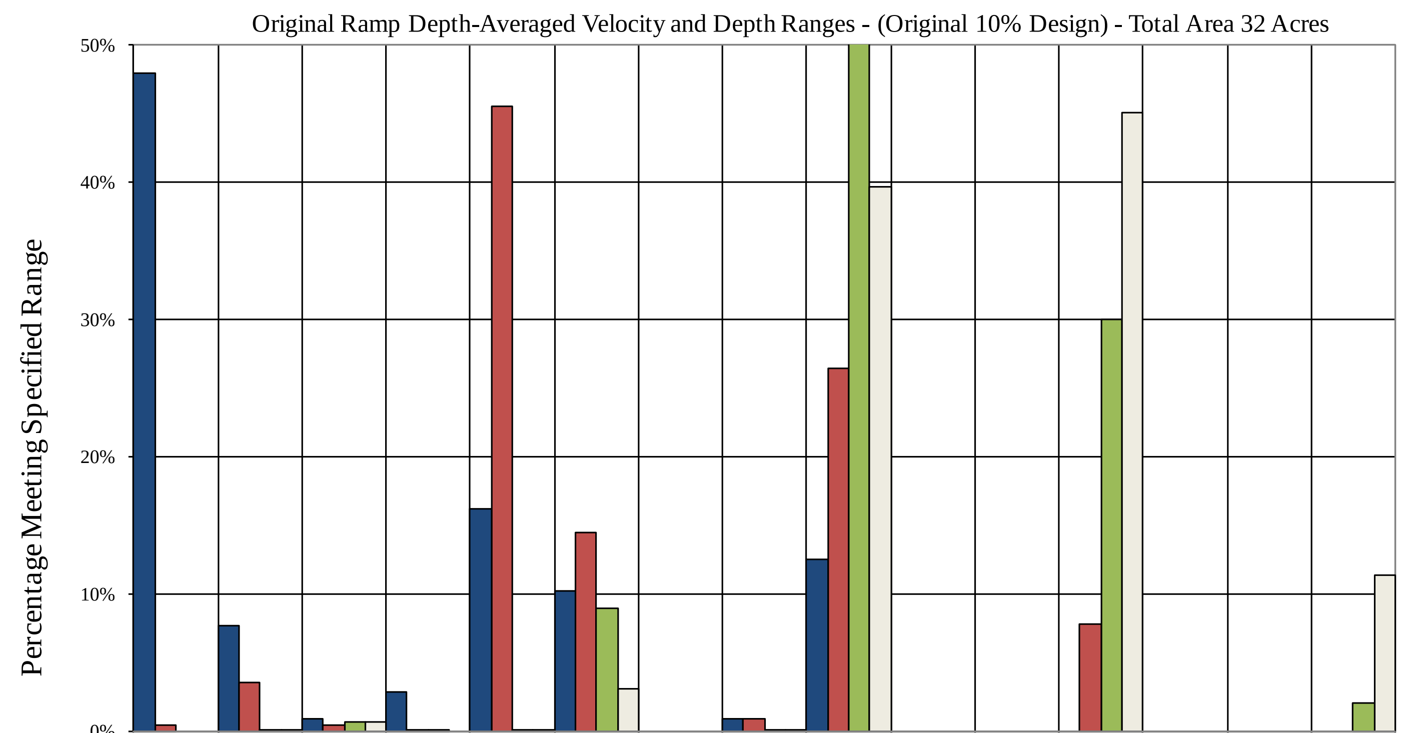



**Figure 8 - Original Ramp passage delineations.**

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria of at least 1 m in depth and less than 6 feet per second velocities. The black lines indicate 1' contours of the proposed grading. Passageways are available at all flows under the 6 fps criteria, excluding the 40 Kcfs simulation at the crest. This problem could be mitigated through modification of the existing dam crest abutment.



Return to TOC




| | 0-1.64ft 0-2ft/s | 1.64-3.28ft 0-2ft/s | >3.28 ft 0-2ft/s | 0-1.64ft 2-4ft/s | 1.64-3.28ft 2-4ft/s | >3.28 ft 2-4ft/s | 0-1.64ft 4-6ft/s | 1.64-3.28ft 4-6ft/s | >3.28 ft 4-6ft/s | 0-1.64ft 6-8ft/s | 1.64-3.28ft 6-8ft/s | >3.28 ft 6-8ft/s | 0-1.64ft >8ft/s | 1.64-3.28ft >8ft/s | >3.28 ft >8ft/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7k | 48% | 8% | 1% | 3% | 16% | 10% | 0% | 1% | 13% | 0% | 0% | 0% | 0% | 0% | 0% |
| 15k | 1% | 4% | 0% | 0% | 46% | 15% | 0% | 1% | 26% | 0% | 0% | 8% | 0% | 0% | 0% |
| 30k | 0% | 0% | 1% | 0% | 0% | 9% | 0% | 0% | 58% | 0% | 0% | 30% | 0% | 0% | 2% |
| 40k | 0% | 0% | 1% | 0% | 0% | 3% | 0% | 0% | 40% | 0% | 0% | 45% | 0% | 0% | 11% |

**Figure 9- Original Ramp Depth/Velocity Classifications.**

This chart displays percent by area classifications of several depth and velocity combinations for the ramp for the set of flows modeled. The predominant flow classification for all flows is depths greater than a meter and velocities in the 4 to 6 fps range. However, at the 30,000 and 40,000 flow simulations significant portions of the ramp exceed 6 feet per second. Analysis of the velocity contours show that this occurs primarily in the thalweg of the ramp and areas adjacent.

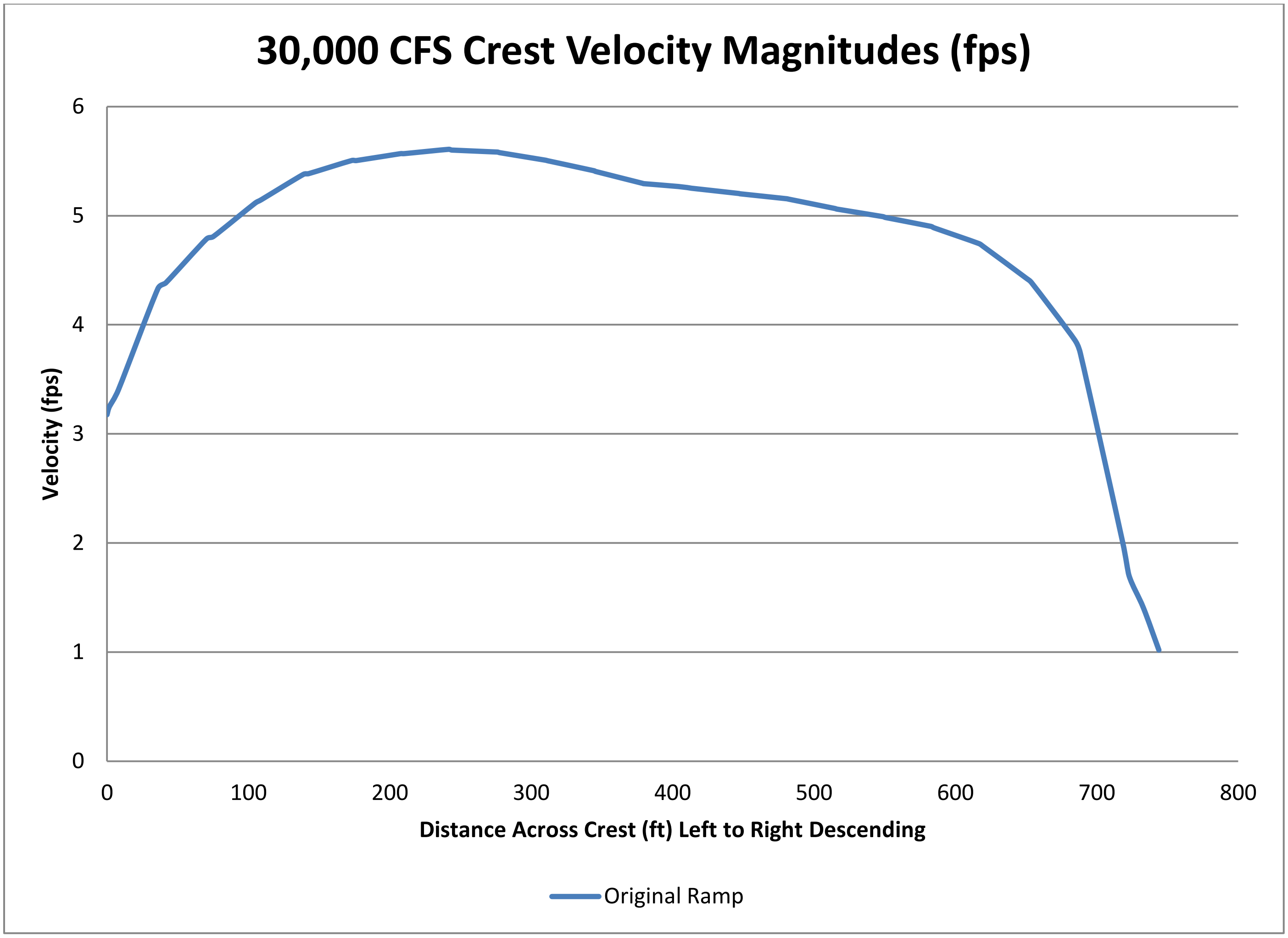



Figure 10 - Original Ramp crest velocity section.

This figure is a cross-section taken from near the proposed crest of the damn displaying velocities in fps for a 30,000 cfs flow rate. Numerical modeling indicates that velocities at the crest are below 6 fps across the crest for this geometry. 30,000 cfs represents a 50% exceedance by duration June flow rate.

# 5 Tripled Slope Ramp Hydraulic Summary

The depth and velocity contours in this section display ADH results for a shortened version of the ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). The revised geometry represents a tripling in slope from the original ramp. The crest and thalweg are of the same configuration as the original ramp proposal. The slope is increased to .006 ft/ft for the first 500' downstream, .012 for the next 400 feet, and .02 ft/ft for the tie into ground. The purpose of these revisions is to reduce material costs for construction of the ramp. It is important that appropriate passage corridors be maintained with any recommended geometry.

The original ramp extends approximately 1600’ from the crest. The Doubled Slope geometry shortens the ramp length by 675’, reducing the total length from the crest to nearly 1100’. The total area of this grading plan is 17 acres. This is a 47% reduction from the original plan.



Return to TOC

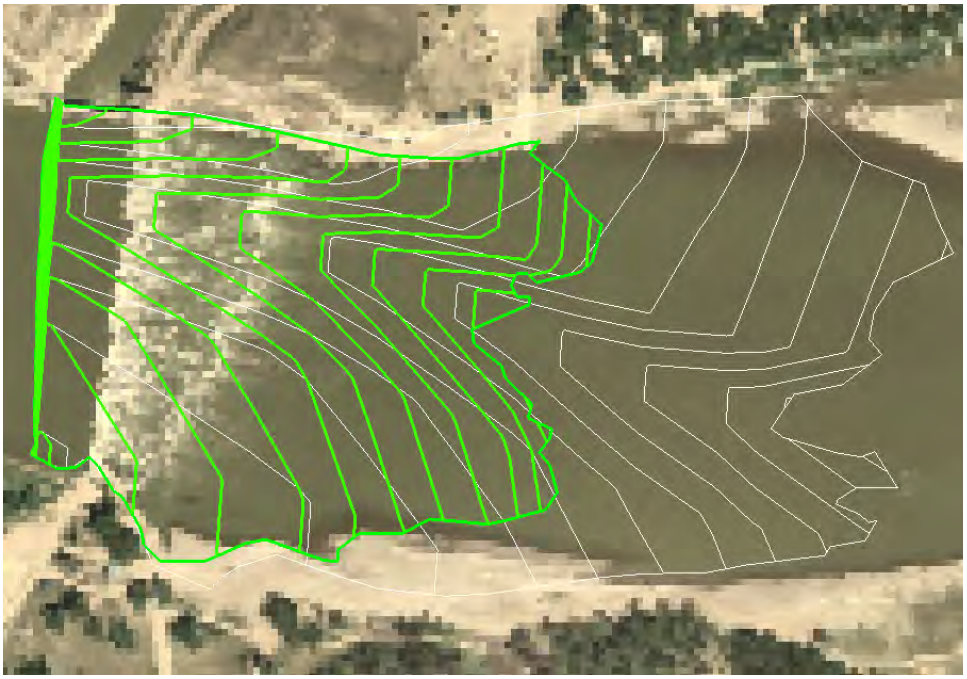


Figure 11 - 1' contours of original and Tripled Slope ramp.

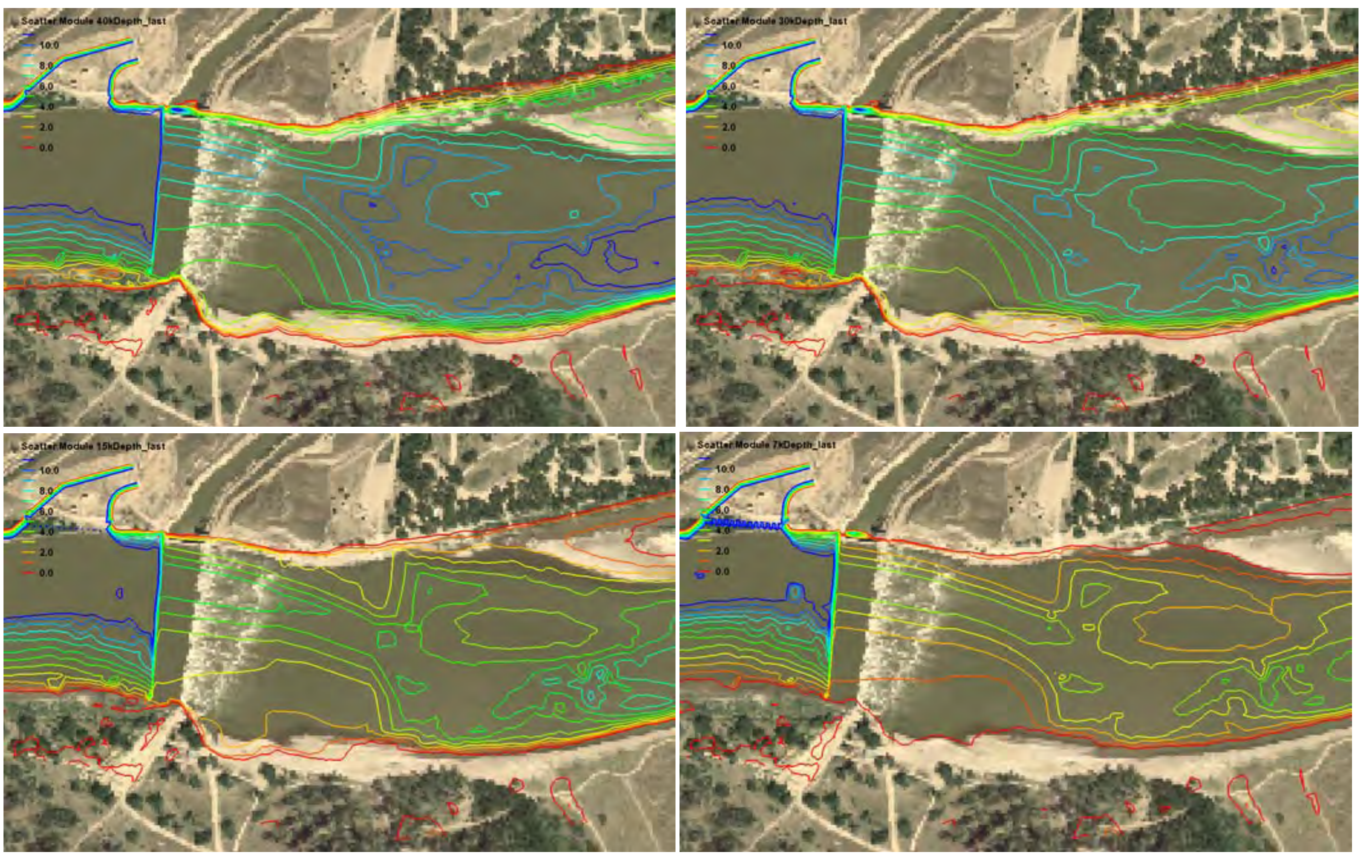



Figure 12 - Tripled Slope Ramp Depth Contours (presented in feet).

Depths throughout the ramp are greater than 1m at both 30 and 40 Kcfs. At 7 and 15 Kcfs, sufficient depths are only found through the low point of the ramp and diminish as the left and right edges of the ramp are approached. For all flows, a majority of the ramp is above depths of 0.5m.

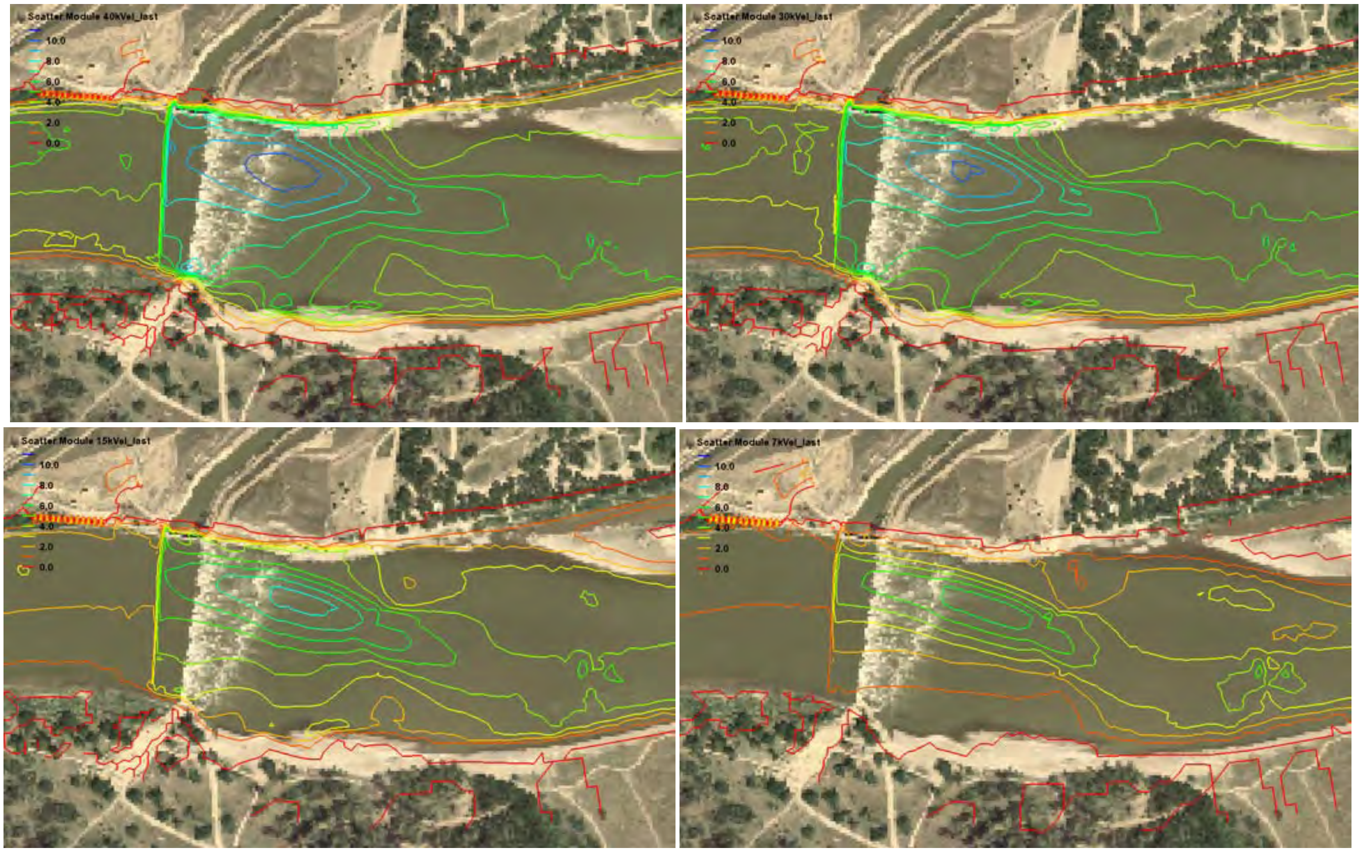



**Figure 13 - Tripled Slope Ramp Velocity Contours (presented in feet/second).**

Velocities throughout the ramp are greater than 6 fps at 40,000 cfs, excluding the fringe areas. At 30,000 cfs, pathways are available through the crest on the left side with velocities peaking at about 6.6 fps. This occurs not at the crest, but adjacent to the old weir crest abutment. At the crest, velocities on the left side are approximately 5.5 fps. At 15,000 and 7,000 cfs, velocities meet the 4 fps criteria throughout, but are not necessarily accompanied with sufficient depths.



Return to TOC

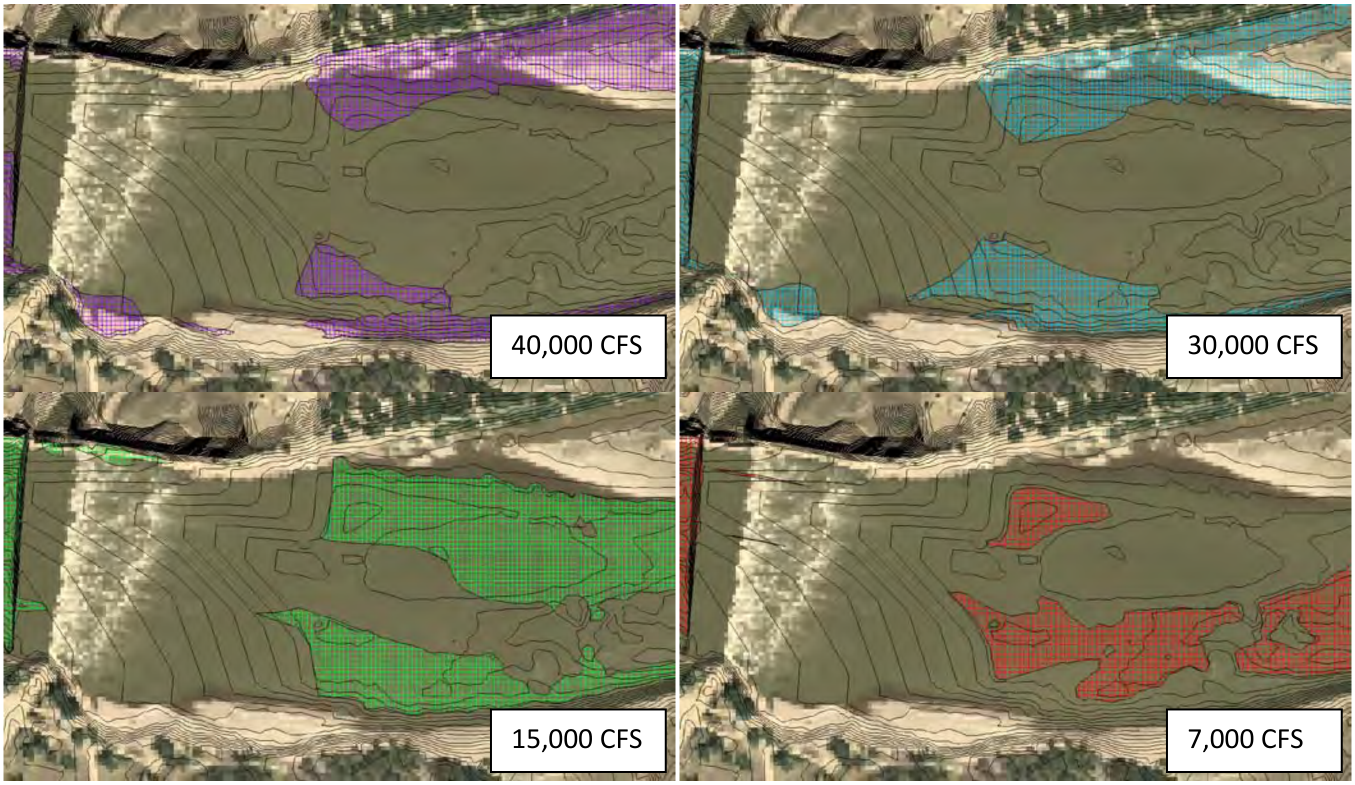



**Figure 14 - Tripled Slope Ramp passage delineations.**

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria of at least 1 m in depth and less than 4 feet per second velocities. The black lines indicate 1' contours of the proposed grading. Corridors are not available at any of the flows simulated at this threshold.



Return to TOC

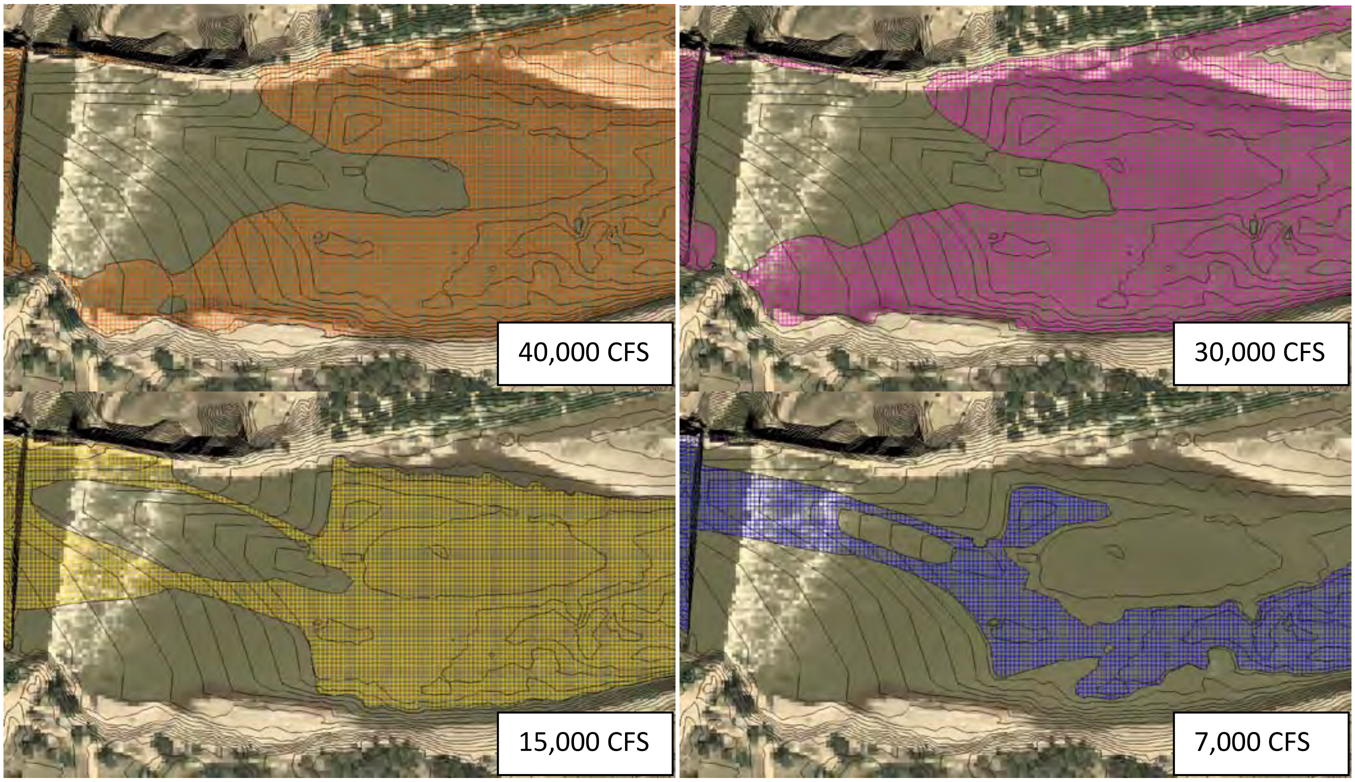
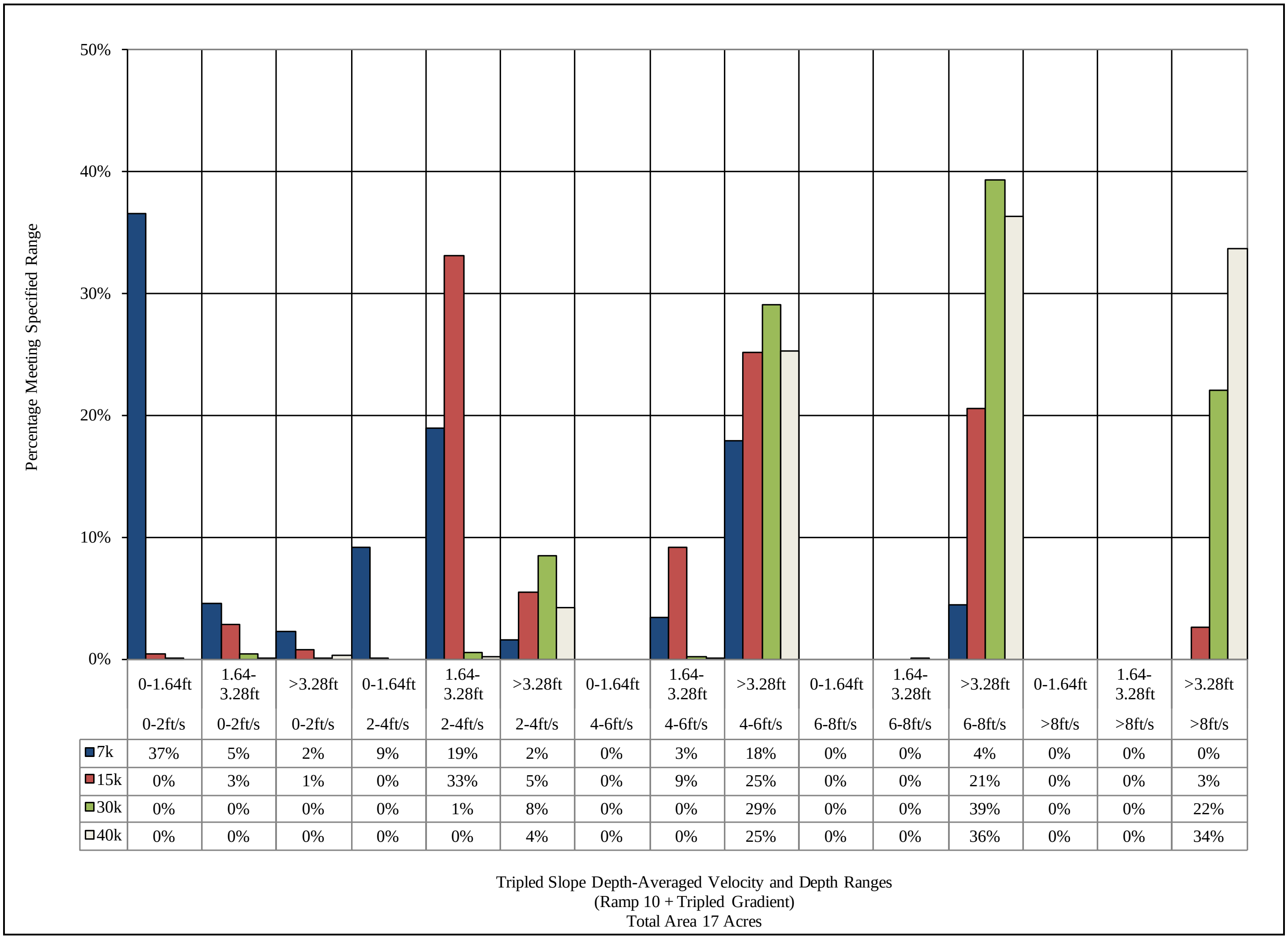



Figure 15 - Tripled Slope Ramp passage delineations.

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria of at least 1 m in depth and less than 6 feet per second velocities. The black lines indicate 1' contours of the proposed grading. Passageways are available at all flows under the 6 fps criteria, excluding the 40 Kcfs and 30Kcfs simulations at the crest. This problem could be mitigated through modification of the existing dam crest abutment.



Return to TOC




| | 0-1.64ft 0-2ft/s | 1.64-3.28ft 0-2ft/s | >3.28ft 0-2ft/s | 0-1.64ft 2-4ft/s | 1.64-3.28ft 2-4ft/s | >3.28ft 2-4ft/s | 0-1.64ft 4-6ft/s | 1.64-3.28ft 4-6ft/s | >3.28ft 4-6ft/s | 0-1.64ft 6-8ft/s | 1.64-3.28ft 6-8ft/s | >3.28ft 6-8ft/s | 0-1.64ft >8ft/s | 1.64-3.28ft >8ft/s | >3.28ft >8ft/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7k | 37% | 5% | 2% | 9% | 19% | 2% | 0% | 3% | 18% | 0% | 0% | 4% | 0% | 0% | 0% |
| 15k | 0% | 3% | 1% | 0% | 33% | 5% | 0% | 9% | 25% | 0% | 0% | 21% | 0% | 0% | 3% |
| 30k | 0% | 0% | 0% | 0% | 1% | 8% | 0% | 0% | 29% | 0% | 0% | 39% | 0% | 0% | 22% |
| 40k | 0% | 0% | 0% | 0% | 0% | 4% | 0% | 0% | 25% | 0% | 0% | 36% | 0% | 0% | 34% |

**Figure 16 - Tripled Slope Ramp Depth/Velocity Classifications.**

This chart displays percent by area classifications of several depth and velocity combinations for the ramp for the set of flows modeled. The predominant flow classification for all flows is depths greater than a meter and velocities in the 4 to 6 fps range for most flows. However, at the 30,000 and 40,000 flow simulations significant portions of the ramp exceed 6 feet per second.

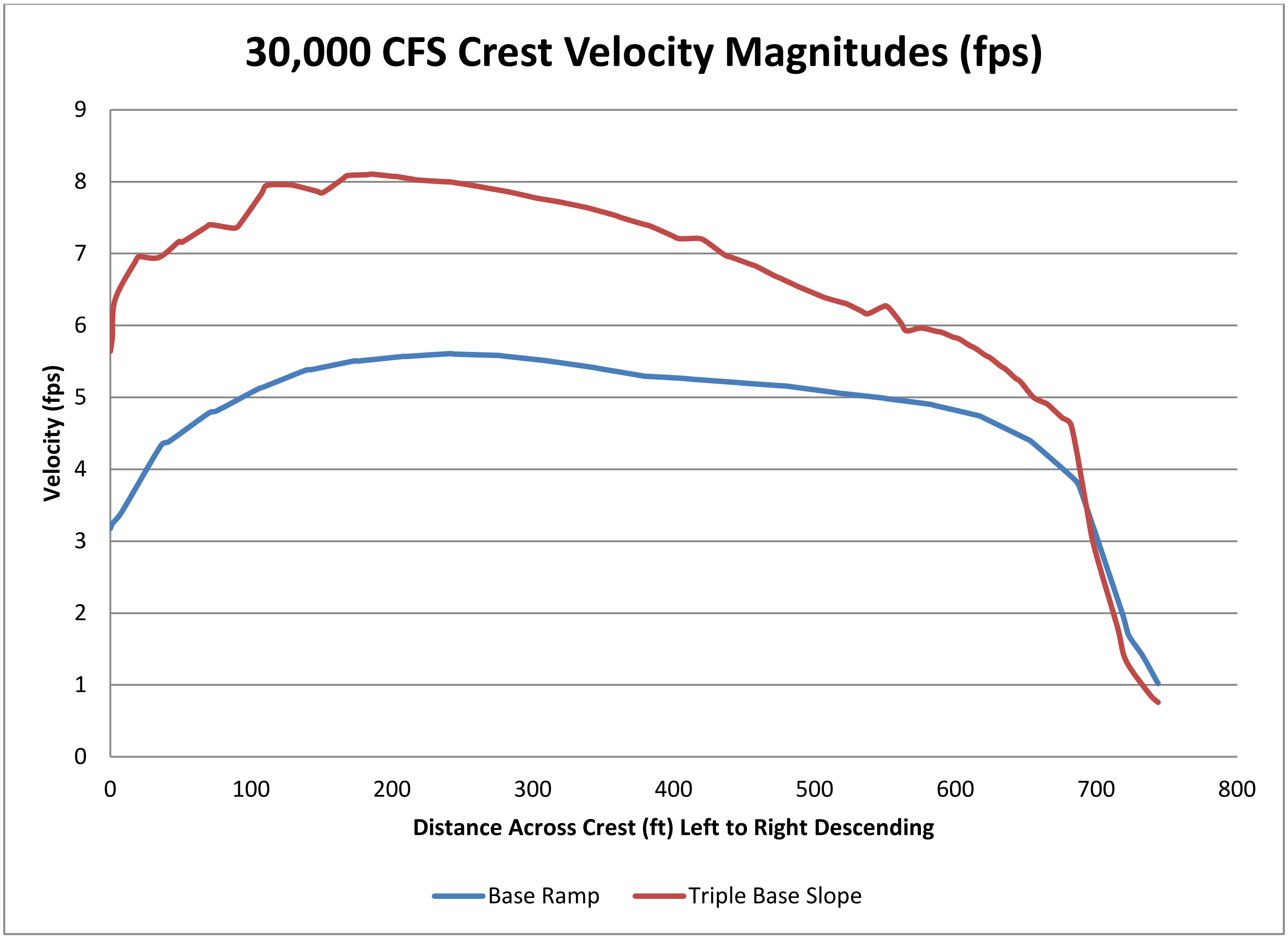



Figure 17 - Tripled Slope Ramp vs Original Ramp crest velocity comparison.

This figure is a cross-section taken from near the proposed crest of the damn displaying velocities in fps for a 30,000 cfs flow rate. Numerical modeling indicates that increases of 1-2.25 fps are resultant from the shortened geometry compared to the original proposal.

# 6 Total Rock Cost ~ $10 mil Ramp Hydraulic Summary

The depth and velocity contours in this section display ADH results for a shortened version of the ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). The slope is set to meet TPC projections based upon an assumed $70/ton rock cost and 6' layer thickness. The result is a total ramp length of ~550' and total ramp area of ~10 acres. Ramp slopes in the downstream direction vary from 1.5% to 2.2%. It is important that appropriate passage corridors be maintained with any recommended geometry.

The original ramp extends approximately 1600’ from the crest. The Total Rock Cost geometry shortens the ramp length by 1050’, reducing the total length from the crest to nearly 550’. The total area of this grading plan is 9 acres. This is a 72% reduction from the original plan.

Figure 18 - 1' contours of original and Total Rock Cost Ramp.

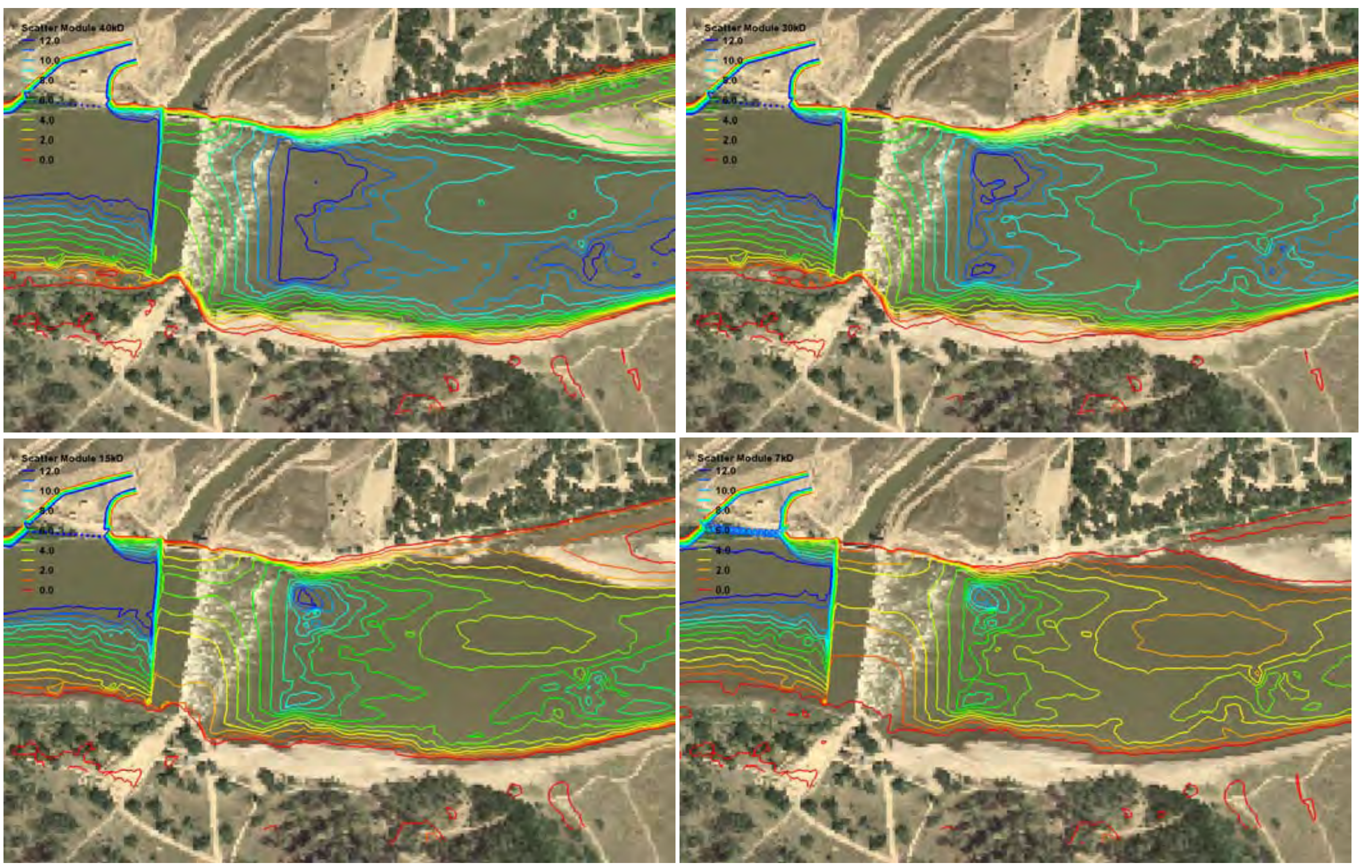



Figure 19 - Total Rock Cost Ramp Depth Contours (presented in feet).



Return to TOC

Depths throughout the ramp are greater than 1m at both 30 and 40 Kcfs. At 7 and 15 Kcfs, sufficient depths are only found through the low point of the ramp and diminish as the left and right edges of the ramp are approached. For all flows, a majority of the ramp is above depths of 0.5m.

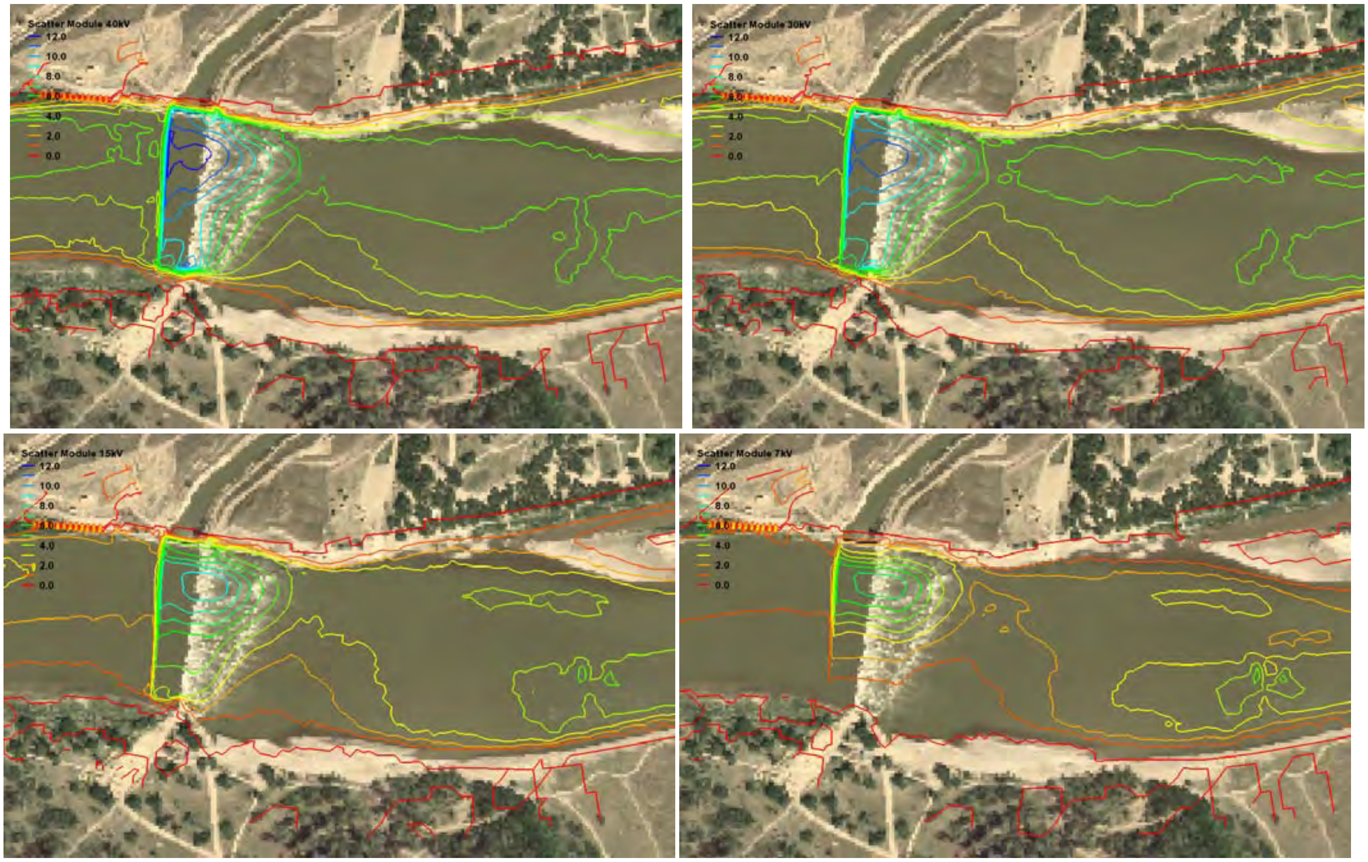


Figure 20 - Total Rock Cost Ramp Velocities (presented in feet per second).

Velocities throughout the ramp are greater than 6 fps at 40,000 cfs and 30,000 cfs. Velocities less than 6 feet per second are available at the 15,000 and 7,000 cfs flow rates, but are accompanied with depths less than a meter (though often greater than ½ meter). The result is that no passage corridors are found at any of the simulated flows, thus the figures are not presented.

# 7 Total Project Costs – Half River Width Ramp

The depth and velocity contours in this section display ADH results for a shortened version of the ramp designed to provide partial river width passage proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). A 300' wide section on the left bank is intended to provide a passage corridor. The remainder of the ramp is sloped at a 10:1 to existing ground. The slope is set to meet TPC projections based upon an assumed $70/ton rock cost and 6' layer thickness. The result is a total ramp length of ~800' and total ramp area of ~10 acres. Passage corridor slopes in the downstream direction are approximately 1.5%. It is important that appropriate passage corridors be maintained with any recommended geometry.

The half river width ramp failed to provide a passage corridor at any of the flows model. This was primarily due to excessive velocities at the crest. Stability concerns also became apparent on the steeper section of the ramp due to



Return to TOC

velocities exceeding 15 fps in the 30,000 cfs and higher simulations. Supercritical flow is not a function of the ADH model used, but it is highly likely that this configuration would produce hydraulic jumps at the crest under many of the flow scenarios that could be encountered at the site.

Figure 21 - 1' contours of original and Half River Width Ramp.



Return to TOC

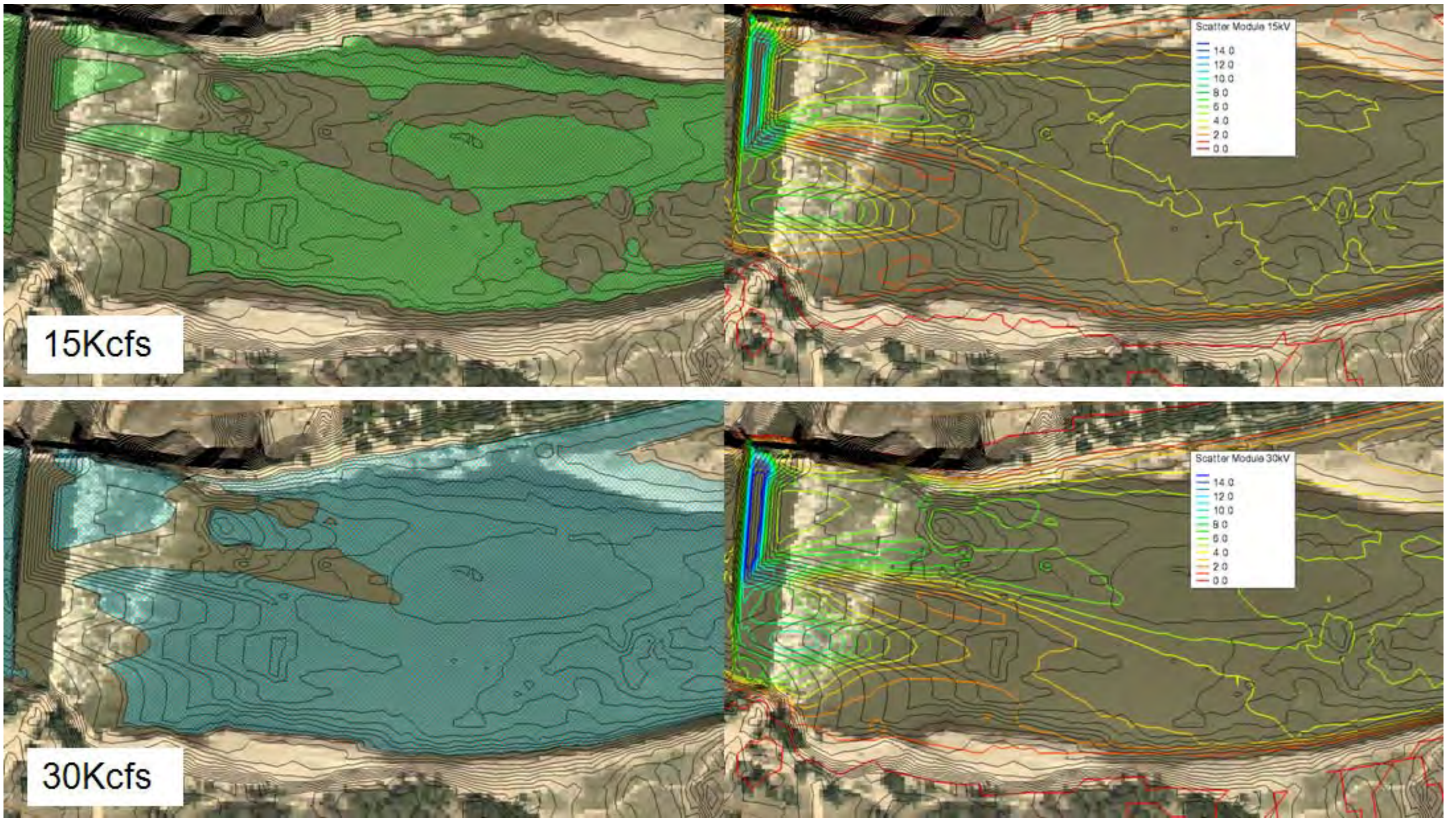



Figure 22 - Half River Width Ramp Velocities and Passage Classifications - 4 fps

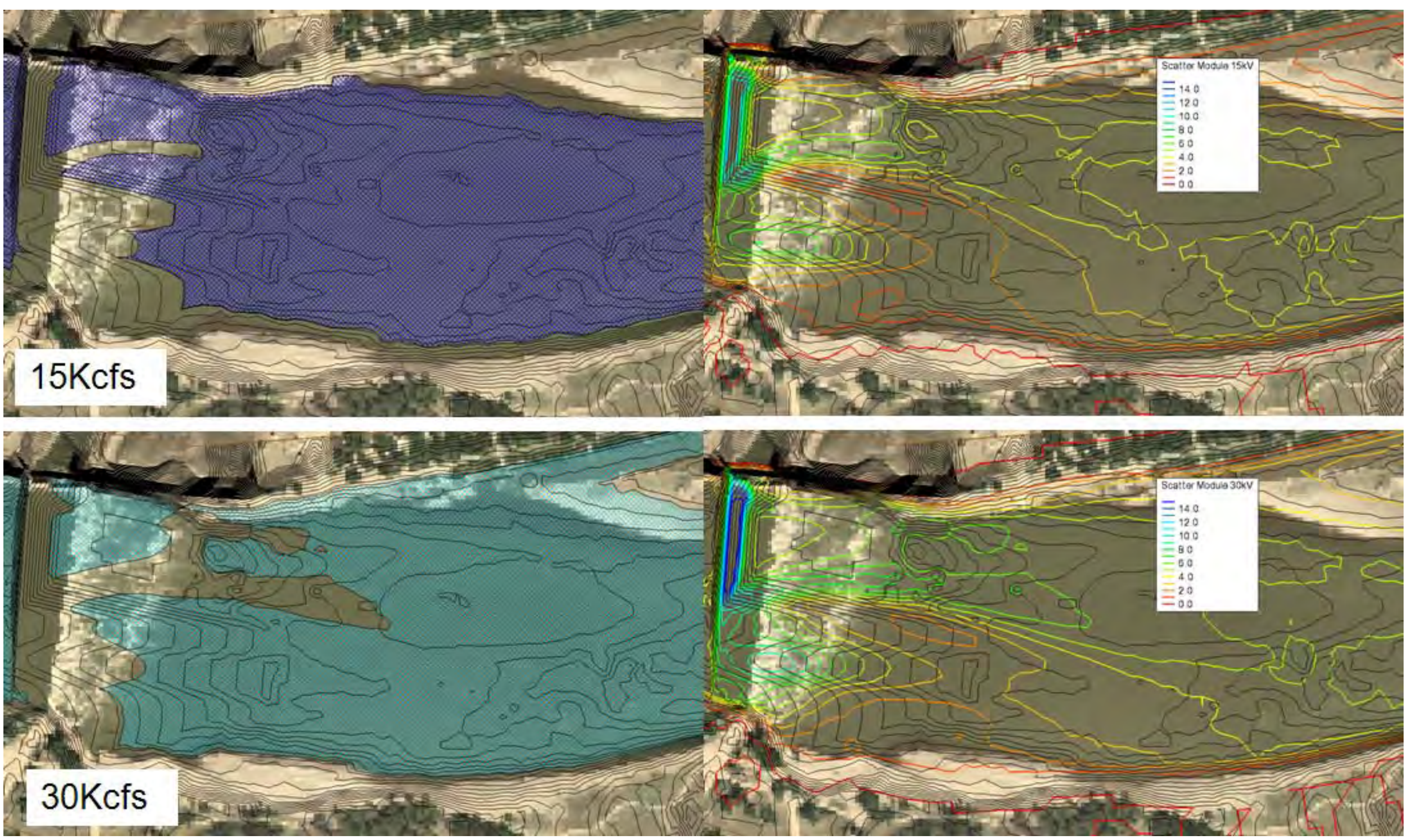



Figure 23 - Half River Width Ramp Velocities and Passage Classifications - 6 fps



Return to TOC

# 8 Steepened Toe Ramp Hydraulic Summary

The depth and velocity contours in this section display ADH results for a shortened version of the ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). The revised geometry represents a doubling in slope on the left bank compared to original and a 2% slope at the right bank toe. The purpose of these revisions is to eliminate areas where cut would be required to place stone on existing grades while maintaining the ability of the ramp to facilitate passage and provide diversion head. An additional purpose of these revisions is to reduce material costs for construction of the ramp. It is important that appropriate passage corridors be maintained with any recommended geometry.

Both the numerical hydraulic model and the physical model of the ramp show the revised geometry shows velocity and depth paths through the ramp similar to the original geometry. The original ramp extends approximately 1600' from the crest. The Steepened Toe geometry shortens the ramp length by 300', reducing the total length from the crest to nearly 1300'. The total area of this grading plan is 25 acres. This is a 22% reduction from the original plan.

Figure 24 - 1' contours of original and Steepened Toe ramp.



Return to TOC

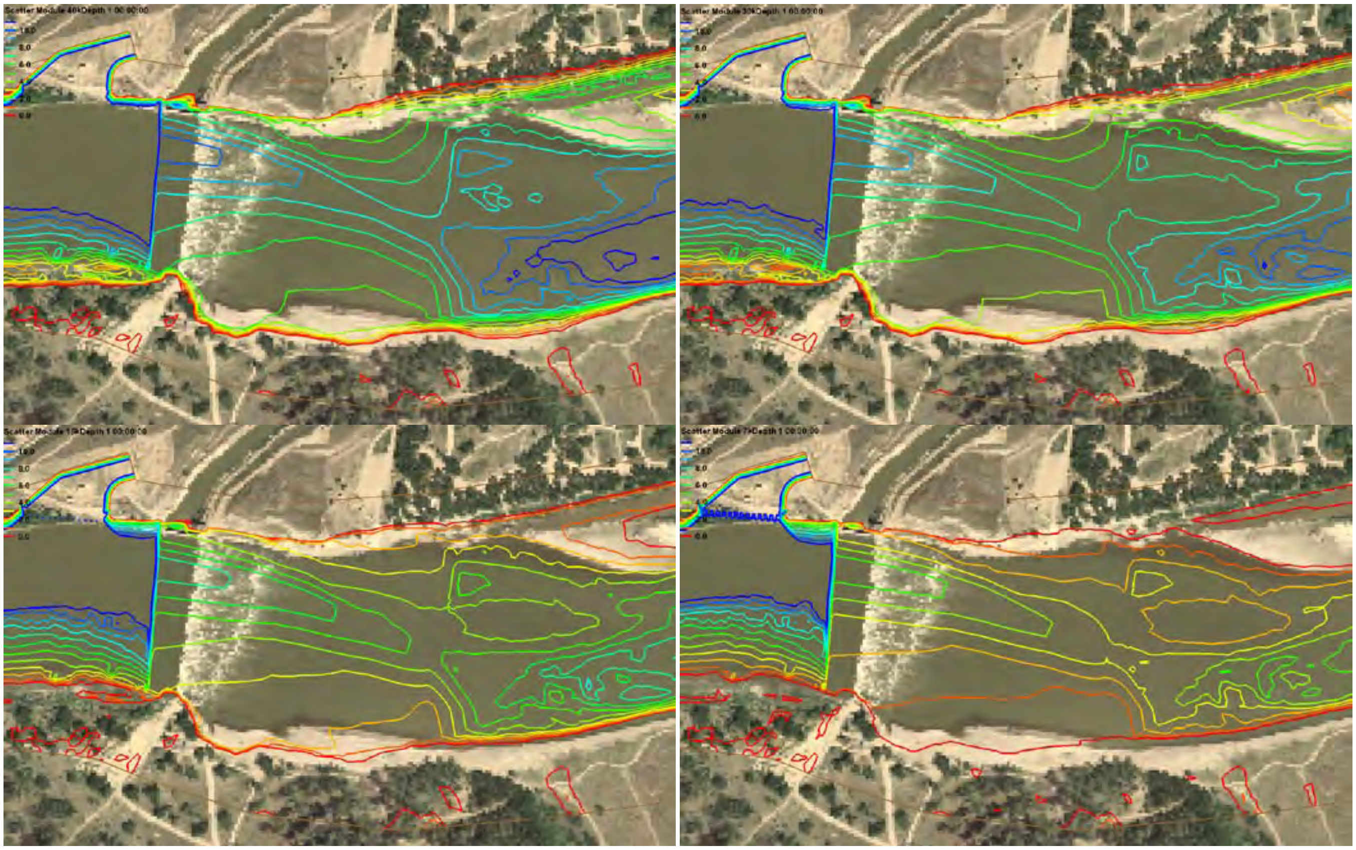


Figure 25 - Steepened Toe Ramp Depth Contours (presented in feet).

Depths throughout the ramp are greater than 1m at both 30 and 40 Kcfs. At 7 and 15 Kcfs, sufficient depths are only found through the low point of the ramp and diminish as the left and right edges of the ramp are approached. For all flows, a majority of the ramp is above depths of 0.5m.



Return to TOC

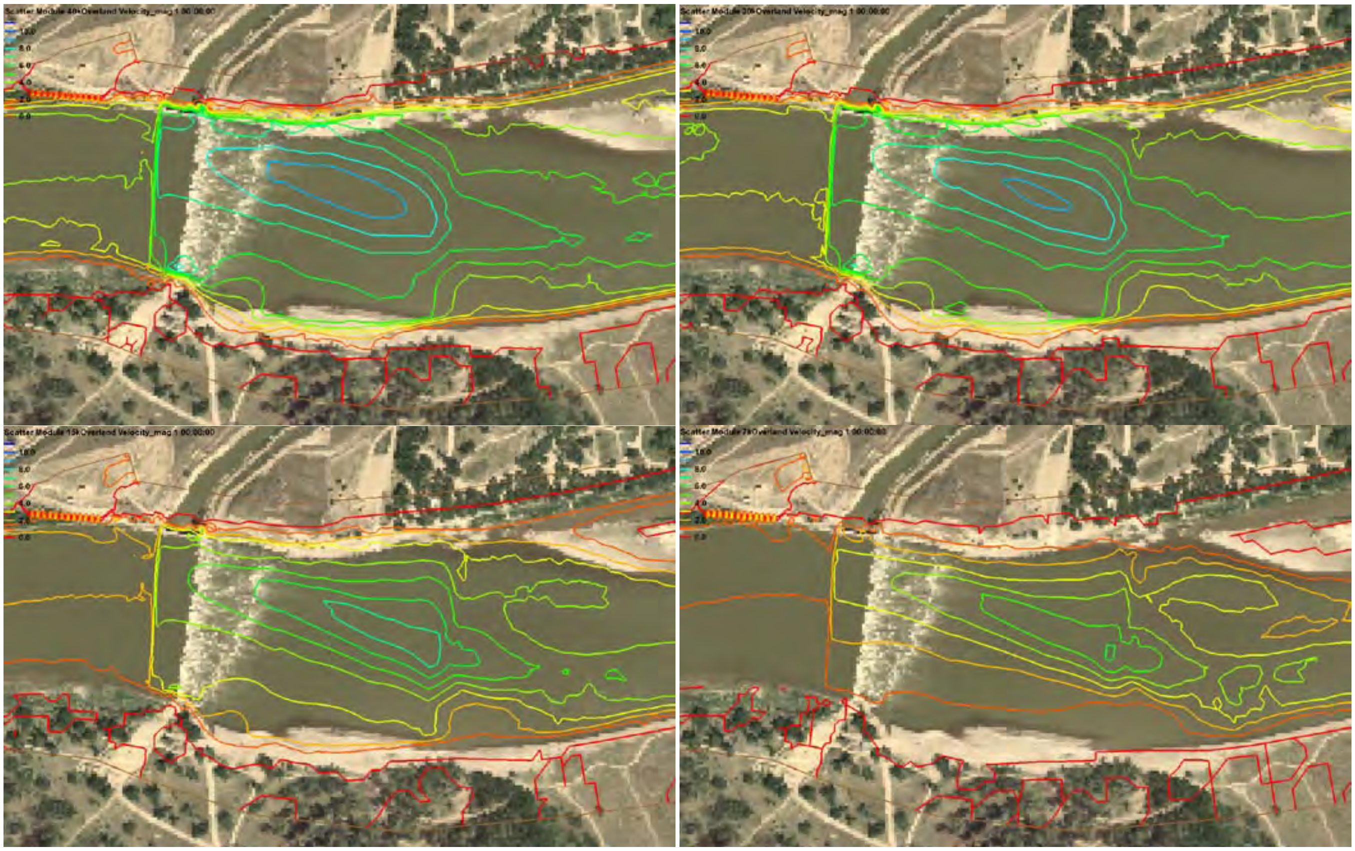


Figure 26 - Steepened Toe Ramp Velocity Contours (presented in feet/second).

Velocities throughout the ramp are greater than 6 fps at 40,000 cfs, excluding the fringe areas. At 30,000 cfs, pathways are available through the crest at the 5-6 fps range. At 15,000 and 7,000 cfs, velocities meet the 4 fps criteria throughout, but are not necessarily accompanied with sufficient depths.



Return to TOC

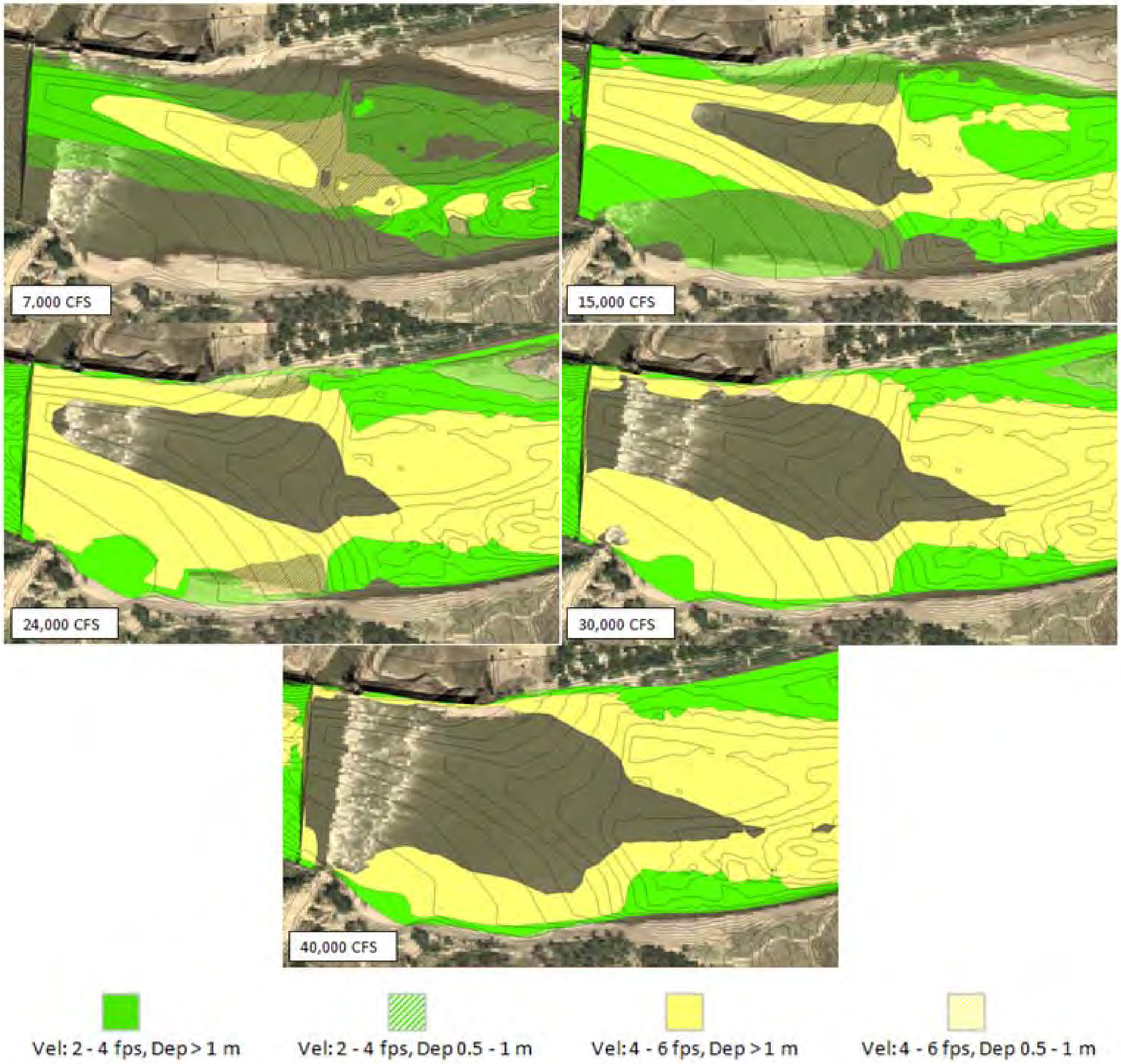


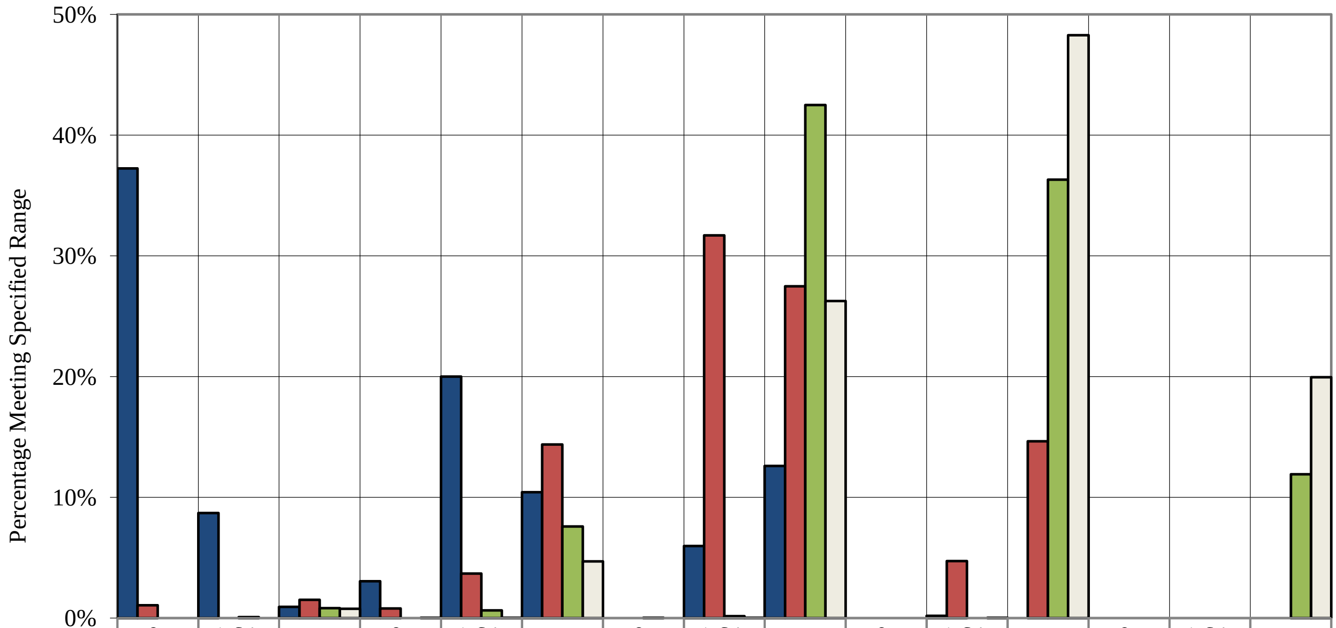

**Figure 27 - Steepened Toe Ramp Passage Delineations.**

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria specified by the BRT. The black lines indicate 1' contours of the proposed grading. At the two lower flows, insufficient depths prevent a passage corridor from extending the entire length of the ramp at 4 fps. At higher flows, the 4 fps velocity criteria is only met on the fringe areas of the ramp. Note the amount of area downstream of the ramp not meeting the 4 fps criteria for all simulations.

Passageways are available at all flows under the 6 fps criteria, excluding the 40 Kcfs simulation at the crest. This problem could be mitigated through modification of the existing dam crest abutment.



Return to TOC




| | 0-1.64ft 0-2ft/s | 1.64-3.28ft 0-2ft/s | >3.28ft 0-2ft/s | 0-1.64ft 2-4ft/s | 1.64-3.28ft 2-4ft/s | >3.28ft 2-4ft/s | 0-1.64ft 4-6ft/s | 1.64-3.28ft 4-6ft/s | >3.28ft 4-6ft/s | 0-1.64ft 6-8ft/s | 1.64-3.28ft 6-8ft/s | >3.28ft 6-8ft/s | 0-1.64ft >8ft/s | 1.64-3.28ft >8ft/s | >3.28ft >8ft/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7k | 37% | 9% | 1% | 3% | 20% | 10% | 0% | 6% | 13% | 0% | 0% | 0% | 0% | 0% | 0% |
| 15k | 1% | 0% | 2% | 1% | 4% | 14% | 0% | 32% | 27% | 0% | 5% | 15% | 0% | 0% | 0% |
| 30k | 0% | 0% | 1% | 0% | 1% | 8% | 0% | 0% | 43% | 0% | 0% | 36% | 0% | 0% | 12% |
| 40k | 0% | 0% | 1% | 0% | 0% | 5% | 0% | 0% | 26% | 0% | 0% | 48% | 0% | 0% | 20% |

**Figure 28 - Steepened Toe Ramp Depth/Velocity Classifications.**

This chart displays percent by area classifications of several depth and velocity combinations for the ramp for the set of flows modeled. The predominant flow classification for all flows is depths greater than a meter and velocities in the 4 to 6 fps range. However, at the 30,000 and 40,000 flow simulations significant portions of the ramp exceed 6 feet per second. Analysis of the velocity contours show that this occurs primarily in the thalweg of the ramp and areas adjacent.



Return to TOC

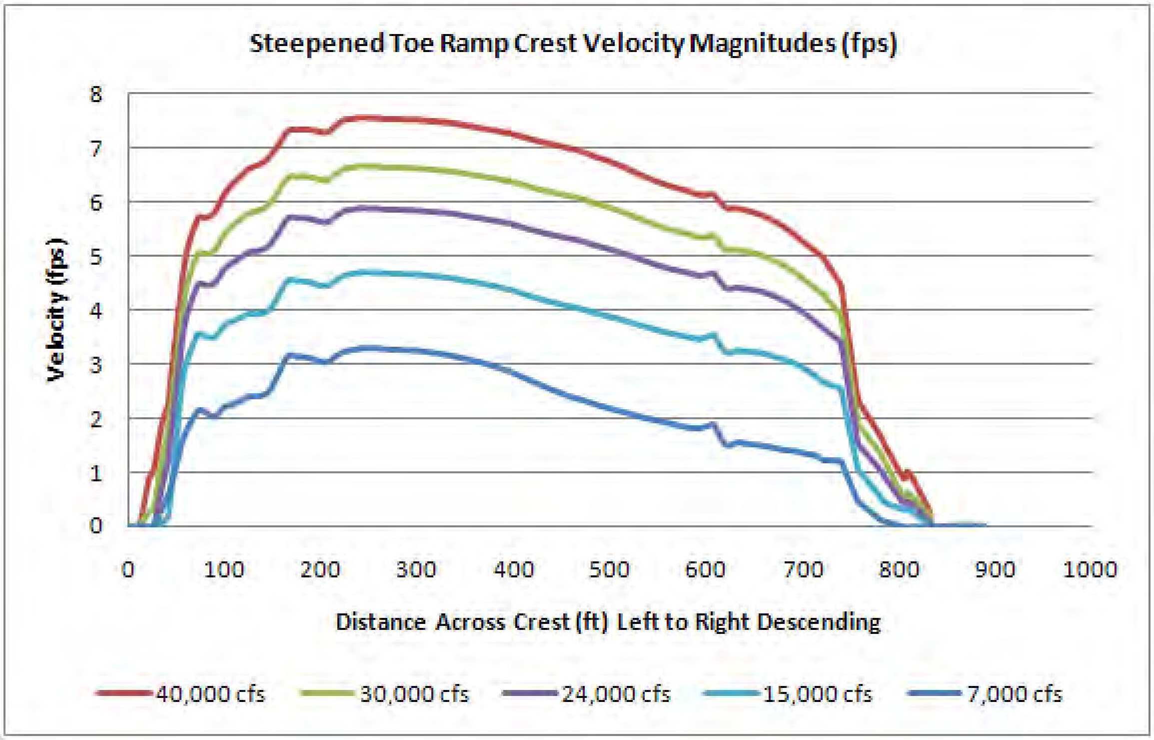



Figure 29 - Steepened Toe Ramp Velocities at the Crest.

This figure is a cross-section taken from near the proposed crest of the damn displaying velocities in fps for a several modeled flow rates. Numerical modeling indicates that increases of 0.5-1 fps are resultant from the shortened geometry compared to the original proposal.

# 9 Doubled Slope Ramp Hydraulic Summary

The depth and velocity contours in this document display ADH results for a shortened version of the ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). The revised geometry represents a doubling in slope from the original ramp. The crest and thalweg are of the same configuration as the original ramp proposal. The slope is increased to .004 ft/ft for the first 500' downstream, .008 for the next 400 feet, and .02 ft/ft for the tie into ground. The purpose of these revisions is to reduce material costs for construction of the ramp. It is important that appropriate passage corridors be maintained with any recommended geometry.

The original ramp extends approximately 1600’ from the crest. The Doubled Slope geometry shortens the ramp length by 600’, reducing the total length from the crest to nearly 1000’. The total area of this grading plan is 19 acres. This is a 40% reduction from the original plan.

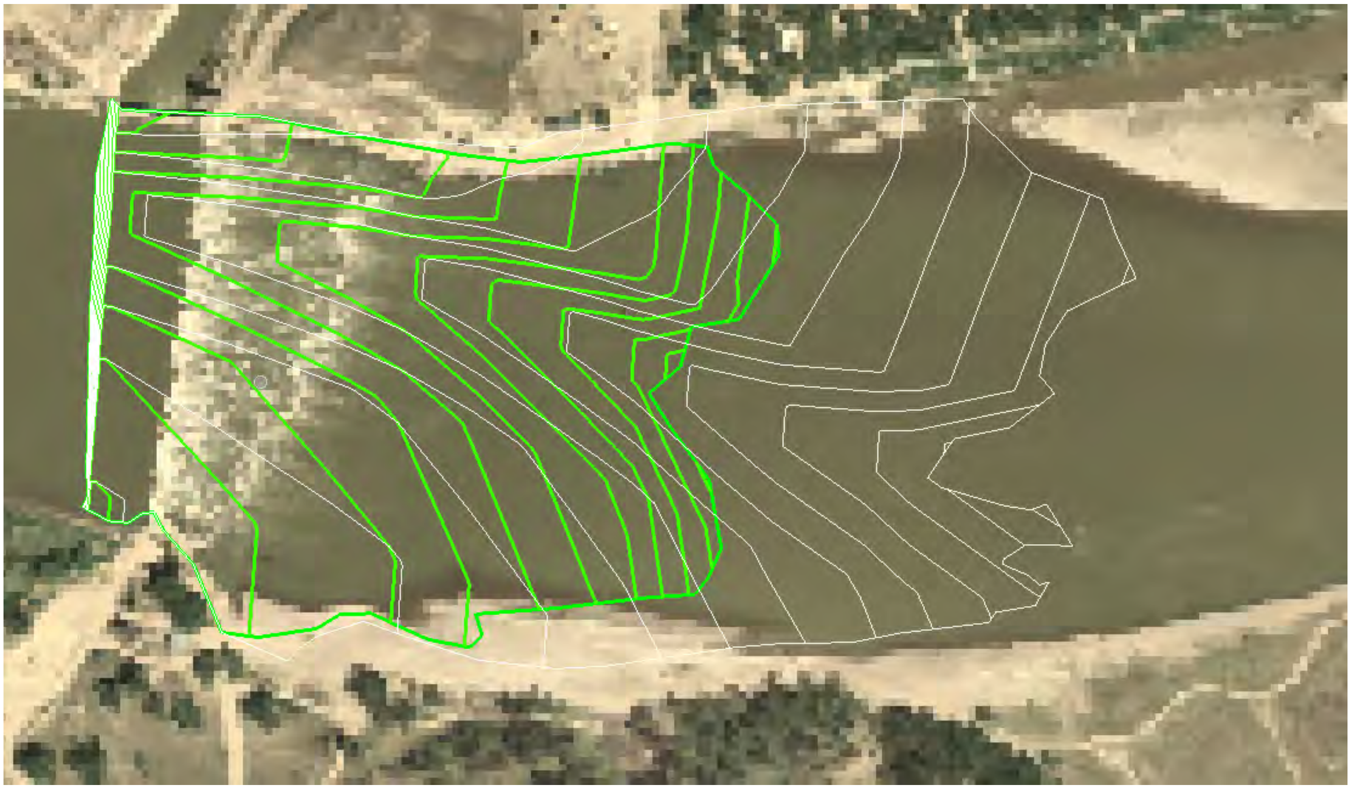


Figure 30 - 1' contours of original and Doubled Slope ramp.



Return to TOC

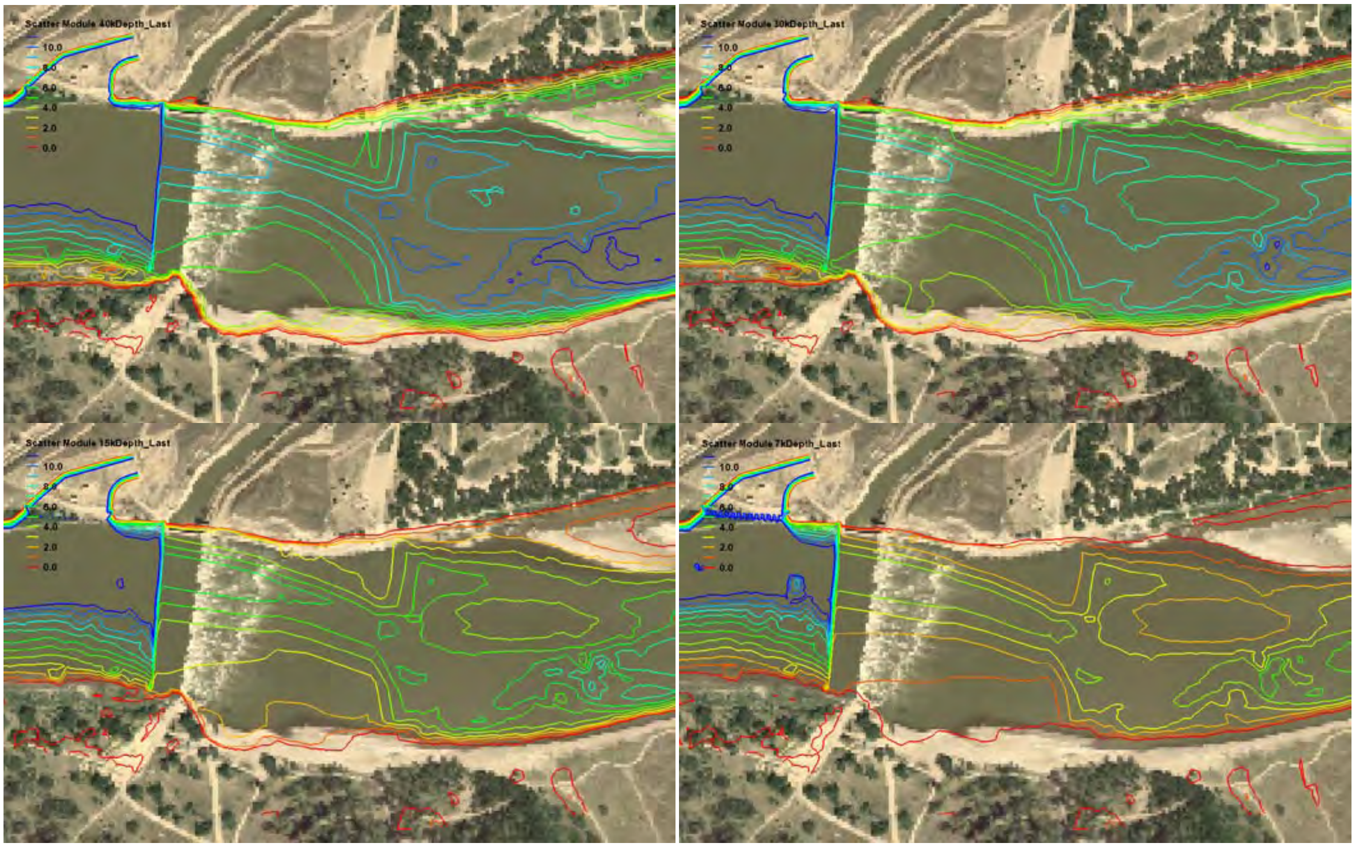



Figure 31 - Doubled Slope Ramp Depth Contours (presented in feet).

Depths throughout the ramp are greater than 1m at both 30 and 40 Kcfs. At 7 and 15 Kcfs, sufficient depths are only found through the low point of the ramp and diminish as the left and right edges of the ramp are approached. For all flows, a majority of the ramp is above depths of 0.5m.



Return to TOC

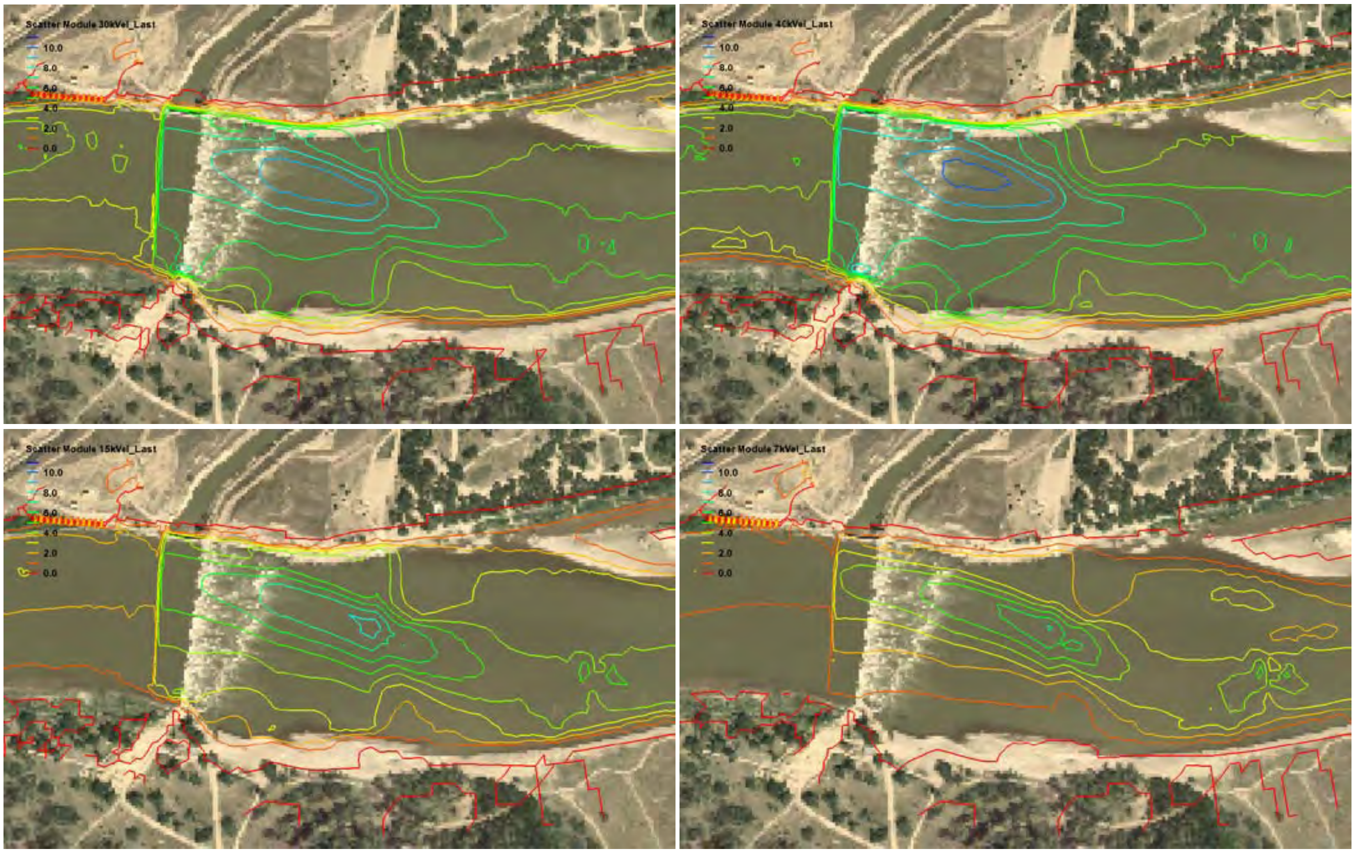



**Figure 32 - Doubled Slope Ramp Velocity Contours (presented in feet/second).**

Velocities throughout the ramp are greater than 6 fps at 40,000 cfs, excluding the fringe areas. At 30,000 cfs, pathways are available through the crest on the left side with velocities peaking at about 6.2 fps. This occurs not at the crest, but adjacent to the old weir crest abutment. At the crest, velocities on the left side are approximately 5.5 fps. At 15,000 and 7,000 cfs, velocities meet the 4 fps criteria throughout, but are not necessarily accompanied with sufficient depths.



Return to TOC

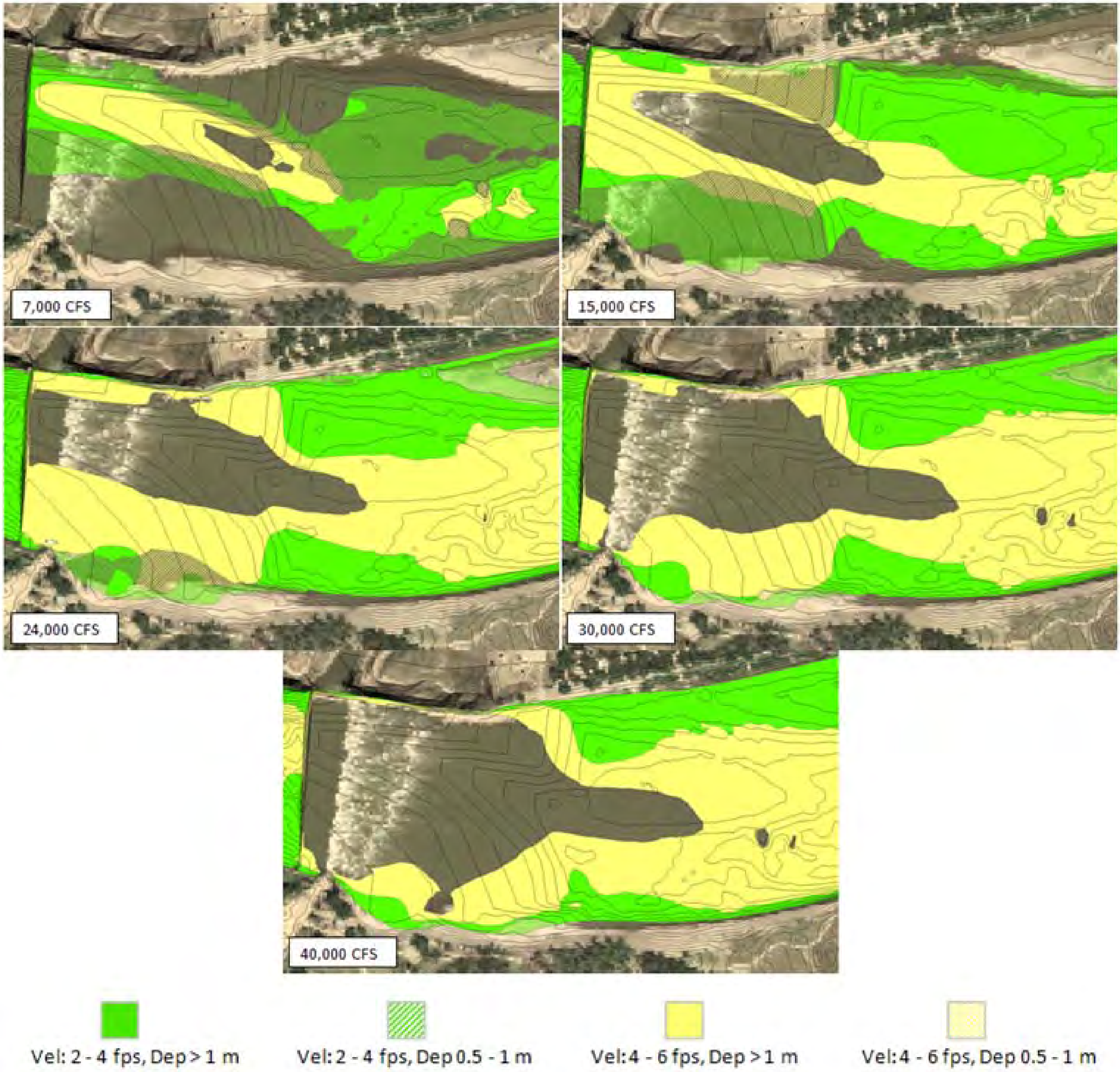
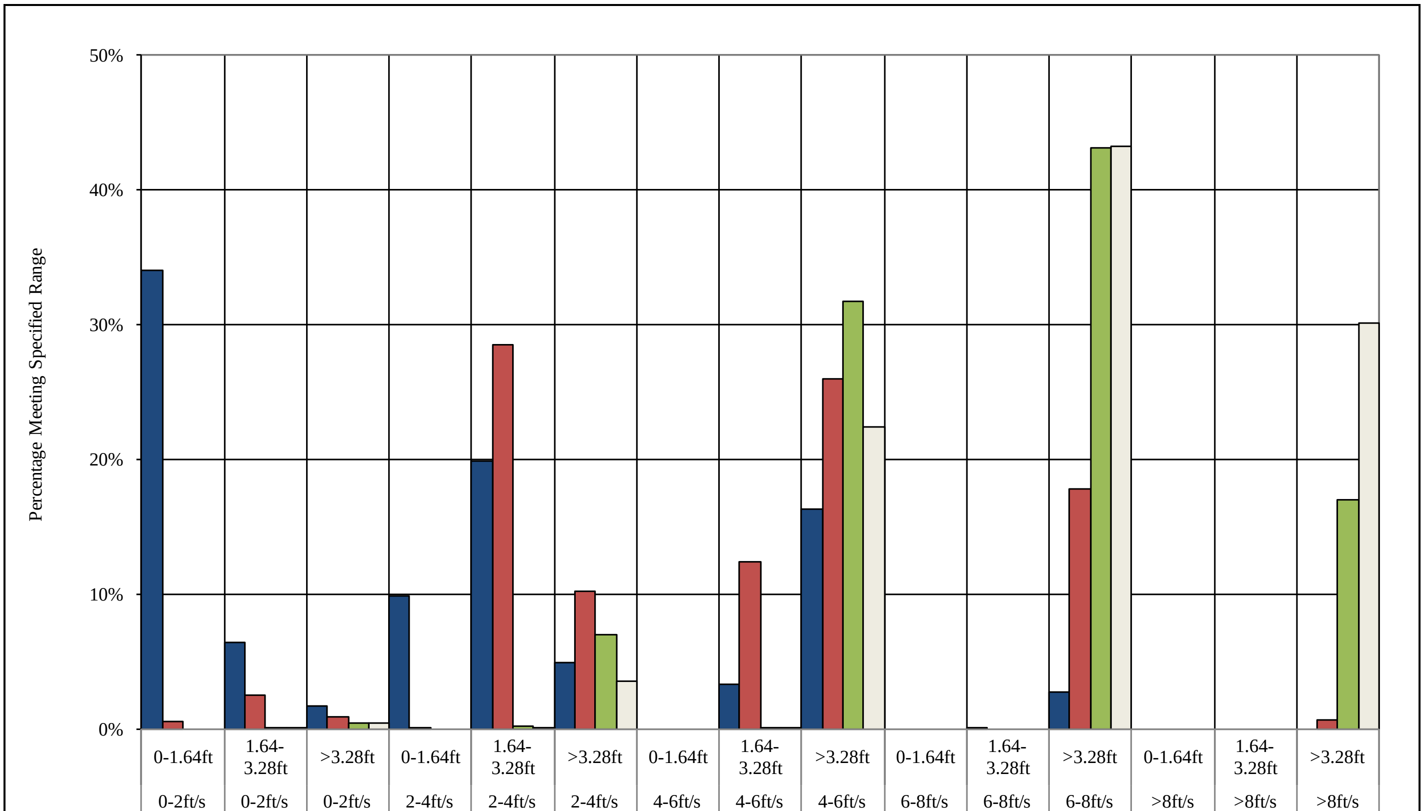



**Figure 33 - Doubled Slope Ramp passage delineations.**

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria specified by the BRT. The black lines indicate 1' contours of the proposed grading. At the two lower flows, insufficient depths prevent a passage corridor from extending the entire length of the ramp. At higher flows, the 4 fps velocity criteria is only met on the fringe areas of the ramp.

Passageways are available at all flows under the 6 fps criteria, excluding the 40 Kcfs simulation at the crest. This problem could be mitigated through modification of the existing dam crest abutment.




| | 0-1.64ft 0-2ft/s | 1.64-3.28ft 0-2ft/s | >3.28ft 0-2ft/s | 0-1.64ft 2-4ft/s | 1.64-3.28ft 2-4ft/s | >3.28ft 2-4ft/s | 0-1.64ft 4-6ft/s | 1.64-3.28ft 4-6ft/s | >3.28ft 4-6ft/s | 0-1.64ft 6-8ft/s | 1.64-3.28ft 6-8ft/s | >3.28ft 6-8ft/s | 0-1.64ft >8ft/s | 1.64-3.28ft >8ft/s | >3.28ft >8ft/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7k | 34% | 6% | 2% | 10% | 20% | 5% | 0% | 3% | 16% | 0% | 0% | 3% | 0% | 0% | 0% |
| 15k | 1% | 2% | 1% | 0% | 29% | 10% | 0% | 12% | 26% | 0% | 0% | 18% | 0% | 0% | 1% |
| 30k | 0% | 0% | 0% | 0% | 0% | 7% | 0% | 0% | 32% | 0% | 0% | 43% | 0% | 0% | 17% |
| 40k | 0% | 0% | 0% | 0% | 0% | 4% | 0% | 0% | 22% | 0% | 0% | 43% | 0% | 0% | 30% |

Doubled Slope Ramp Depth-Averaged Velocity and Depth Ranges
(Ramp 10 + Doubled Gradient)
Total Area 19 Acres

**Figure 34 - Doubled Slope Ramp Depth/Velocity Classifications.**

This chart displays percent by area classifications of several depth and velocity combinations for the ramp for the set of flows modeled. The predominant flow classification for all flows is depths greater than a meter and velocities in the 4 to 6 fps range for most flows. However, at the 30,000 and 40,000 flow simulations significant portions of the ramp exceed 6 feet per second.



Return to TOC

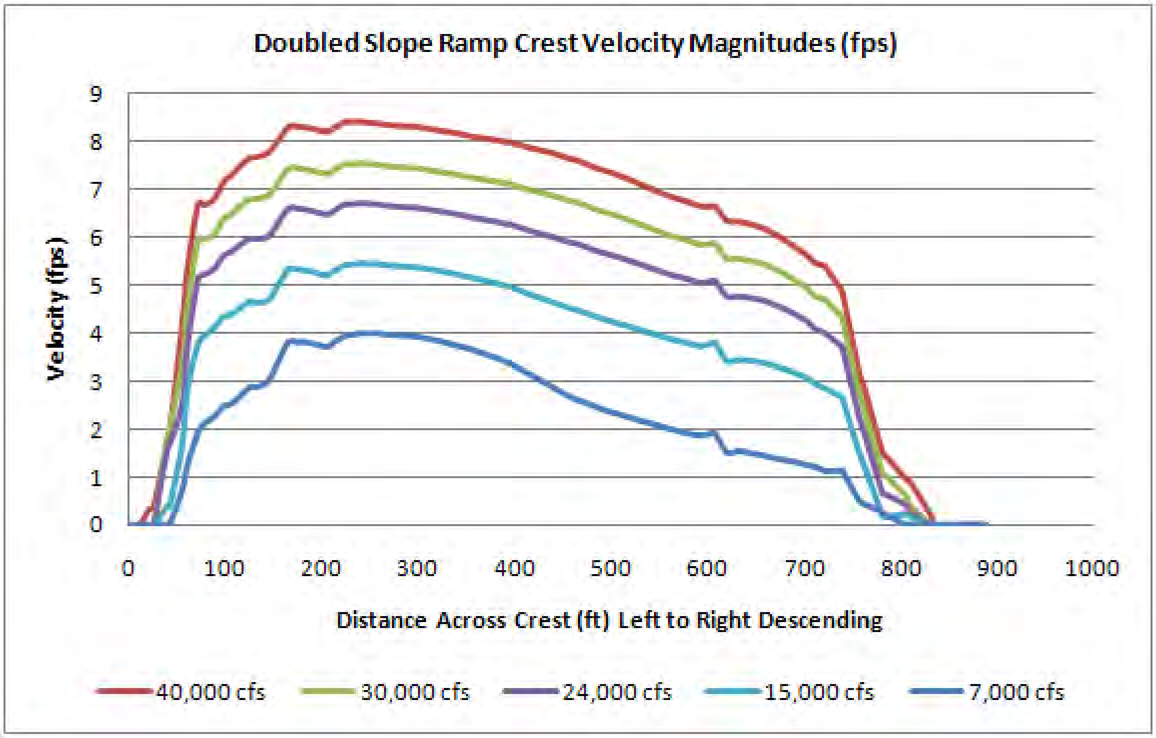



Figure 35 - Doubled Slope Ramp Velocities at the Crest.

This figure is a cross-section taken from near the proposed crest of the damn displaying velocities in fps for a 30,000 cfs flow rate. Numerical modeling indicates that increases of 1-1.75 fps are resultant from the shortened geometry compared to the original proposal.

## 10 High Flow Bench Ramp Hydraulic Summary

The depth and velocity contours in this section display ADH results for a shortened version of the ramp proposed at Intake. The figure below displays one foot contours of the original ramp (white) and the revised geometry (green). The revised geometry represents the addition of a high flow bench to the doubled slope ramp geometry presented earlier in this document. The crest and thalweg are of the same configuration as the original ramp proposal with the addition of a 100’ wide bench along the left bank, requiring partial removal of the existing dam abutment. The high flow bench is raised two feet from the ramp adjacent to it. The purpose of this revision is to display the effect top width widening has on increasing passage corridors.



Return to TOC

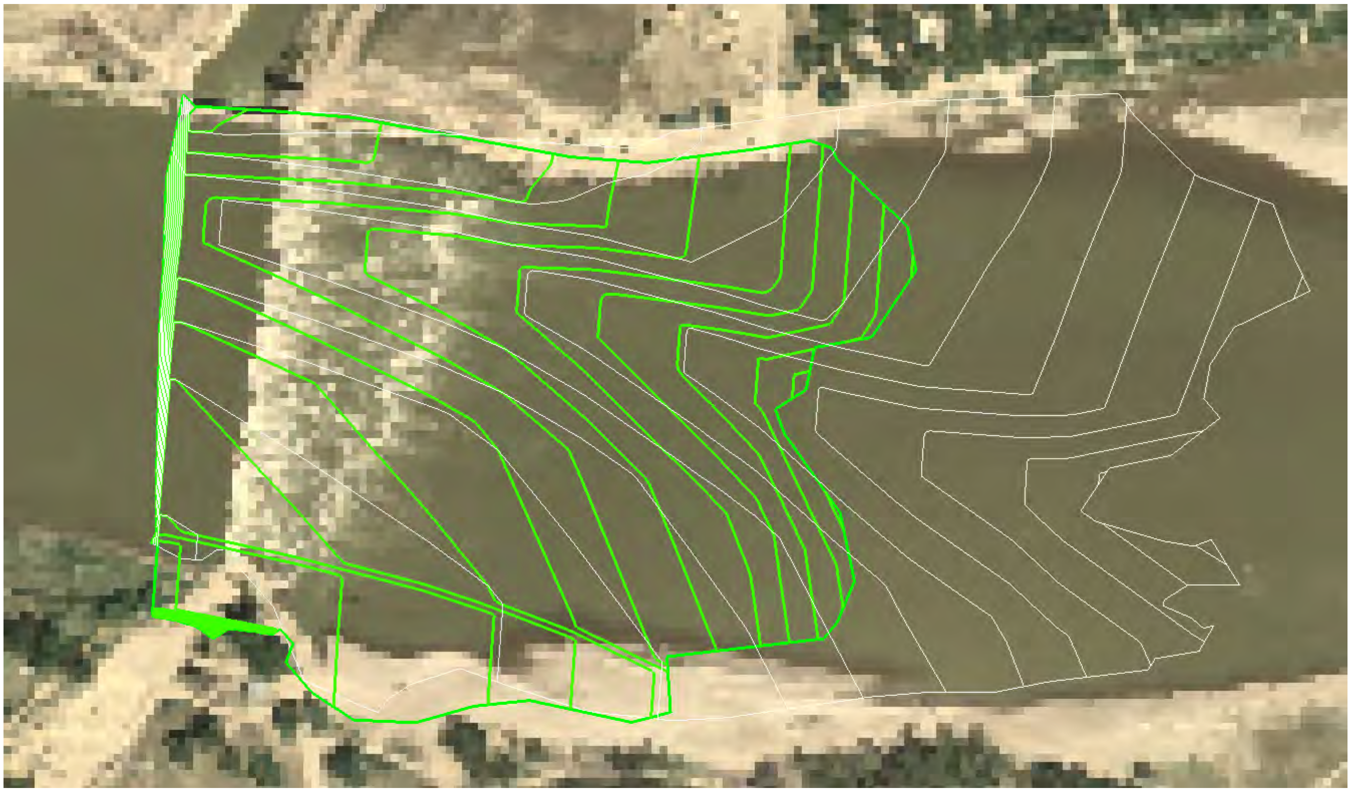


Figure 36 - 1' contours of original and High Flow Bench ramp.

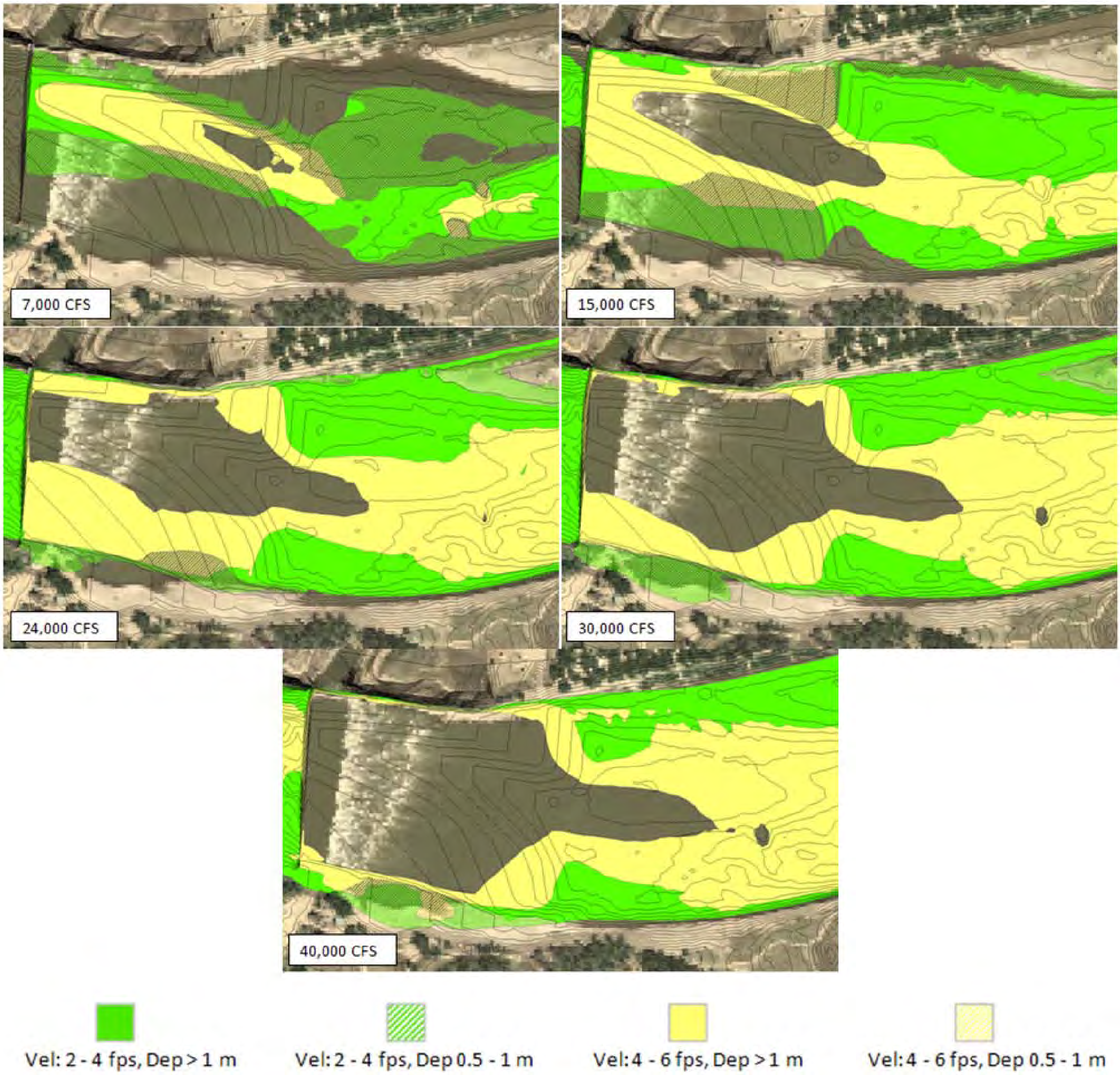



**Figure 37 - High Flow Bench Passage Corridors**

The colored portions of the figures above indicate areas of the ramp where hydraulic models show results meeting depth and velocity criteria specified by the BRT. The black lines indicate 1' contours of the proposed grading. At the two lower flows, insufficient depths prevent a passage corridor from extending the entire length of the ramp at 4 fps. At higher flows, the 4 fps velocity criteria is only met on the fringe areas of the ramp. Note the amount of area downstream of the ramp not meeting the 4 fps criteria for all simulations.

Passageways are available at all flows under the 6 fps criteria, excluding the 40 Kcfs simulation at the crest. This problem could be mitigated through modification of the existing dam crest abutment.

Inclusion of the high flow depths serves to increase suitable depths on the lower flow simulations and provide areas of suitable velocities during the higher flow simulations. If this option were to be included in a selected geometry, further adjustment to its configuration would be undergone to maximize the feature's utility.

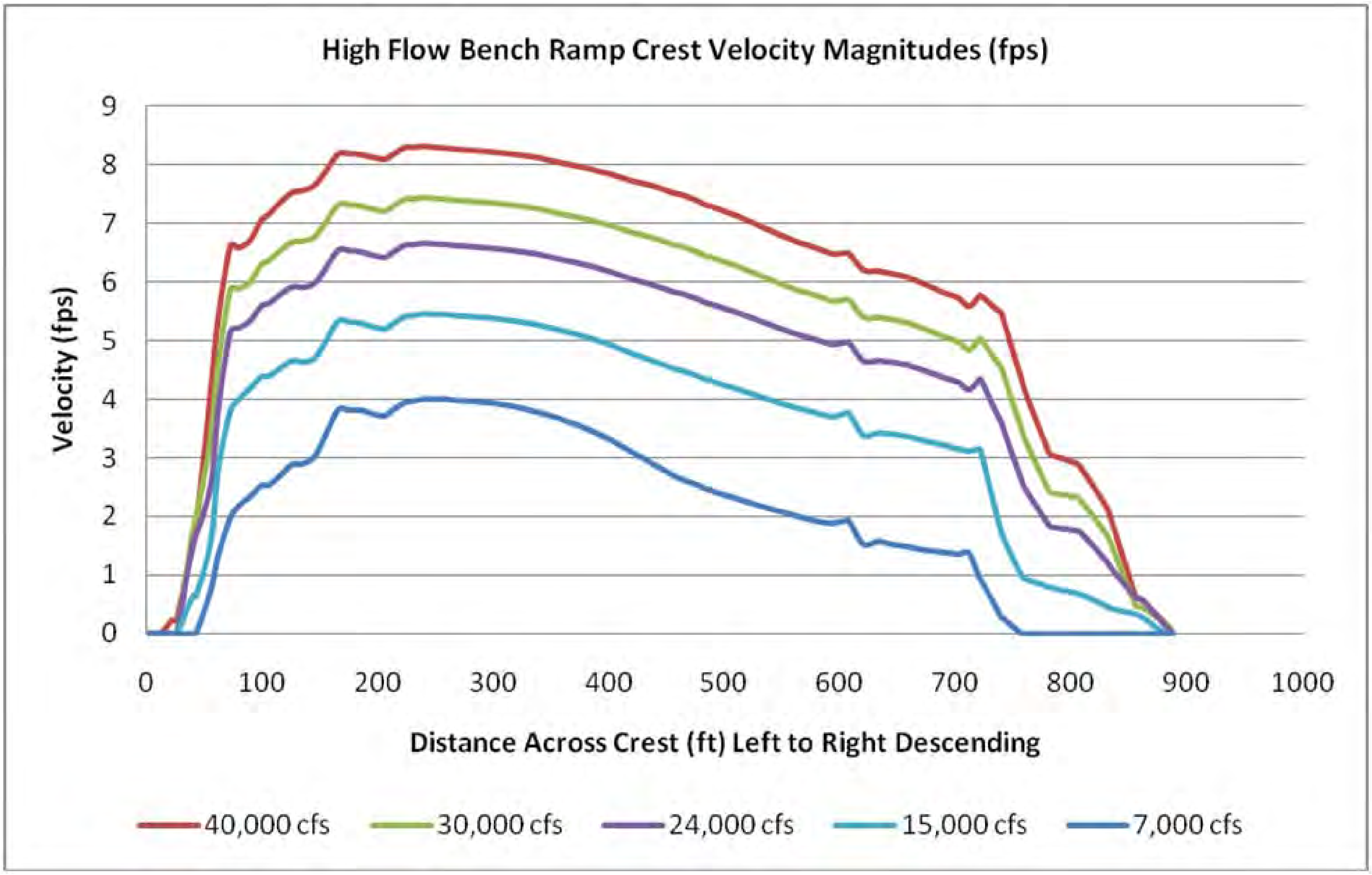



Figure 38 - High Flow Bench Crest Velocities

# Intake Diversion Dam Modification
# Lower Yellowstone Project, Montana

## Intake Fish Passage Option Evaluation Summary
## May 2012

## Attachment 4

## Constructability Overview



Return to TOC

# Constructability Overview
# May 2012

## 1. Introduction.

Constructability is an extremely important component of the project which did not receive adequate consideration prior to certification of TPC for the ramp project. The original concept plan for construction of the 1% uniform ramp was for placement of material in the wet. The 2009 Value Engineering study included, as part of the suggestion for reduction of rock layer thickness and use of granular material for subgrade, use of a geotextile filter layer between the rock layer and the subgrade. This approach of filter layer construction is not feasible. As the geometry of the rock ramp becomes more complex, and is tied to such small changes in grade, the quality control component of the project becomes even more important. Quality control is most difficult during construction in the wet.

Three main options for ramp construction have been considered which include:

- The originally proposed construction in the wet
- Diversion of half of the stream using a center channel sheet pile wall with additional cut off sheet pile at each end of the work area to facilitate construction in the dry by halves (cofferdam alternative cost 3)
- Full stream diversion.

Construction in the wet is not considered feasible due to logistics and quality control concerns however, discussion of the approach is included for completeness as that approach formed a significant component of the original conceptual design.

Two options for full stream diversion have been proposed. In one option the Yellowstone flow is diverted via the existing high flow bypass channel which requires construction of an extensive system of levees to constrain flow and to protect the work area (cofferdam alternative cost 1). This option would have to have the diversion removed during the irrigation season to allow for function of the headworks.

The second option involves construction of a shorter bypass channel around the immediate work area which requires extensive excavation (cofferdam alternative cost 2). Both options would require extensive channel protection and grade control.

## 2. Ramp Construction

### 2.1 Construction in the Wet

The original concept for construction of the ramp called for placement of rock without dewatering of the site. A portion of the channel was to be isolated by installation of a dividing berm corresponding with the lateral limits of the cofferdam required for the construction of the weir. Stream flow downstream of the cofferdam would be stilled and redirected but water levels would be altered only by changing of flow direction. This method would require blocking-off half of the stream at a time or having to cross flowing water as the weir sections are completed and the cofferdam is removed if smaller cofferdam segments were used.



Return to TOC

An example of a full channel bypass ramp constructed in the wet is the Glen Colusa Gradient Control Structure on the Sacramento River in California. This structure comprises a 0.3% uniform grade ramp that was constructed in the wet by direct placement of rip rap on the existing river substrate using excavators and other heavy equipment working from barges. This structure has had significant maintenance and rework over it's operational life though it should be noted that ramp stability issues have not been documented to have had any adverse impact on fish passage. It should also be noted that the fish passing the Glen Colusa structure have different depth and velocity requirements than the pallid sturgeon.

A primary issue with construction in the wet is grade control and subgrade preparation. All of the ramp designs meeting BRT passage criteria required slopes at least 200 ft of 0.002 ft/ft with additive increases in slope by the same amount in successive segments of the ramp. Attaining a uniform grade at that level of detail for subgrade preparation and effective filter layer placement using an excavator is very unlikely. The existing rock debris field would have to manipulated to allow for proper placement and compaction of fill material, compaction of the material would be extremely difficult. The problem with wet construction becomes more significant as adjacent segments of channel are filled with rip rap which would raise the overall water level or move flows in the channel. At some point it may not be possible for construction equipment to enter the channel due to excessive water depths. It may be necessary to divert some component of the flow out of the river to attain workable water depths.

Another significant issue with construction in the wet is limited access to the site for work. Working benches will need to be constructed and expanded to facilitate access as the ramp is constructed. The number of crews working in the channel and the provision of rock to those crews will be limited by the number of haul roads constructed which in turn will impact the overall construction duration.

Work in the wet is not possible during ice out or periods of high spring flows. Access may also be complicated by pallid presence in the work area. The result of the access issues is a shortened work season beginning late in the summer and proceeding into the winter with slowed productivity during the winter period when work is possible.

There are additional safety concerns working in the wet, especially during the winter months winter when Hyperthermia becomes a significant risk. In addition, when working in turbid water adjacent to deeper portions of the channel there is added risk for substrate failure or operator error resulting in losing the machine in deep water or overturning of the machine and potential drowning of the operator.

### 2.2 Half stream Diversion

In this construction scenario a half stream cofferdam is constructed upstream of the weir construction similar to construction in the wet. The cofferdam parallel with the new crest structure would consist of granular fill with smaller material near the center and larger material near the outer slopes, and sheet pile driven at the centerline to a depth to cut-off seepage. A center line sheetpile wall would be constructed, probably parallel to the alignment of the natural thalweg. Construction of this structure would involve removing rock from the existing rock debris field, driving sheet pile, replacing the rock and adding additional rock to protect the sheet pile. A granular/ sheet pile cofferdam section would be continued to the river bank to complete the coffered area. As with construction in the wet, isolation of the work area would need to be completed if pallid sturgeon are present in the work area. Once the sheet pile is installed the site would be dewatered and seepage water would need to be continually pumped.



Return to TOC

Construction quality control would be significantly better under dry conditions.  Based on currently available knowledge about the substrate material it is likely to be granular and capable of supporting tracked equipment which would facilitate rapid grading of large areas. Use of a geotextile filter layer would be feasible if cost effective. Rapid placement of the subgrade would provide more area for placement excavators to work during rock placement and more avenues for haul trucks to utilize to provide rock to those excavators. Overall productivity would be significantly improved as long as rock supply to the site was maintained.

Negative considerations for this approach include the added capital cost of the sheet pile, sheet pile installation and removal costs, and care of water costs. It is possible that high flows may also overtop the cofferdam at times which could periodically impact work within the dewatered area. The upstream and downstream portions of the cofferdam would have to be removed prior to ice out to allow for conveyance of ice out flows and high spring flows. It is very likely that a portion of the centerline sheet pile could be damaged and require replacement due to ice impacts. Quality control of portions of the ramp constructed adjacent to the sheetpile prior to dewatering and as the sheet pile is removed would be limited since that construction would be completed in the wet. It is likely that the buttress material next to the sheet pile may provide the only avenue for wall removal access which would impede removal efficiency and my pose safety risks working in deeper portions of a flooded stream channel with a narrow travel corridor. It is possible that a diversion of some portion of the flow could be required during work on the second half of the ramp due to channel capacity being taken up by the ramp material.

### 2.3 Full Stream Diversion

In this scenario a full channel width cofferdam is constructed in a location which facilitates utilization of the headworks structure for irrigation purposes for the duration of construction. As in the other two construction options it requires isolation of the work area prior to the arrival of pallid sturgeon. Once site controls are installed, however, they do not need to be removed until all ramp construction is complete and no breaks in the construction season would be required.

Under this option the entire ramp footprint would be accessible and with sufficient pre-staging of rock and other construction material on both sides of the channel, equipment utilization and construction management can be optimized. With the large open area grade control can more easily be maintained over the entire ramp than with the other two options. Other than placement and removal of the upstream cofferdam risks of working in or around water, especially during winter months, is significantly reduced or eliminated.

The significant negative aspect to this construction approach is the cost and technical implications of diverting the entire flow of the Yellowstone river around the work site which combine to make this option infeasible

## 3. Bypass Channel Construction

Construction of a bypass channel is much more straightforward than construction of a rock ramp.  A significant portion of the work effort is the soil excavation to create the main channel. The alignment of the fish bypass channel exit near the existing diversion dam will require the tramway tower and support facility to be removed and relocated for preservation to meet SHPO requirements.  Existing rock piles near the existing diversion dam abutment area will be utilized in the project.



Return to TOC

The lothologic profile in the excavation alignment comprises cohesive to non-cohesive fine grained soils(silt and fine sand with some clay) in the upper part of the excavation and coarse grained (cobble with gravel to fine sand matrix, often bimodal) non-cohesive soils in the lower part of the profile. Depositionally the deposts appear to represent a point bar deposit which has been overlain by finer grained overbank or similar deposits. Ground water is encountered at shallow depths in most areas of the bypass channel excavation as determined by test pits excavated during the summer of 2012. Given the coarse nature of the deeper sediments and the close proximity to the Yellowstone River influx of ground water was rapid in most of the test pits.

Removal of the upper fine grained unit may be facilitated by scrapers though it is likely that pumping of the groundwater from the underlying cobble and gravel layer would impede traction and the effective use of scrapers. The coarse grained layers have no cohesion and when excavated the side walls of the excavation suffer slope failure under the influence of groundwater seepage pressures until an angle of reposed has been achieved.

Initially, a small pilot ditch could be excavated along the entire length of the new channel alignment, or along part of it, to facilitate excavation drainage as long as it didn't adversely impact truck traffic and production. Complete excavation of the northern bank profile as part of that ditch and then working the excavation to the south would allow unimpeded traffic flow. Culverted haul roads could also be constructed to facilitate access across the ditch. A haul road would be left alongside the north bank to facilitate rip rap placement, which would need to be complete before final access across the new channel was cut off.

The excavation for the rock structures would be performed prior to excavation of the main channel. Sheetpile cofferedams would be used to facilitate dewatering with water being pumped to the pilot ditch for conveyance away from the work areas. Limiting the excavated opening will limit the water infiltration. After the rock structure is completed the dewatering for this area can cease. The remainder of the channel would be excavated by backhoes and off-road articulated haul trucks. To avoid instability and heaving of the channel bottom during the excavation process, the pilot channel would be deepened and groundwater allowed to equalize and the excavation process continue.

4 **Cofferdams.** The work within the new channel will be protected by a cofferdam at the upstream entrance and the downstream exit. These two cofferdams will be constructed early in the construction. The upstream cofferdam will consist of sheet pile driven below grade into the large alluvial material to prevent underseepage. The zone of the cofferdam will be large riprap on both the upstream and downstream with a 20' wide crest and 1V on 2H side slopes (help resist ice forces). The cofferdam at the downstream exit will be lower in height because it will be below the existing diversion dam, it will be a similar cross section but most of the cross section will be cohesive material. Some of the rock placement on the new channel side slopes will be placed after the cofferdams are removed. The rock for the entrance, exit, vertical grade control, and horizontal control



Return to TOC

structures would come from either commercial sources in Wyoming or South Dakota, or development of a quarry near the site, or a combination of both.

**5 New Crest Dam.** To maintain the proper head for the operation of the new headworks the existing dam will either need to be modified or replaced. If replaced, the new diversion dam would consist of two lines of z-section sheet pile. The new dam will be located upstream of the existing dam by a distance of approximately 40 feet. The sheet pile will be driven in the river bottom which a fairly uniform strata of shales, claystones, siltstones, and the top elevation several feet above the river water level and will act as it's own cofferdam. This will allow the river to continue to flow during the construction process. Sheet pile rectangular cells will be created by t-sheets perpendicular to the main sheets. Rock will be placed on both sides of the structure to add stability to the sheetpile walls. There should be little infiltration or seepage of water into the sheet piles cells after dewatering pumping due to the impermeability of the river substrata. The cells will be pumped full of concrete. The sheet pile will be pulled if possible or cut off several feet the design crest elevation to avoid impact of the metal with electroreceptivity of some of the native fish. It is anticipated the cells would be completed in minimum lengths of 40 feet. The work can be performed from both banks of the river, and by using anchored barges.

An access road from the north bank is anticipated to be constructed along the existing rock ramp which would be required to be removed after construction is complete. The area between the new and existing diversion dams will be filled with granular sands, and gravels excavated from the bypass channel alignment, which would be capped with a riprap layer. This placement can be performed by hauling and dumping on the completed surface and worked from the south bank. The upstream face of the new diversion dam will be protected with the excavated granular material and capped with riprap on a 1V on 3H slope. That material would most likely be placed by barge. A barge inlet is planned to be excavated on the south bank upstream of the diversion dam. The inlet will be used to launch the barge(s) and to dock and load the barges during the construction duration.



Return to TOC

**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Intake Fish Passage Option Evaluation Summary**
**May 2012**

# Attachment 5

## Ramp Coffer Dam Concept Evaluation



Return to TOC

## 1. PURPOSE

The purpose of this document is to summarize the results of a concept level analysis conducted to evaluate major features of various ramp coffer dam scenarios along with associated hydraulic impacts.

## 2. INTRODUCTION

A number of construction techniques and phasing methods are possible for construction of the dam crest and rock ramp. This document summarizes the major features required for several proposed methods.

**NOTE:** Minimal analysis has been completed on the various alternatives. The information contained herein is intended to allow for a comparison between the various construction methods, but values given are subject to change based on a more detailed evaluation.

Floodplain impacts and increased velocities are a concern for many of the possible situations. This document summarizes a concept level analysis conducted to evaluate the hydraulic conditions resulting from several of the methods.

Each of the methods described below allow for construction of the rock ramp in the dry. It was determined that adequate quality control would not be feasible otherwise.

## 3. ANALYSIS

This analysis was conducted using the hydraulic model HEC-RAS version 4.1.0. The HEC-RAS model is a one-dimensional hydraulic model that was developed to calculate water surface profiles for a uniform, steady state flow by the standard step method. The standard step method computational procedure is based on the solution of the one-dimensional energy equation and friction loss evaluated with Manning's equation.

Because HEC-RAS is a one-dimensional model, the velocities and velocity increases/reductions given in this document are based on cross sectional averages. Localized velocities cannot be evaluated with this model. Additionally, the water surface elevations presented herein are assumed to be at the same elevation across the river. Despite these limitations, the relative increase/decrease in water surface elevation and velocity are useful in providing a general idea of the change in hydraulic conditions for the various scenarios. The HEC-RAS model can be used to rapidly evaluate a large number of alternatives. Note that certain simplifying assumptions were made in the HEC-RAS model in order to evaluate all the various alternatives.

The construction conditions evaluated include the following:

1. Original Conditions (prior to headworks coffer dam (HCD) construction)
2. With HCD
3. With HCD and south half of ramp coffer dam (RCD)

Return to TOC

4. With south half of RCD, HCD removed
5. With HCD and south third of RCD
6. With south third of RCD, HCD removed
7. With HCD and south fourth of RCD
8. With south fourth of RCD, HCD removed
9. Coffer dam blocking entire river near location of new headworks with excavated bypass channel
10. Coffer dam blocking entire river near upstream end of Joe's island (near upstream end of right bank high flow channel)
11. South half of ramp complete, north half of RCD in place
12. Coffer dam blocking entire river near location of new headworks with only a pilot channel excavated, remaining flow allowed to spread out over the island

Concept evaluation of conditions 10-12 are presented in this report.

Conditions 2-8 and 11 were compared against original conditions to evaluate increases in energy grade elevation and increases in channel velocities. The comparison of energy grade is reflective of the change in water surface elevation, but provides a better idea of the actual impact without accenting limitations of the one-dimensional model. The energy grades and channel velocities for the 2-yr, 10-yr, 50-yr, and 100-yr events were computed using the HEC-RAS model.

In addition to comparing the various conditions head-on, a second comparison was made assuming a construction season limited to August through February. Assuming construction is limited to Aug-Feb avoids the spring flood as well as ice-out conditions. The USACE Omaha Hydrology Section developed seasonal discharge-frequency curves for Aug-Feb and Aug-Mar. The Aug-Feb discharge frequency values are compared against the annual values in Table 1.

Return to TOC

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project: | Intake Dam Modifications | | | | | Sheet No. | 4/19 |
| Subject: | Ramp Coffer Dam Concept Evaluation | | | | | | |
| Computed by: | CJM | Date: | DEC2010 | Checked by: | | Date: | |

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**Table 1 Flow Frequency**

| Percent Chance Exceedance | Return Period (years) | Seasonal: Aug-Feb (cfs) | Annual-Post Yellowtail Dam (cfs) |
|---|---|---|---|
| 0.2 | 500 | 128,507 | 114,000 |
| 0.5 | 200 | 96,637 | 105,000 |
| 1 | 100 | 77,223 | 97,200 |
| 2 | 50 | 61,117 | 89,400 |
| 5 | 20 | 43,967 | 78,700 |
| 10 | 10 | 33,515 | 70,100 |
| 20 | 5 | 24,764 | 60,600 |
| 50 | 2 | 14,982 | 45,300 |
| 80 | 1.25 | 9,961 | 33,300 |
| 90 | 1.11 | 8,334 | 28,200 |
| 95 | 1.05 | 7,314 | 24,500 |
| 99 | 1.01 | 5,949 | 18,600 |

Flow exceedance by duration values are given in Table 2.

**Table 2 Flow-Duration Values**

| | Discharge (cfs) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent Time Flow Equaled or Exceeded | Annual | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| 1 | 65,500 | 19,800 | 12,300 | 11,300 | 13,500 | 22,900 | 50,500 | 38,100 | 53,200 | 93,000 | 73,200 | 25,400 | 17,900 |
| 10 | 25,500 | 11,700 | 10,900 | 8,790 | 9,450 | 11,600 | 17,500 | 14,500 | 31,100 | 54,700 | 37,500 | 13,800 | 11,500 |
| 20 | 14,700 | 10,700 | 10,100 | 8,290 | 8,140 | 9,460 | 12,800 | 12,500 | 23,300 | 46,200 | 30,300 | 11,500 | 9,710 |
| 30 | 11,300 | 9,940 | 9,480 | 7,930 | 7,510 | 8,660 | 10,900 | 10,500 | 19,400 | 40,500 | 26,300 | 9,890 | 8,780 |
| 50 | 8,460 | 8,710 | 8,080 | 7,100 | 6,600 | 7,400 | 8,720 | 8,470 | 14,800 | 30,700 | 17,100 | 7,080 | 6,660 |
| 80 | 5,640 | 6,010 | 5,590 | 5,020 | 4,800 | 4,910 | 6,230 | 6,130 | 9,770 | 18,700 | 7,780 | 3,980 | 4,320 |
| 90 | 4,530 | 5,120 | 4,790 | 4,210 | 4,110 | 4,490 | 5,160 | 5,470 | 7,560 | 14,900 | 5,730 | 2,710 | 3,600 |
| 95 | 3,800 | 4,360 | 4,160 | 3,520 | 3,210 | 4,180 | 4,200 | 5,000 | 6,230 | 12,400 | 4,930 | 1,770 | 3,060 |
| 99 | 2,130 | 3,710 | 2,230 | 2,130 | 2,160 | 2,990 | 3,110 | 3,850 | 4,530 | 8,570 | 3,590 | 1,390 | 2,020 |

Return to TOC

***Full River Width Coffer Dams***
Cursory analyses on full river coffer dams (conditions 10 and 12) have been completed. Available information is presented below.

*Condition 10  Upstream Full River Coffer Dam (Coffer Dam 1)*
Based on the available topographic data, it appears that the highest reasonable tie-off elevation on both banks without extensive levees is about elevation 2006 ft NAVD88.  A coffer dam at this elevation could reasonably be tied off on both banks near the upstream end of Joe’s Island near the right bank chute split (≈ RS 37500).  The entire Yellowstone River would then be diverted in to the right bank chute.  Figure 1 shows the elevation 2006 contours on both banks and potential coffer dam alignment.  Figure 2 shows the Yellowstone River cross sectional geometry just downstream from the potential coffer dam alignment.  Note that Figure 2 only extends to the left bank.  The tie-off “levee” from the point where the coffer dam alignment turns to the southwest would only be approximately 2-4 feet high except where it crosses the left bank high flow channel where it would be approximately 6 ft high.

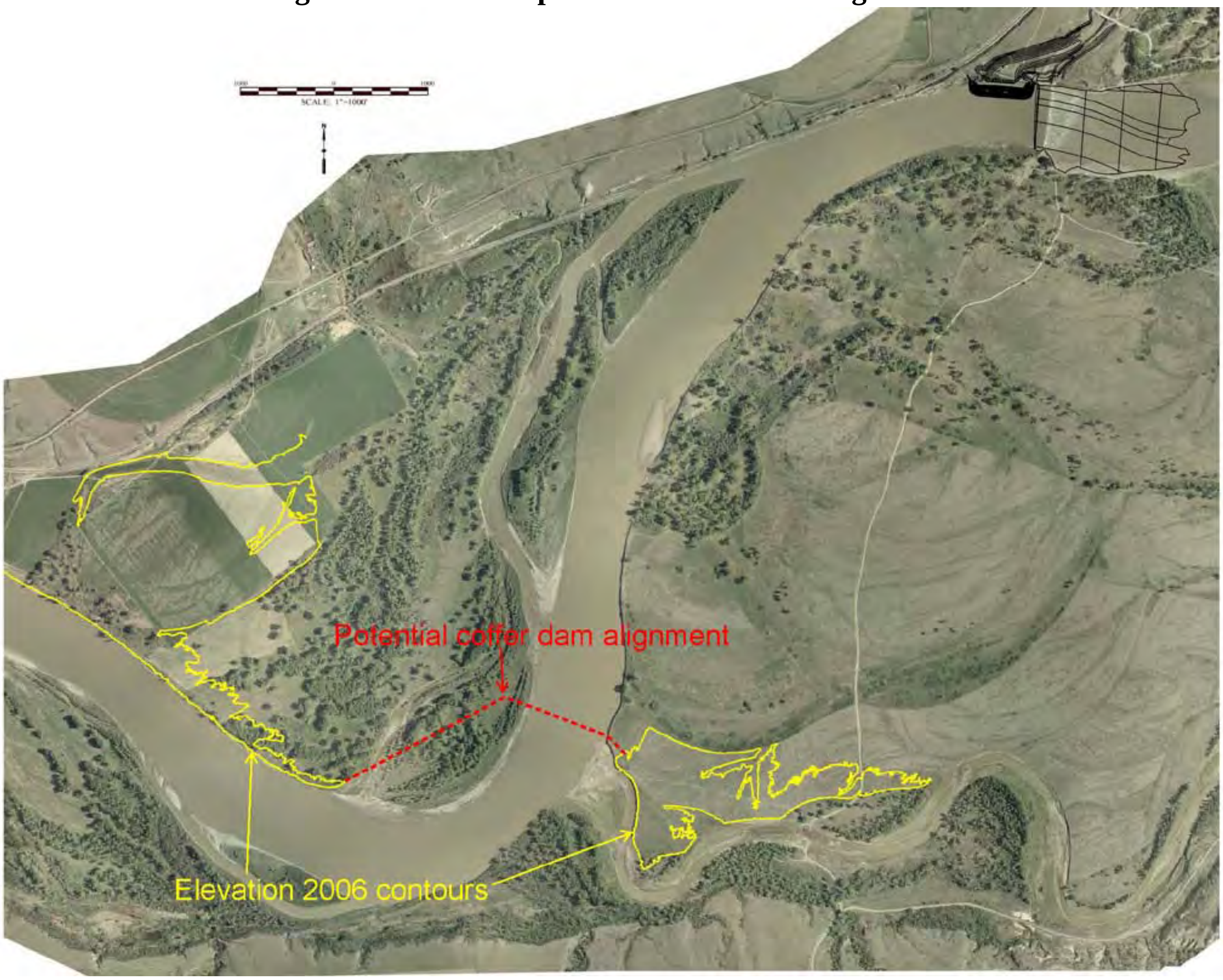
Based on the stage-discharge rating curve at the upper end of the right bank chute, a discharge of approximately 8000cfs can be conveyed by the chute before a coffer dam at elevation 2006 would be overtopped..  Therefore, during a 2-year event (based on the Aug-Feb seasonal discharges) a little more than half of the flow would be diverted into the right bank chute before overtopping or flanking the coffer dam.  A flow of 8000cfs has greater than 90% annual chance of exceedance.  As shown in Table 2, the 50% exceedance discharge by duration during October and November is 8710 and 8080 cfs, respectively.  The high risk of coffer dam overtopping associated with the 2006 top elevation is assumed to be unacceptable.  Figures 1 and 2 are shown for informational purposes only.

Return to TOC

US Army Corps of Engineers
Omaha District

| Project: | Intake Dam Modifications | | | | | Sheet No. | 6/19 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Subject: | Ramp Coffer Dam Concept Evaluation | | | | | | |
| | | | | | | | |
| Computed by: | CJM | Date: | DEC2010 | Checked by: | | Date: | |

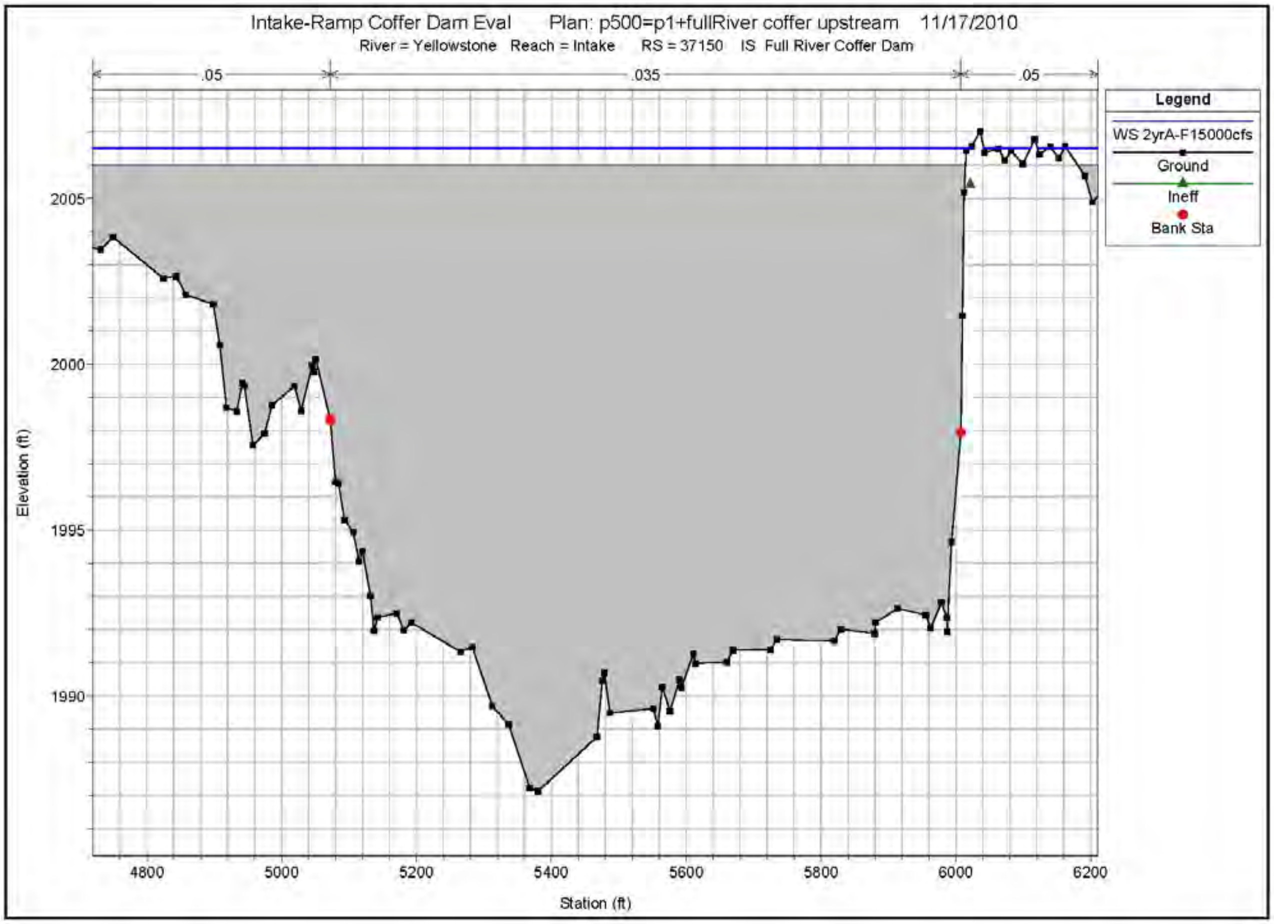
**Figure 1 Potential Upstream Coffer Dam Alignment**




Return to TOC

| Project: | Intake Dam Modifications | | | | | Sheet No. | 7/19 |
|---|---|---|---|---|---|---|---|
| Subject: | Ramp Coffer Dam Concept Evaluation | | | | | | |
| Computed by: | CJM | Date: | DEC2010 | Checked by: | | Date: | |

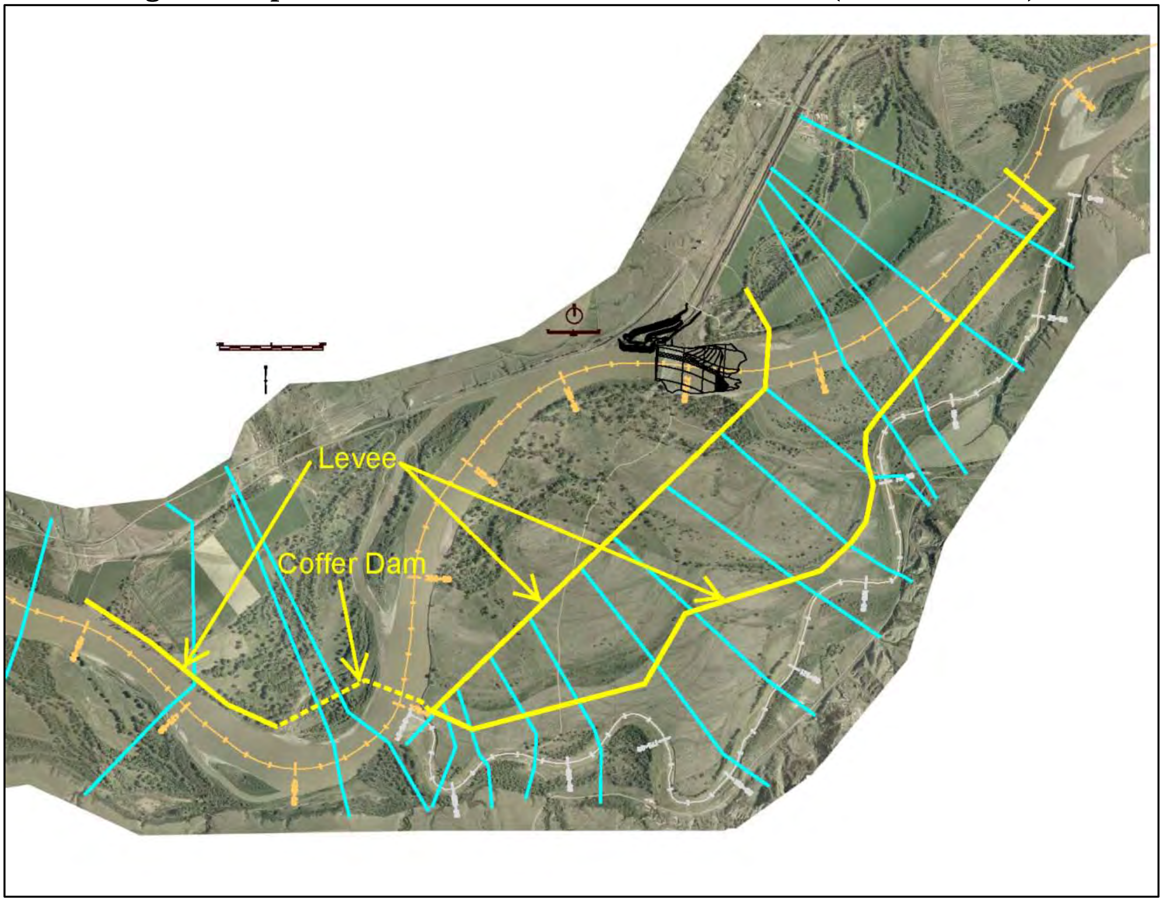
**Figure 2 Upstream Coffer Dam Cross Section**




Another option for the upstream coffer dam is to raise the top elevation and construct tie-off levees upstream and downstream in order to prevent flanking. Two options for the downstream tie-off levee were evaluated: one that follows the chute and one that extends from the coffer dam directly to the downstream side of the proposed ramp footprint (see Figure 3). The advantage of the longer levee option is that it requires stabilization at only one location to bring flow back into the main channel. However, the shorter levee option results in lower levee/coffer dam elevations and is the preferred alternative.

Return to TOC

**Figure 3 Upstream Coffer Dam with Tie-off Levees (Coffer Dam 1)**




Using a discharge of 33,500cfs (10-year Aug-Feb flow), the top of coffer dam would need to be at or above approximately 2011.3 ft NAVD88 based on the computed water surface elevation (i.e. no freeboard). The 10-year profile is approximately 3.4 feet above the 2-year (Aug-Feb) profile. Thus, a zero freeboard 10-year levee is equivalent to a 3.4 feet freeboard 2-year levee height. The 50-year profile is approximately 2.7 feet above the 10-year profile.

The 33,500 cfs profile results in a coffer dam with a maximum height of approximately 24 ft in the Yellowstone River thalweg. The levee would extend upstream approximately 6500 ft to tie off with natural ground at elevation 2012 (not accounting for freeboard). Downstream, the levee would extend from the coffer dam directly to the downstream end of the proposed ramp footprint, then across the main channel to prevent backwater from entering the project area. The total levee length would be approximately 18,000 ft in addition to the approximately 950 ft of sheetpile coffer dam. A cellular coffer dam or other method may be required due to the height (i.e. a single row of sheet pile may not be adequate). Maximum upstream levee height would be approximately 14 ft (on the left bank upstream, crossing the left high flow chute). The average levee height would be in

Return to TOC

the 5-8 ft range. At the downstream tie-off, the levee would cross the main channel and would reach a maximum height of approximately 18 ft. Water surface elevations and approximate ground elevations at each cross section are shown on Plate 1.

While velocities against most of the levee are expected to be relatively low, some sort of erosion protection would likely be required. At a minimum, the lower portion of the levee should be wrapped with a geomembrane or similar erosion protection material.

For either coffer dam top elevation, erosion protection would be required at the downstream end of the high flow channel to bring the diverted flow back into the main channel. Minimal analysis has been completed on the required protection, but at a minimum, a rock riprap grade control structure would be required. The following grade control structure dimensions can be used for estimating purposes.

- Width ≈ 500 ft (approximately twice the 2-yr top width)
- Length ≈ 75 ft (based on ≈ 5 ft elevation difference, assume transition at 1V:15H)

For the coffer dam with tie-off levee at the downstream end of the proposed ramp location, additional erosion protection would be required between the tie-off levee and the downstream end of the chute where flow cascades over the bank and enters the Yellowstone River main channel. There are two locations that are depressed relative to surrounding ground. It is assumed flow would concentrate in these two locations and bank armoring would be required. For estimating purposes, the following configuration can be used for each bank armoring site:

- Width ≈ 600 ft (based on approximate width of depressions)
- Elevation difference ≈ 16 ft
- Slope length ≈ 100ft (based on 6:1)

To account for uncertainties in flow concentration locations and because this is a concept level evaluation, it is recommended that the volume of rock computed for the bank armoring be doubled. The additional rock could be stockpiled on site and placed as needed depending on flow conditions.

Additional rock will be required on the levee face at the location of the upstream bank armoring site as it is anticipated that flow will concentrate in the depression near the levee as it flows into the main channel. Rock should also be placed on the levee face as it crosses the main channel as this is one location where flow will be returning.

Rock size for the scour hole and for the bank armoring can be assumed to be similar to that used in the rock ramp. While this rock would likely not be able to be used in the ramp, it may be possible to reclaim the rock following construction and stockpile it for use in future ramp repairs or adjustments. Rock erosion protection quantity is summarized as follows:

Return to TOC

Bank Armoring for Yellowstone River
2 sites, each 600’x100’, doubled for concept estimate = 26,800 sq yds

U/S Levee Face
200’x20’=225 sq yds

Main Channel Levee
100’x20’=450 sq yds

Grade Control Structure, D/S end of high flow channel
500’x75’=4200 sq yds

Total Rock Area ≈ 32,000 sq yds

All rock – assume 30 inch D100. For short duration reliability during construction period, 1D100 or 30 inch layer thickness is reasonable.

Figure 4 shows the location of the proposed grade control structure and bank armoring.

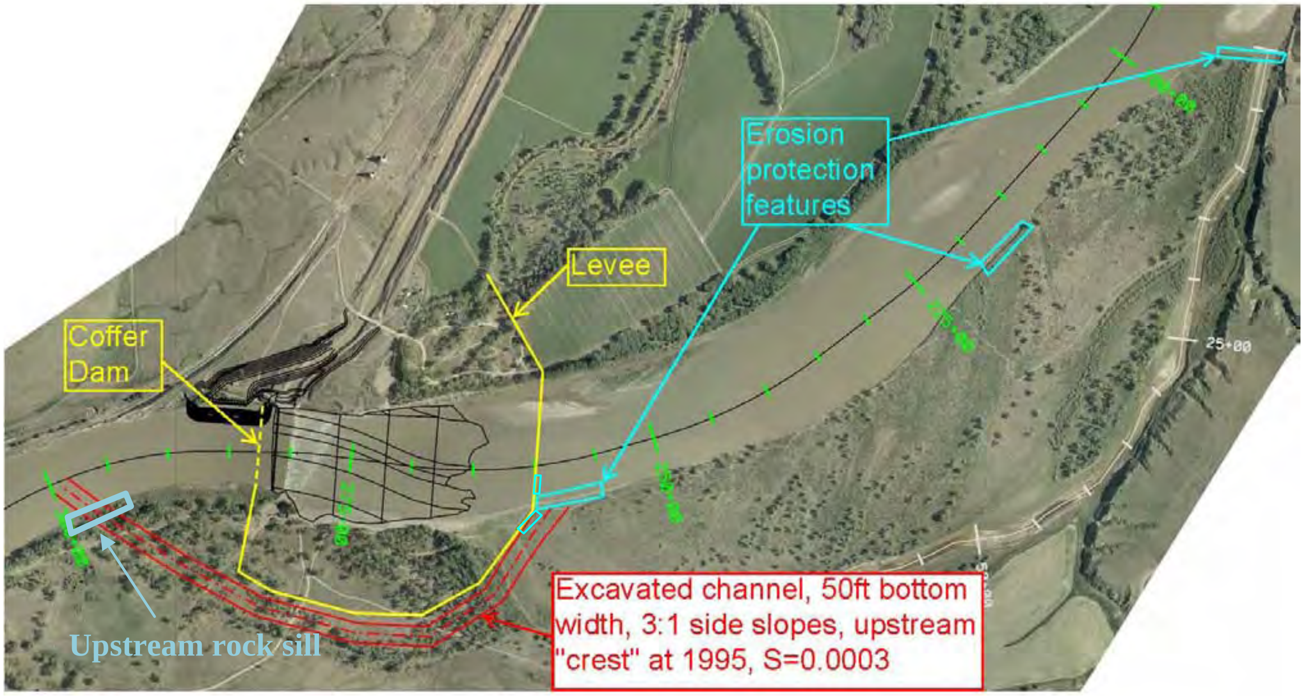
Return to TOC

**Figure 4 Grade Control and Bank Armoring Locations**


*Condition 12 Full River Coffer Dam at new Headworks (Coffer Dam 2)*
The concept of condition 12 is to build a full river width coffer dam between the ramp crest and new headworks. A small bypass channel would be excavated to carry low flows around the ramp footprint, and higher flows would be allowed to spread out over the island. A levee that ties into the coffer dam on the upstream side and wraps around the proposed ramp footprint, preventing backwater from entering the work area, would be required. Similar to the full coffer dam upstream, erosion protection features would be required to convey water back into the main channel. A general overview of the concept is presented in Figure 5.

Return to TOC

**Figure 5 Full River Coffer Dam at New Headworks-Overview (Coffer Dam 2)**




Major features included in this concept are summarized below:

- Coffer dam
  - Length ≈ 700ft
  - Water surface for 2-yr Aug-Feb discharge = 2002.1
  - Water surface for 10-yr Aug-Feb discharge = 2003.9
  - Water surface for 100-yr Aug-Feb discharge = 2006.6
  - Maximum height ≈ 26ft (based on 10yr water surface, no freeboard)
- Earthen levee
  - Length ≈ 5600 ft
  - Maximum height ≈ 20 ft for 10-yr water surface (in main channel thalweg downstream)
  - Average height range for 10-yr, not including freeboard = 4-6ft
  - Profile range – 10-yr exceeds 2-yr by about 1.8 feet along the levee
- Excavated channel
  - Length ≈ 4500ft
  - Bottom width = 50ft
  - Side slopes = 3H:1V
  - Channel slope = 0.0003 ft/ft
  - Upstream "crest" invert elevation = 1995
  - Average depths of excavation ≈ 3-7 ft
- Erosion protection
  - Upstream rock sill crest

Return to TOC

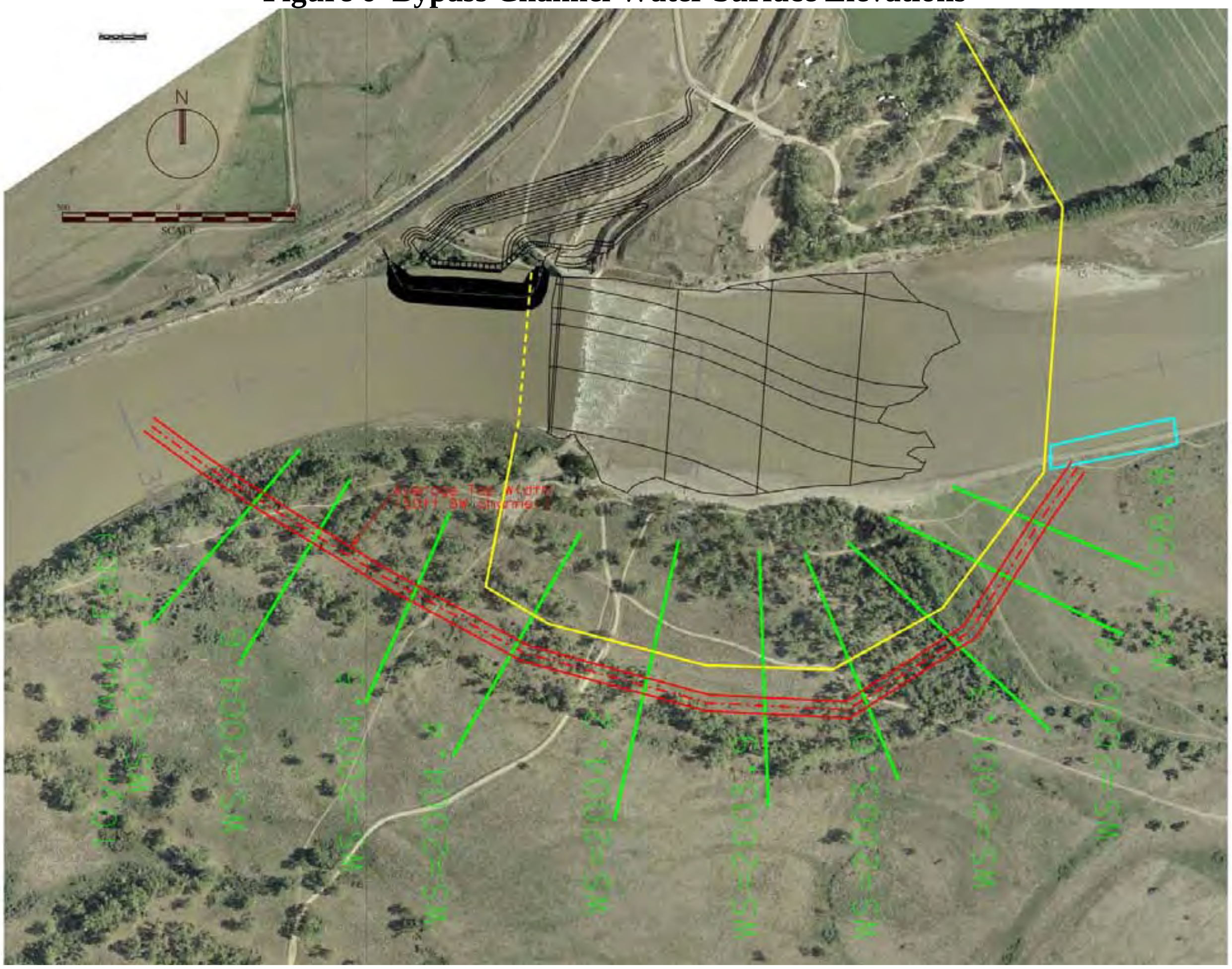
- Width ≈ 500ft
- Length (in direction of flow) ≈ 150 ft
- Rock area ≈ 8400 sq yds
- Rock size similar to that used in ramp, 30 in D100

- Grade control structure at downstream end of high flow chute
  - For concept level estimating purposes, assume similar to that described in upstream full river coffer dam alternative, total rock of 4200 sq yds
- Bank armoring
  - For concept level estimating purposes, assume similar to that described in upstream full river coffer dam alternative, total rock of 26,800 sq yds
  - Note that the downstream end of the excavated channel will require additional rock due to the significant drop from excavated invert to main channel invert. A large drop in water surface and high velocities are expected. Rock protection area estimated as 225'x500' = 13,000 sq yds (based on 15ft drop at 1V:15H and top width of 10-yr)
- All erosion protection rock = 52,400 sq yds. Assume 30 inch D100. Layer thickness of 1xD100 suitable for short duration construction period

Water surface elevations for the 10-year Aug-Feb discharge are shown in Figure 6.

Return to TOC

**Figure 6 Bypass Channel Water Surface Elevations**



***Partial River Coffer Dams (Coffer Dam 3)***

Cursory evaluations were conducted on a number of partial river coffer dam alternatives. It was then determined that construction issues would prevent constructing the ramp in thirds or fourths. This section evaluates construction of the ramp in halves.

For this evaluation, construction sequencing was assumed to take place in two phases. Phase 1 would include a coffer dam blocking off the north half of the ramp work area. This phase would include construction of the ramp thalweg. Phase 2 would coffer off the south half of the ramp with all flow going over the completed north half of the ramp. The portion of the coffer dam extending longitudinally down the middle of the river was assumed to start in the middle on the upstream end, extend downstream to where it intersects the thalweg rock layer thickness boundary, then continue to the downstream end of the ramp at the edge of the thalweg rock layer thickness boundary. The assumed coffer dam location is shown in Figure 7.

Return to TOC

**Figure 7 Half Ramp Coffer Dam-General Plan (Coffer Dam 3)**


The assumed coffer dam location follows the edge of the thalweg rock layer thickness boundary so as to minimize quality control difficulties associated with crossing the thalweg. While this alignment constricts flow to a relatively narrow conveyance area during the first half of construction, it is nearly offset during the second half of construction when all flow is directed over the north half of the completed ramp (rather than existing conditions river bed).

Both phases were evaluated in the HEC-RAS model. Figure 8 shows the computed water surfaces for both phases as well as the proposed coffer dam elevations. Proposed coffer dam elevations are based on the higher computed water surface elevation between the two phases plus two feet of freeboard. Computations were performed for both the all season and Aug-Feb 10-year profiles.

Return to TOC

**Figure 8 Half Coffer Dam Profiles**

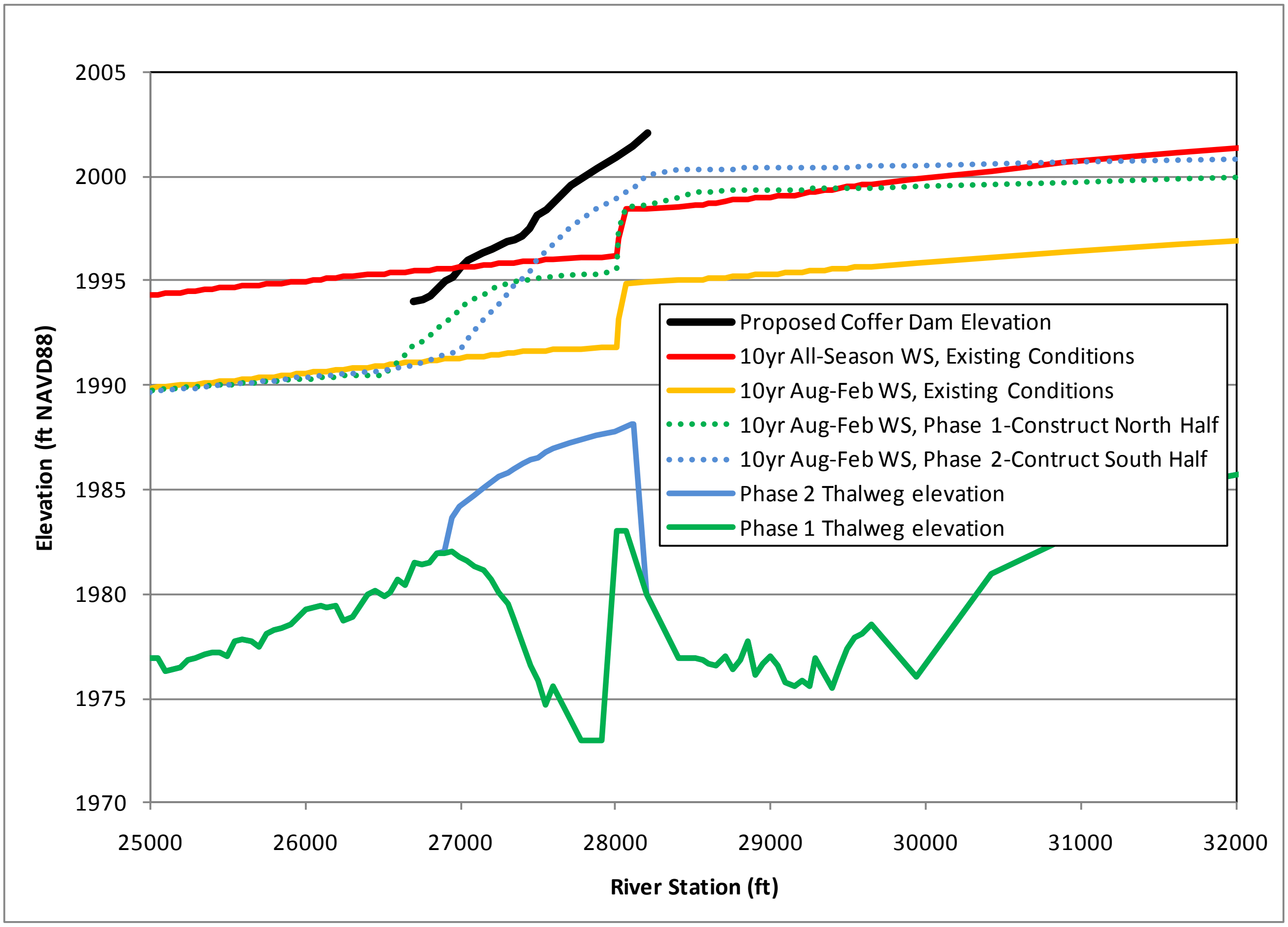



Table 3 compares energy grade elevations and velocities between existing conditions and the two phases.

Return to TOC

US Army Corps of Engineers
Omaha District

| Project: | Intake Dam Modifications | | | | Sheet No. | 17/19 |
|---|---|---|---|---|---|---|
| Subject: | Ramp Coffer Dam Concept Evaluation | | | | | |
| Computed by: | CJM | Date: | DEC2010 | Checked by: | Date: | |

**Table 3 Half Coffer Dam Energy and Velocity Comparision**

| | Max increase in energy grade elevation over original conditions (ft) | | | | Average increase in velocity over original conditions (ft/s), RS 26696-28406 (existing dam is RS 28000, proposed crest is RS 28120, d/s end of ramp is RS 26696) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2-yr | 10-yr | 50-yr | 100-yr | 2-yr | 10-yr | 50-yr | 100-yr |
| Phase 1-Construct North Half | 4.4 | 5.2 | 5.3 | 4.7 | 3.6 | 3.3 | 1.1 | 1.3 |
| Phase 2-Construct South Half | 8.2 | 8.8 | 9.1 | 9.3 | 5.0 | 5.7 | 6.1 | 6.1 |
| Phase 1-Construct North Half * | -1.1 | 0.1 | 2.1 | 3.5 | 0.4 | 1.6 | 2.7 | 1.9 |
| Phase 2-Construct South Half * | 2.3 | 3.3 | 5.7 | 7.1 | 1.4 | 3.1 | 4.6 | 5.2 |

* Comparison in these rows uses all-season discharges for original conditions and August-February discharges for construction

To prevent erosion and potential undermining of the longitudinal coffer dam, rock placement is recommended. Rock with a similar gradation as the ramp rock could be used and placed along the wet side of the coffer dam. It is assumed that the rock used to stabilize the coffer dam could be reclaimed and used in the rock ramp.

Figure 8 shows the cross sections used in the HEC-RAS model and Table 4 gives water surface elevations for several discharges for both Phases.

**Figure 8 HEC-RAS Cross Sections**


Return to TOC

**Stationing of Critical Features:**

| River Station | Feature |
|---|---|
| 37,300 | Upstream Coffer Dam |
| 28,115 | New Weir Upstream Crest (U/S of 10 ft section) |
| 28,105 | Ramp Rock Start (D/S side of concrete weir) |
| 26,900 | Ramp centerline toe along thalweg |
| 26,700 | Downstream coffer dam alignment-half coffer |
| 26,050 | Downstream coffer dam alignment-full coffer upstream and downstream (further downstream to take advantage of topography for flow returning to the river) |

**Table 4 Half River Coffer Dam Water Surface Elevations**

| | Water Surface Elevations (ft NAVD88) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Phase 1 | | | Phase 2 | | | |
| | 2-yr (Aug-Feb) | 10-yr (Aug-Feb) | 100-yr (Aug-Feb) | 2-yr (Aug-Feb) | 10-yr (Aug-Feb) | 100-yr (Aug-Feb) | Concept top of coffer dam elevation |
| River Station | 15,000 cfs | 33,500 cfs | 77,200 cfs | 15,000 cfs | 33,500 cfs | 77,200 cfs | (ft NAVD88) |
| | | | | | | | |
| 28407 | 1995.4 | 1999.0 | 2002.6 | 1996.3 | 2000.3 | 2006.8 | |
| 28203 | 1995.2 | 1998.6 | 2002.1 | 1996.2 | 2000.1 | 2006.8 | 2002.1 |
| 28115 | 1995.2 | 1998.5 | 2002.1 | 1995.9 | 1999.5 | 2005.2 | 2001.5 |
| 28105 | 1991.0 | 1997.5 | 2002.1 | 1995.8 | 1999.5 | 2005.2 | 2001.5 |
| 27998 | 1990.9 | 1995.6 | 2002.1 | 1995.5 | 1998.9 | 2004.1 | 2000.9 |
| 27880 | 1990.9 | 1995.3 | 2002.1 | 1995.2 | 1998.4 | 2003.4 | 2000.4 |
| 27706 | 1990.9 | 1995.3 | 2002.0 | 1994.6 | 1997.6 | 2002.3 | 1999.6 |
| 27597 | 1990.9 | 1995.2 | 2001.9 | 1994.0 | 1996.8 | 2001.1 | 1998.8 |
| 27550 | 1990.8 | 1995.2 | 2001.9 | 1993.8 | 1996.4 | 2000.4 | 1998.4 |
| 27498 | 1990.8 | 1995.1 | 2001.9 | 1993.6 | 1996.1 | 2000.1 | 1998.1 |
| 27447 | 1990.7 | 1995.0 | 2001.9 | 1993.2 | 1995.5 | 1998.6 | 1997.5 |
| 27399 | 1990.7 | 1995.0 | 2001.8 | 1992.9 | 1995.1 | 1998.0 | 1997.1 |
| 27348 | 1990.7 | 1995.0 | 2001.8 | 1992.6 | 1994.8 | 1997.7 | 1997.0 |
| 27301 | 1990.6 | 1994.9 | 2001.7 | 1992.3 | 1994.4 | 1997.3 | 1996.9 |
| 27249 | 1990.5 | 1994.7 | 2001.7 | 1991.9 | 1993.9 | 1996.8 | 1996.7 |
| 27199 | 1990.4 | 1994.6 | 2001.5 | 1991.6 | 1993.5 | 1996.5 | 1996.6 |
| 27147 | 1990.2 | 1994.3 | 2001.4 | 1991.2 | 1993.1 | 1996.5 | 1996.3 |
| 27093 | 1990.1 | 1994.2 | 2001.3 | 1990.8 | 1992.6 | 1996.2 | 1996.2 |
| 27045 | 1989.9 | 1994.0 | 2001.2 | 1990.4 | 1992.2 | 1996.2 | 1996.0 |
| 26998 | 1989.8 | 1993.7 | 2001.0 | 1990.0 | 1991.7 | 1996.1 | 1995.7 |
| 26946 | 1989.5 | 1993.2 | 2000.8 | 1988.8 | 1991.6 | 1996.1 | 1995.2 |
| 26900 | 1989.3 | 1993.0 | 2000.6 | 1988.5 | 1991.5 | 1996.1 | 1995.0 |
| 26850 | 1989.1 | 1992.7 | 2000.5 | 1988.4 | 1991.3 | 1996.0 | 1994.7 |
| 26799 | 1988.8 | 1992.3 | 1997.6 | 1988.3 | 1991.2 | 1995.9 | 1994.3 |
| 26751 | 1988.5 | 1992.1 | 1997.5 | 1988.2 | 1991.1 | 1995.8 | 1994.1 |
| 26697 | 1987.7 | 1992.0 | 1995.2 | 1988.0 | 1991.0 | 1995.7 | 1994.0 |
| 26646 | 1987.7 | 1991.5 | 1994.2 | 1987.9 | 1990.9 | 1995.7 | |

Return to TOC

## 4. SUMMARY

Three methods of construction phasing were considered and a concept level analysis was completed to lay out major features. The three concepts considered were a full river coffer dam upstream using the existing high flow chute, a full river coffer dam near the proposed ramp crest using a bypass channel, and a two phase half river coffer dam. Results of this cursory analysis are expected to be used to develop a concept level cost estimate for the various methods.

**NOTE:** Minimal analysis has been completed on the various alternatives. The information contained herein is intended to allow for a comparison between the various construction methods, but values given are subject to change based on a more detailed evaluation.

Return to TOC

# Intake Diversion Dam Modification

# Lower Yellowstone Project, Montana

## Intake Fish Bypass Option Evaluation Summary

**May 2012**

**Updated 6JULY2012**

## Attachment 6

## Bypass Channel Hydraulics and Sediment

Return to TOC

## Table of Contents





Return to TOC

## List of Figures



## List of Tables



## List of Appendices





Return to TOC

## 1. INTRODUCTION

Analysis was completed to evaluate a bypass channel for fish passage around the Intake Dam. The concept level analysis completed in April 2011 was used as a starting point. Three concept bypass channels were proposed in April 2011, one each for diversion percentages of 10%, 15%, and 30% of total Yellowstone River flow. Coordination with the U.S. Department of Interior, Bureau of Reclamation (Reclamation) and the Biological Review Team (BRT) led to refinements in the cross sectional shape and alignment of the proposed channel. This document discusses the 30% design of the current proposal consisting of a bypass channel that diverts approximately 15% of total Yellowstone River flow.

Hydraulic modeling was completed with HEC-RAS to evaluate the proposed alignment and channel cross section configuration. In addition to the hydraulic analysis, HEC-RAS was used to evaluate general sediment transport tendencies with various bypass designs. Two main objectives of the sediment modeling were to evaluate bypass channel stability and transport capacity within the main channel of the Yellowstone River.

Sustainability and passage issues with the flow and sediment relationship between the Yellowstone River and the bypass channel may be summarized as:

- Divert too much flow into the bypass channel and the main Yellowstone River channel has sediment deposition with impacts to the irrigation diversion
- Divert too much sediment into the bypass channel and the bypass channel has deposition
- Divert only clear water into the bypass channel causes stability issues with bank/bed erosion
- Fish passage may be compromised with insufficient bypass channel flow depth, attractive flow, or turbulent flow conditions
- Sediment erosion and deposition model results contain a high degree of uncertainty

This Attachment is meant to serve as a general overview of the bypass channel analysis. Additional information is presented in the six appendices to this attachment. Details pertaining to the sediment analyses are presented in Appendices A and B. Appendix C lists and describes the components of the 30% design. Appendix D compares 11 natural side channels on the Yellowstone River with the proposed bypass. Appendix E consists of an evaluation of the characteristics of an armor layer in the bypass channel. Appendix F is from the USGS and describes their sediment sampling efforts on the Yellowstone River near Intake in 2011. Appendix G is an analysis completed by Reclamation pertaining to the bypass channel configuration (channel cross sectional shape, upstream and downstream ends, and flow augmentation structure concept).

## 2. BYPASS FEATURES

The following proposed features summarize the bypass channel alternative.

### 2.1 Bypass channel excavation

A bypass channel would be excavated from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. The proposed alignment is



Return to TOC

approximately 15,500 ft long at a slope of 0.0006 ft/ft (natural Yellowstone River slope in the project area is approximately 0.0004 ft/ft to 0.0007 ft/ft) and excavation is currently estimated at approximately 1.2 million cubic yards. The channel cross section has a 40ft bottom width and side slopes varying from 1V:12H to 1V:3H. The bypass channel would divert approximately 15% of total Yellowstone River flows.

### 2.2 Upstream control structure

A structure designed to control discharge into the bypass channel would be situated on the upstream end of the channel. The structure would likely be composed of riprap with a concrete sill. The control structure would be backfilled with natural river size rock to give the appearance of a seamless channel invert. The purpose of the structure is to provide stability during extreme events to prevent excessive flow through the bypass.

### 2.3 Channel plug

A channel "plug" would be constructed approximately 1 mile downstream from the upstream end of the bypass in the existing high flow chute to keep normal flows in the proposed bypass. The channel plug would have a low-level discharge pipe and would be designed for overtopping during larger events to maintain the existing chute's current functionality.

### 2.4 Riprap at bends for lateral stability

Bank riprap is proposed at two outside bends to minimize the risk of losing the bypass channel planform.

### 2.5 Vertical control structures

Two vertical control structures (riprap sills) are proposed for maintaining channel slope and allowing for early identification of channel movement. Similar to the upstream control structure, these would be overexcavated and backfilled with natural river size rock to give the appearance of a seamless channel invert while providing stability during extreme events.

### 2.6 Downstream vertical control structure

A riprap sill is proposed at the downstream end of the channel to maintain channel elevations (similar to vertical control structures).

### 2.7 Downstream lateral stability structure

A riprap bank stabilization feature would be constructed on the descending right bank of the bypass channel to prevent downstream migration (relative to the Yellowstone River) of the downstream end of the bypass channel.

### 2.8 New dam

In order to maintain irrigation diversion capabilities without impacting the bypass channel, a new dam is proposed. The new dam would preclude the necessity of adding large rock to the crest of the existing dam to maintain diversion capabilities (as is currently done).



Return to TOC

### 2.9 Flow augmentation structure

A weir constructed using roller compacted concrete would be constructed near the tie-in between the downstream end of the bypass channel and Yellowstone River. The weir would increase attractive flow in the bypass channel when Yellowstone River discharges are above approximately 7,000cfs. The flow augmentation structure is proposed as a potential future adaptive management technique to increase flow at the downstream end of the bypass channel if monitoring determines additional flow is required for successful passage.

### 2.10 Armor Layer

Current modeling efforts indicate a degradational trend within the bypass channel. Modeling shows that an increase in size of the bypass bed material minimizes expected degradation; therefore, construction of an armor layer is proposed. The proposed armor layer would be similar to naturally formed armor layers found in the Yellowstone River on bars. The intent would be to minimize bypass channel degradation while providing substrate similar to reaches upstream and downstream from the project.

## 3. BACKGROUND

Passage of the pallid sturgeon around Intake Dam by means of a bypass channel has been discussed and evaluated for over a decade. This analysis uses best available information along with suggestions from Reclamation and the BRT.

Criteria used to develop and evaluate the alternatives are based on suggestions from the Biological Review Team (BRT). The main criteria used to develop the 30% design alternative pertain to depth and velocity. Similar to previous evaluations of the rock ramp and bypass channel, flow and depth ranges as shown in Table 1 were used based on BRT passage criteria. The target range is velocity less than 4 ft/s and depth greater than 1 meter with scaled passage ability for ranges of 4-6 ft/s and/or 0.5-1.0m.

**Table 1 Depth and Velocity Ranges used for Evaluation**

| Depth Ranges | |
|---|---|
| (m) | (ft) |
| 0-0.5 | 0-1.64 |
| 0.5-1.0 | 1.64-3.28 |
| >1.0 | >3.28 |

| Velocity Ranges |
|---|
| (ft/sec) |
| 0-2 |
| 2-4 |
| 4-6 |
| 6-8 |
| >8 |

## 4. ANALYSIS

The analysis used HEC-RAS version 4.1.0 dated January 2010. A previously created existing conditions model was used as the base model. Using various bypass channel alignments, new cross sections were extracted from a LiDAR based digital terrain model (DTM) using Bentley's Microstation/InRoads software package.



Return to TOC

## 4.1 General Modeling Information

Three separate HEC-RAS models were used in the overall analysis. First, an inclusive model was created to evaluate flow splits between the main channel of the Yellowstone River and the proposed bypass channel. Second, because HEC-RAS does not have the capability to evaluate sediment transport through flow splits, separate models were created to evaluate sediment in the main channel and the bypass channel.

Sediment transport modeling is notoriously difficult. The data utilized to predict bed change is fundamentally uncertain and the theory employed is empirical and highly sensitive to a wide array of physical variables. Sediment transport measurements often show variations over more than one order of magnitude. This inherent uncertainty in sediment transport is compounded when numerical models are used to simplify natural processes. While HEC-RAS is a useful tool for evaluating sediment transport, the results of the model should not be used as quantitative estimates of scour/deposition or degradation/aggradation. The model can provide useful information pertaining to general trends, but many parameters used in the model have wide ranges of uncertainty and the computed results should be used with caution. Review of model results should consider that this is still preliminary design with detail suitable at this design phase.

The inclusive model evaluated only the hydraulics (i.e. no sediment) and was used to develop channel configurations (length/slope, bottom widths, depths, etc.) for various flow split percentages. A large range of discharges were modeled from extreme low flows (3000cfs) to the 0.2% annual chance of exceedance flood (500-year). The low flow of 3000cfs represents the 90-95% exceeded by duration discharge during the low flow month of August based on gaging records at Sidney and Glendive. Table 2 gives flow-frequency values and Table 3 gives flow-duration values.



Return to TOC

**Table 2 Flow Frequency**

| Percent Chance Exceedance | Return Period (yrs) | Discharges (cfs) for various scenarios. Recommended values areAnnual Post Yellowtail Dam; seasonal values used in evaluation of various construction timelines to lower risk. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Seasonal: Aug-Feb | Seasonal: Aug-Mar | Annual (period of record) | **Annual-Post Yellowtail Dam** | Winter (1Jan-15Apr) Post Yellowtail Bulletin 17b | Winter (1Jan-15Apr) Post Yellowtail Top Half |
| 0.2 | 500 | 128,507 | 192,400* | 192,400 | **114000** | 249000 | 213000 |
| 0.5 | 200 | 96,637 | 172,300* | 172,300 | **105000** | | |
| 1 | 100 | 77,223 | 148,907 | 156,900 | **97200** | 128000 | 123000 |
| 2 | 50 | 61,117 | 114,710 | 141,400 | **89400** | 94600 | 94100 |
| 5 | 20 | 43,967 | 78,968 | 120,600 | **78700** | 61500 | 62800 |
| 10 | 10 | 33,515 | 57,696 | 104,200 | **70100** | 43100 | 43800 |
| 20 | 5 | 24,764 | 40,334 | 86,900 | **60600** | | |
| 50 | 2 | 14,982 | 21,709 | 60,400 | **45300** | 14900 | 12300 |
| 80 | 1.25 | 9,961 | 12,688 | 41,200 | **33300** | | |
| 90 | 1.11 | 8,334 | 9,886 | 33,400 | **28200** | | |
| 95 | 1.05 | 7,314 | 8,171 | 28,000 | **24500** | | |
| 99 | 1.01 | 5,949 | 5,925 | 19,800 | **18600** | | |

* Discharges reduced to not exceed annual discharges

**Table 3 Flow Duration**

| | Discharge (cfs) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent Time Flow Equaled or Exceeded | Annual | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| | | | | | | | | | | | | | |
| 1 | 65,500 | 19,800 | 12,300 | 11,300 | 13,500 | 22,900 | 50,500 | 38,100 | 53,200 | 93,000 | 73,200 | 25,400 | 17,900 |
| 50 | 8,460 | 8,710 | 8,080 | 7,100 | 6,600 | 7,400 | 8,720 | 8,470 | 14,800 | 30,700 | 17,100 | 7,080 | 6,660 |
| 80 | 5,640 | 6,010 | 5,590 | 5,020 | 4,800 | 4,910 | 6,230 | 6,130 | 9,770 | 18,700 | 7,780 | 3,980 | 4,320 |
| 90 | 4,530 | 5,120 | 4,790 | 4,210 | 4,110 | 4,490 | 5,160 | 5,470 | 7,560 | 14,900 | 5,730 | 2,710 | 3,600 |
| 95 | 3,800 | 4,360 | 4,160 | 3,520 | 3,210 | 4,180 | 4,200 | 5,000 | 6,230 | 12,400 | 4,930 | 1,770 | 3,060 |
| 99 | 2,130 | 3,710 | 2,230 | 2,130 | 2,160 | 2,990 | 3,110 | 3,850 | 4,530 | 8,570 | 3,590 | 1,390 | 2,020 |



Return to TOC

The focus of the main channel sediment model was to evaluate general tendencies in bed change for a range of flow split percentages. Of particular concern is deposition of sediment in front of the irrigation diversion headworks. Excessive deposition would require frequent maintenance and is not desirable.

The third model included only the bypass channel and focused on general tendencies in bed change. Many assumptions were used in creating the model and no calibration/verification was possible. Therefore, the model results contain a high degree of uncertainty.

### 4.2 Bypass Channel Configuration

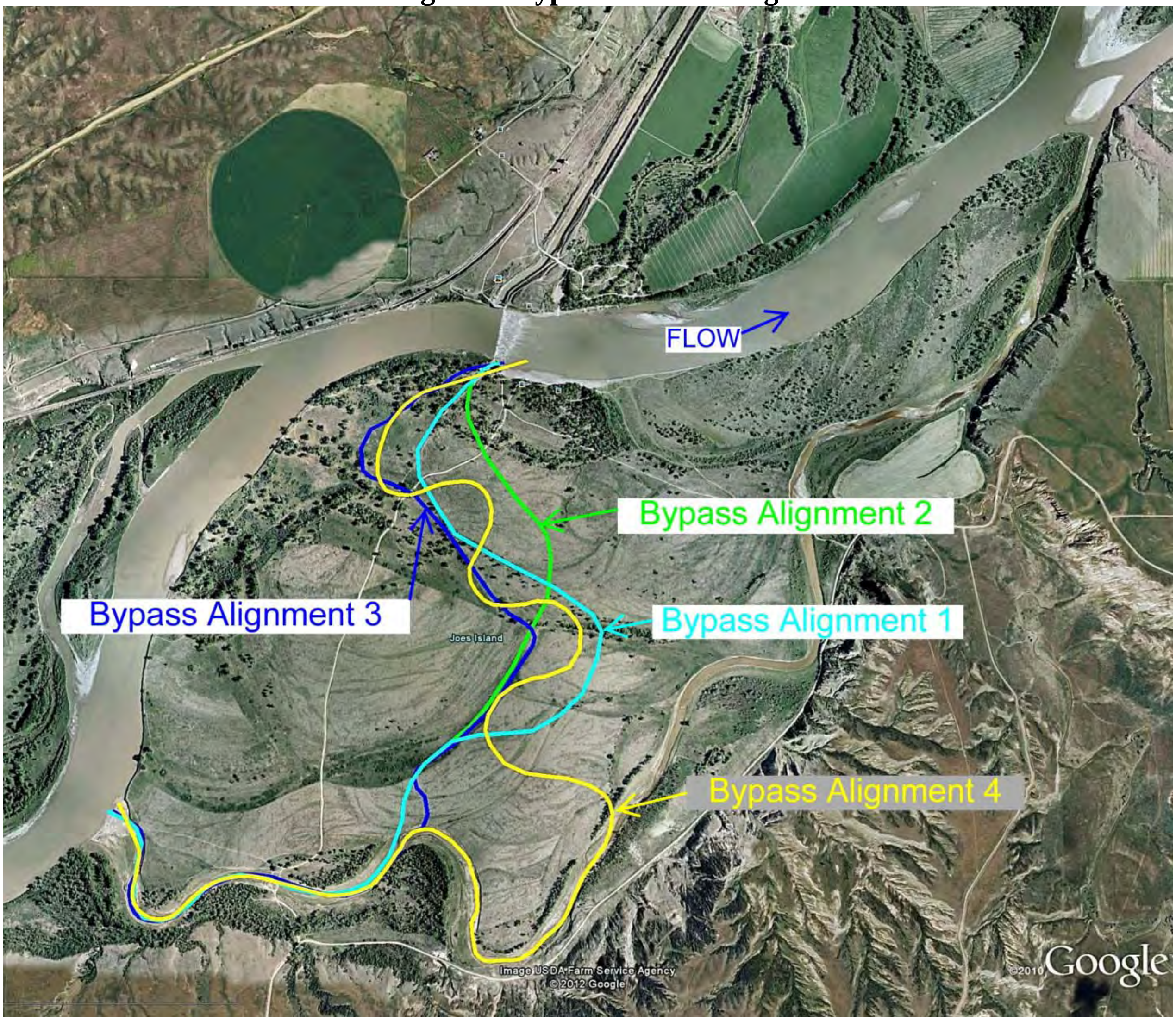
The various bypass alignments were developed based on length required to obtain the desired channel slope as well as to minimize excavation quantities. Four alignments are shown in Figure 1.

Alignments 1 and 3 have similar lengths (≈15,500ft) and alignment 2 is slightly shorter (≈13,500ft). Alignment 3 was developed to maximize the use of historic channel scars and swales following a site visit in August 2011 and supersedes Alignment 1. Alignment 4 is 1.5 times longer than Alignment 3, representing a slope of 0.0004 ft/ft vs. the 0.0006 ft/ft slope of Alignment 3. Alignments 1 and 2 are shown only because they were discussed in the original concept evaluation (April 2011). The longest, Alignment 4, was only recently considered based on comments from the BRT pertaining to the pallid's preferred substrate and the natural armor layer that would be expected to develop for the flatter slope.



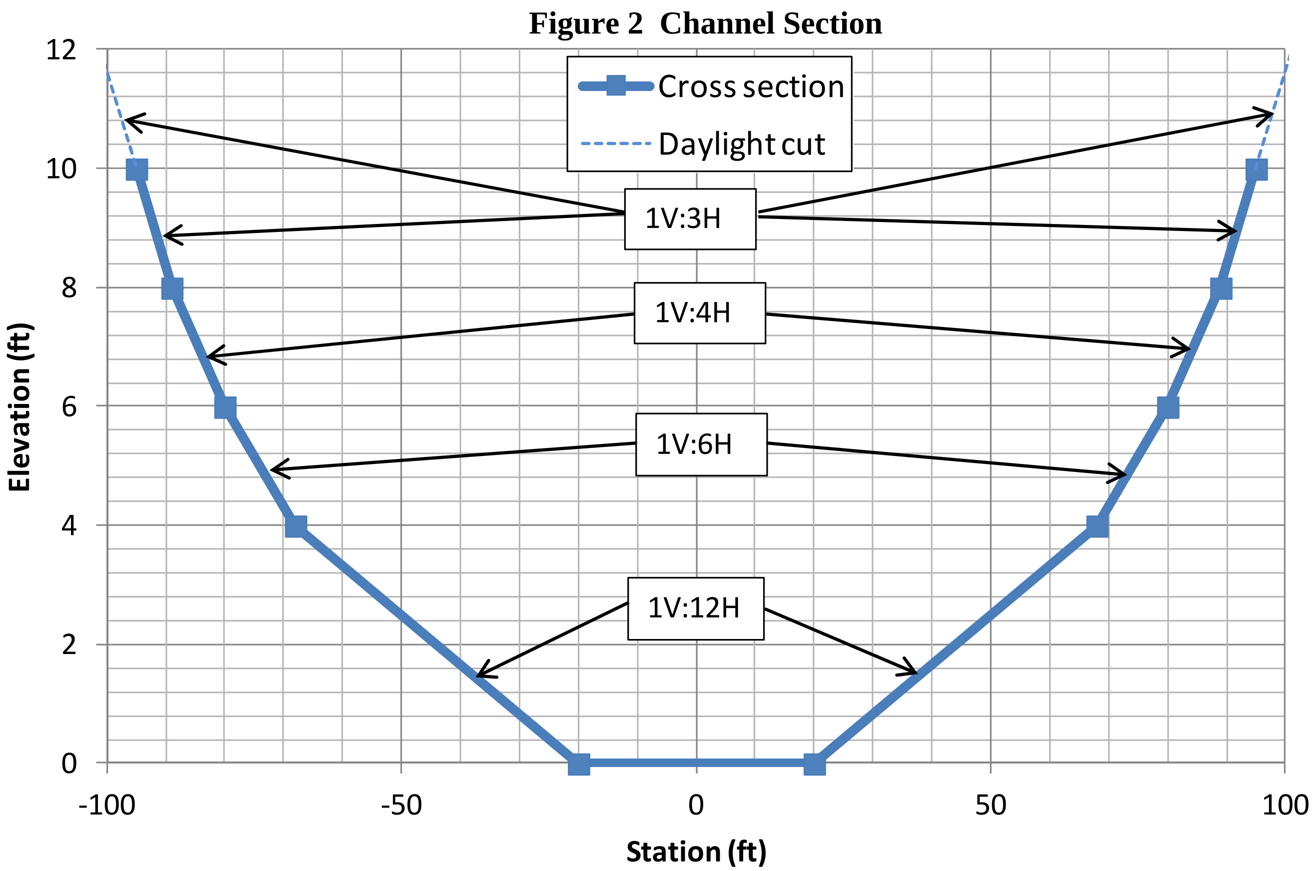
Return to TOC

**Figure 1  Bypass Channel Alignments**




Following the concept analysis presented in April 2011, further coordination with Reclamation and the BRT led to a channel with a 40 ft bottom width, side slopes varying between 1V:12H and 1V:3H, and a longitudinal slope of 0.0006 ft/ft.  The channel section is shown in Figure 2.

Details on the channel configuration, in addition to other project components, can be found in Appendix C, 30% Design Features.




Many alternatives were developed using the inclusive model to roughly determine flow splits between the Yellowstone River and the bypass channel. The selected alternative (15% Diversion) for the 30% design is summarized in Table 4 along with three others for comparison.

The channel configuration using Alignment 3 and the section shown in Figure 2 will hereinafter be referred to as the **15% base bypass alternative**. It diverts 10%-17% of Yellowstone River flows and is considered the 15% diversion alternative. Also evaluated were 10% and 30% diversion alternatives.

The 10% diversion alternative utilizes a cross section similar to that shown in Figure 2, but half the width (i.e. bottom width is 20ft, each side slope section only half as wide). The 30% diversion utilizes the same side slopes as those shown in Figure 2 with a 200ft bottom width.



Return to TOC

## Table 4 Bypass Channel Flow Splits and Configurations

| Recurrence interval (annual, post-Yellowtail flows) | Total Yellowstone River discharge | Flow Splits for Base and Alternatives: BASE (existing right bank chute assuming new headworks with existing dam) | | 10% Diversion | | 15% Diversion | | 30% Diversion | | Long Alignment | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (cfs) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) |
| <2-yr | 3000 | 0 | 0 | 220 | 7 | 310 | 10 | 890 | 30 | 273 | 9 |
| <2-yr | 7000 | 0 | 0 | 650 | 9 | 860 | 12 | 2220 | 32 | 755 | 11 |
| <2-yr | 15000 | 0 | 0 | 1550 | 10 | 2140 | 14 | 4770 | 32 | 1897 | 13 |
| <2-yr | 30000 | 790 | 3 | 3220 | 11 | 4510 | 15 | 9290 | 31 | 4019 | 13 |
| 2-yr | 45300 | 2280 | 5 | 5180 | 11 | 7170 | 16 | 13720 | 30 | 6417 | 14 |
| 5-yr | 60600 | 4050 | 7 | 7340 | 12 | 9900 | 16 | 18130 | 30 | 8937 | 15 |
| 10-yr | 70100 | 5220 | 7 | 8770 | 13 | 11690 | 17 | 20780 | 30 | 10558 | 15 |
| 20-yr | 78700 | 6090 | 8 | 9990 | 13 | 13210 | 17 | 23240 | 30 | 11919 | 15 |
| 50-yr | 89400 | 7280 | 8 | 11540 | 13 | 14940 | 17 | 26260 | 29 | 13534 | 15 |
| 100-yr | 97200 | 8090 | 8 | 12650 | 13 | 16280 | 17 | 28170 | 29 | 14815 | 15 |
| 500-yr | 114000 | 9920 | 9 | 15570 | 14 | 19290 | 17 | 32490 | 29 | 17760 | 16 |

Pertinent Bypass Channel Parameters

| | 10% Diversion | 15% Diversion | 30% Diversion | Long Alignment |
|---|---|---|---|---|
| Alignment | 3 | 3 | 3 | 4 |
| Bypass Channel Length (ft) | 15500 | 15500 | 15500 | 23250 |
| Bypass Channel Longitudinal Slope | 0.00060 | 0.00060 | 0.00060 | 0.00040 |
| Bypass Channel Bottom Width | 20 | 40 | 200 | 40 |
| Bypass Channel Side Slopes | Vary from 1V:12H to 1V:3H | | | |
| Approximate Excavation Quantity (cubic yards) | 800,000 | 1,200,000 | 2,600,000 | 1,700,000 |

The upstream and downstream inverts were the same for all four alternatives. The very upstream invert (fishway exit) was set at 1990.3 ft NAVD88 and the downstream invert (fishway entrance) is 1981.0 ft NAVD88 for a total drop of 9.3 ft.

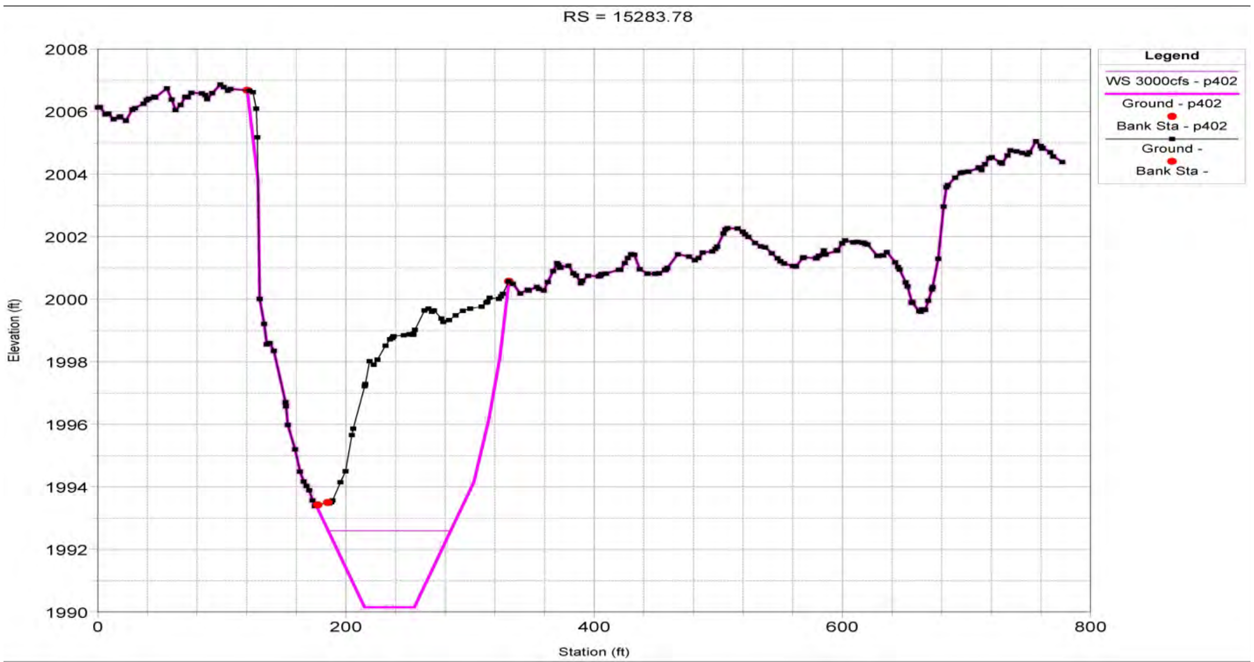
Typical channel cuts from the 15% alternative are compared to existing ground in Figure 3. Note that the “RS=####” in the upper portion of the figure refers to the river station in feet from the downstream end of the bypass channel.

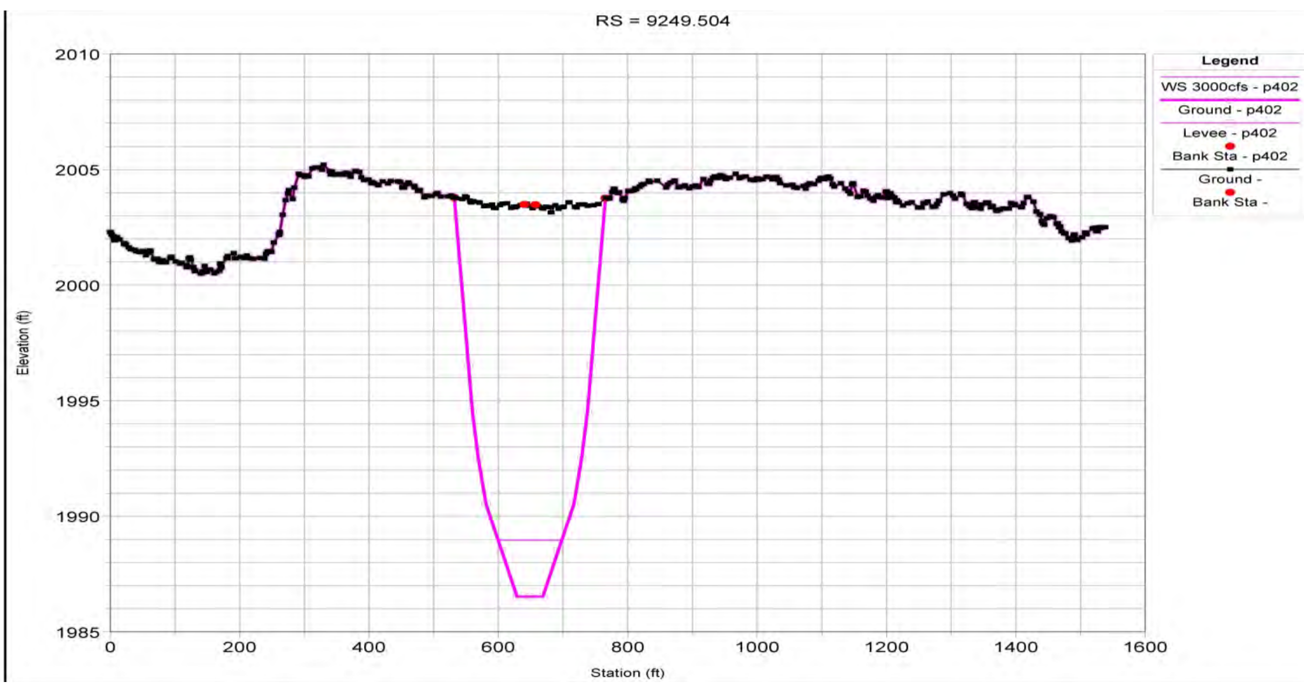


Return to TOC

**Figure 3 Typical Channel Cuts**

(Note: first cut shown is upstream in existing high flow chute, second is downstream across Joe's Island)






Return to TOC

## 5. HEC-RAS MODEL LIMITATIONS

Limitations of the 1-dimensional HEC-RAS model preclude the evaluation of certain detailed project features and functions. Detailed evaluation of the following items (in addition to others) is beyond or limited by the capabilities of HEC-RAS:

- Downstream (fishway entrance) configuration (i.e. precise orientation and guide wall configuration).
- Connection of main channel thalweg to bypass channel.
- Bank/toe protection. Because the HEC-RAS model is 1-dimensional, it does not directly account for secondary velocities in bends.
- Sediment modeling was performed with limited detail for this design phase. Sediment transport modeling is notoriously difficult. The data utilized to predict bed change is fundamentally uncertain and the theory employed is empirical and highly sensitive to a wide array of physical variables. Sediment transport measurements often show variations over more than one order of magnitude. This inherent uncertainty in sediment transport is compounded when numerical models are used to simplify natural processes.

## 6. RESULTS AND DISCUSSION

### 6.1 Configuration

For discussion purposes, the "configuration" of the bypass channel consists of the following elements (in addition to others):

- Horizontal alignment
- Length
- Longitudinal slope
- Bottom width
- Side slopes
- Inlet and outlet configuration
- Scour protection

Various combinations of the bypass channel elements can be used to produce a range of flow diversion percentages, velocity/depth characteristics, and excavation/riprap quantities. It is apparent that trade-offs between various elements may have desirable or undesirable effects (e.g. a larger bottom width generally allows a higher percentage of diverted flow but results in larger excavation quantities; with other elements kept constant, shorter length results in smaller excavation quantities but gives a steeper slope and increased velocities, etc.)

The selected configuration for the 15% Bypass Alternative was developed in conjunction with Reclamation and the BRT. Comments received from a BRT review of the draft 30% design in March 2012 indicate that a coarse sand bed material might be more attractive to pallid sturgeon than gravels or cobbles. Further evaluation of a longer, flatter bypass channel may be warranted in the next design phase. The evaluation would compare the costs associated with the increased excavation quantities for a longer channel with the costs associated with adding the channel armor layer. At this time (March 2012) the longer channel concept is not well developed. As the channel slope is decreased, flow velocities and sediment transport also decrease and



Return to TOC

sustainability may be in question. However, quantities for purposes of a cost estimate were estimated to allow for a comparison between excavation costs and the channel armor layer.

Ten Yellowstone River side channels, in addition to the existing high flow chute at Intake, were evaluated and compared based on available GIS information and aerial photography. Based on visual observations of the side channels and measurements using GIS, chute lengths, sinuosity, and top widths were estimated. Results are summarized below in Table 5. See Appendix D, Reference Reach Comparison, for details.

**Table 5 Reference Reach Summary**

| Reach Identifier | Orientation and distance from Intake Dam | Approximate chute length | Estimated energy grade slope in reference reach chute |
|---|---|---|---|
| | | (ft) | (ft/ft) |
| 1 | 54 miles d/s | 9900 | 0.00008 |
| 2 | 38 miles d/s | 9400 | 0.0004 |
| 3 | 34 miles d/s | 11400 | 0.0002 |
| 4 | 31 miles d/s | 22100 | 0.0004 |
| 5 | 19 miles d/s | 10600 | 0.0006 |
| 6 | 9 miles d/s | 8700 | 0.0006 |
| 7 | Existing chute at Intake | 24700 | 0.0005 |
| 8 | 17 miles u/s | 5000 | 0.0006 |
| 9 | 23 miles u/s (at Glendive) | 13600 | 0.0003 |
| 10 | 28 miles u/s | 10400 | 0.0005 |
| 11 | 33 miles u/s | 7500 | 0.0006 |
| | | | |
| PROPOSED BYPASS | Proposed bypass at Intake | 15500-23250 | 0.0004-0.0006 |

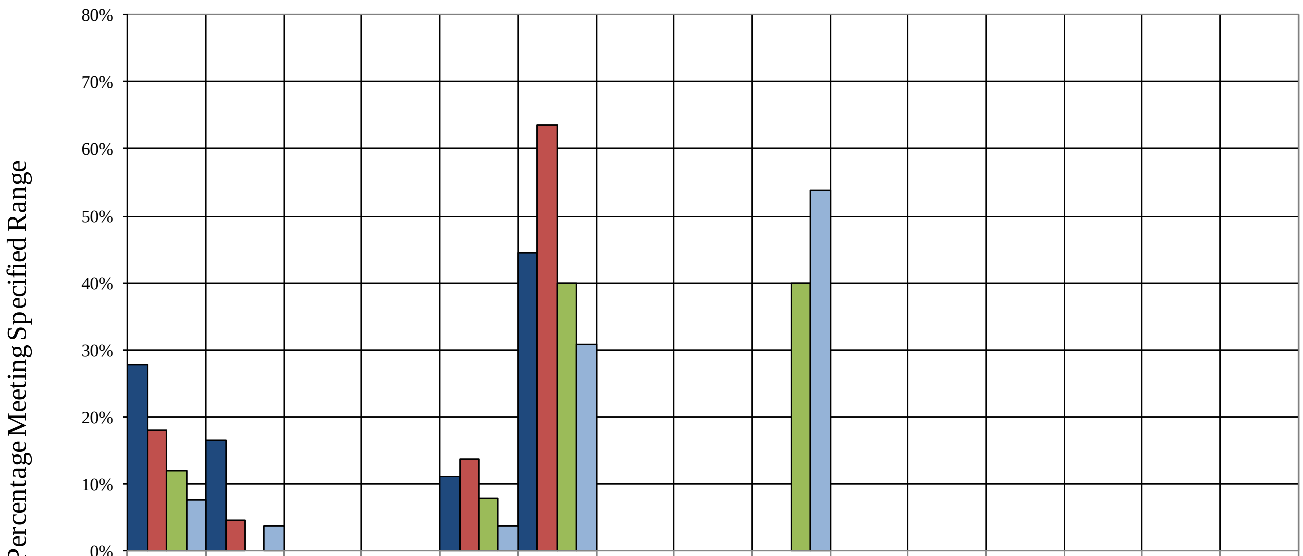


Return to TOC

### 6.2 Depths and Velocities

Figure 4 shows the percentage of the base 15% alternative meeting various depth/velocity ranges. Note that because of the simplified channel geometry within the HEC-RAS model, the depth and velocities throughout the bypass channel are relatively uniform. Additionally, the classification chart was only created for the 15% diversion alternative. Classification charts for the other alternatives are expected to look similar to the 15% chart.

**Figure 4 Percentages of Bypass Meeting Depth/Velocity Ranges**




| | 0-1.64ft 0-2ft/s | 1.64-3.28ft 0-2ft/s | >3.28ft 0-2ft/s | 0-1.64ft 2-4ft/s | 1.64-3.28ft 2-4ft/s | >3.28ft 2-4ft/s | 0-1.64ft 4-6ft/s | 1.64-3.28ft 4-6ft/s | >3.28ft 4-6ft/s | 0-1.64ft 6-8ft/s | 1.64-3.28ft 6-8ft/s | >3.28ft 6-8ft/s | 0-1.64ft >8ft/s | 1.64-3.28ft >8ft/s | >3.28ft >8ft/s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7k | 28% | 17% | 0% | 0% | 11% | 44% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 15k | 18% | 5% | 0% | 0% | 14% | 64% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 30k | 12% | 0% | 0% | 0% | 8% | 40% | 0% | 0% | 40% | 0% | 0% | 0% | 0% | 0% | 0% |
| 40k | 8% | 4% | 0% | 0% | 4% | 31% | 0% | 0% | 54% | 0% | 0% | 0% | 0% | 0% | 0% |

Bypass Channel-Alignment 3-15% Diversion Alternative

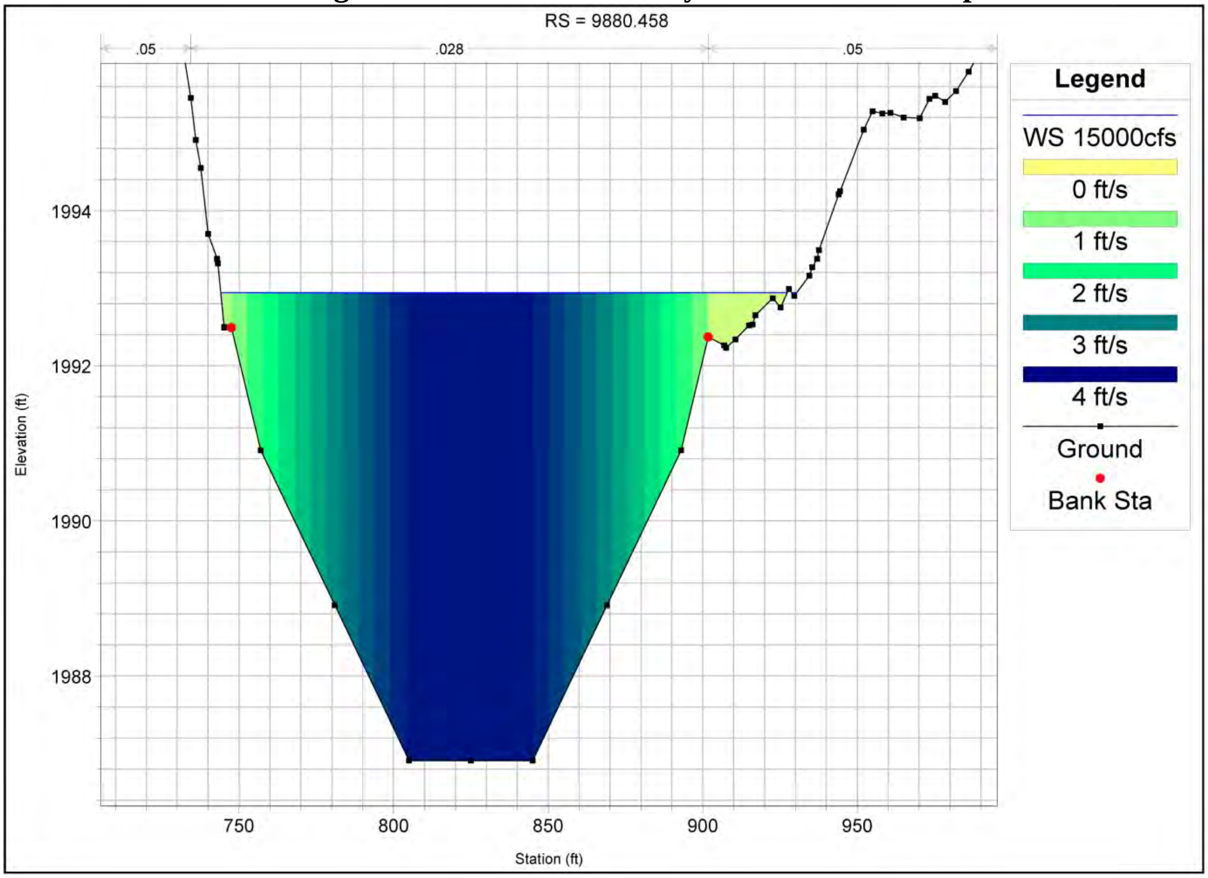
40ft Bottom width, varying side slopes, Channel slope=0.0006

The depth/velocity ranges computed for Figure 3 were determined using the flow/velocity distribution feature within HEC-RAS. This feature allows for the estimation of a velocity distribution across the channel rather than a simple average velocity for the whole section. A screen shot of the velocity distribution from HEC-RAS is shown in Figure 5.



Return to TOC

**Figure 5 HEC-RAS Velocity Distribution Example**




## 6.3 Channel Stability

Channel stability analysis performed for this study has a high degree of uncertainty due to the limited available data and detail of modeling. The relative risk for stability measures pertains to the frequency and magnitude of required maintenance. While some bypass channel dynamics is acceptable, continued bank failure or erosion would likely impact fish passage performance of the channel and also alter the desired flow split between the main Yellowstone River and the bypass channel.

Proposed stability measures for the 15% alternative include the following:

- Upstream and downstream grade control and lateral control
- Two grade control structures, spaced approximately evenly between the upstream and downstream ends
- Riprap revetments at 2 outside bends
- Channel armor layer to prevent excessive degradation

As discussed above in section 5.1, there may be some tradeoff with the channel armor layer by excavating a longer, flatter channel. However, this evaluation has not been completed as of March 2012.



Return to TOC

An analysis was completed to evaluate characteristics of the armor layer that would likely form naturally in the bypass channel. Details on the analysis can be found in Appendix E, Bypass Channel-Stable Channel Materials Analysis.

### 6.4 Sediment Continuity

Sediment continuity refers to the requirement to maintain sediment transport for both the Yellowstone River and the bypass channel. In the existing condition, the Yellowstone River is able to transport both suspended material and bed material over the diversion dam. Available data indicates that the system is in an equilibrium condition and does not exhibit any long term aggradation or degradation trends. The potential for the bypass channel to disrupt sediment continuity limits the maximum bypass channel flow rate.

Sediment sampling was conducted in 2011 by the U.S. Geological Survey for the U.S. Army Corps of Engineers. Details pertaining to the sampling efforts and results of the sampling can be found in Appendix F, DRAFT USGS Sediment Sampling Report.

There is a risk of sediment deposition within the bypass channel due to the desire for low velocities for fish passage. Depending on the size and type of materials entering the bypass channel over the range of flows, large quantities of sediment could deposit within the channel. Additionally, during extreme events that inundate the entire island with depths greater than a few feet (50-100 year range or greater), a large portion of the bypass channel could be filled with sediment. The need to maintain sediment transport through the bypass channel may impact the ability to meet fish passage design criteria.

Another concern relative to sediment is current versus with-project transport capacity in the vicinity of the dam and headworks structure. Depending on the configuration of the diversion inlet and nearby flow patterns, it is likely that the bypass channel will take very little, if any, bedload sediment from the main channel. This larger sediment will then continue downstream and could potentially be deposited in front of the dam and headworks since there would be less flow available to transport similar volumes of larger sediment. The current system apparently transports much of this bedload up and over the existing dam. With 10-15% of total flows diverted around the dam, sediment buildup in front of the headworks is a concern. Extensive analysis and data collected over a period of many years is required to evaluate the sediment balance within the system (from upstream to downstream of the bypass channel as well as downstream in the irrigation canal).

As a result of the requirement to maintain sediment transport in the Yellowstone River, a minimum river flow is required. Consequently, the maximum bypass channel flow will also be limited. Detailed analysis is required to define the upper limit for bypass channel flow. Based on observations in other rivers, sustainable chutes with flows in the range of 5 – 10% of the main channel flow are often observed. On the lower Missouri River, stability issues and main channel deposition have occurred when chute flows exceed 10%. The requirement to maintain sediment transport may limit bypass channel flows to a rate less than desired for fish passage.

Based on available gage data, the Yellowstone River at Sidney is estimated to have moved approximately 900,000 tons of sediment from May 1 through August 30 in 2007 as suspended load. Assuming an additional 15% moving as bed load gives a total load of over 1,000,000 tons. Using a density of 95 lb/ft$^3$, computations estimate results in over 800,000 yd$^3$ of material being transported by the Yellowstone River during a single irrigation season. The potential for deposition that is outside the scope of an O&M issue is a concern.

One possible solution to sedimentation in the vicinity of the headworks would be to construct a sluiceway through the dam crest and existing rock field. The sluice would likely be a gated set of large culverts with a training wall to create high velocities in front of the headworks to flush sediment deposits.

Three sediment sluice options were described in the Final Environmental Assessment (2010). However, since construction of the new headworks and backfilling behind the old headworks, two of the proposed sluice options that used the old headworks structure as a gate structure are no longer feasible. Therefore, sediment sluicing would likely use an in-channel sluiceway consisting of a gate structure located just upstream from the dam crest, four 8-ft wide by 6-ft tall vertical lift gates, and two covered conduits 20.5-ft wide by 10-ft high extending downstream through the dam crest to the toe of the existing rock field.

### 6.5 Ice Impacts

The upstream end of the bypass channel would likely be subject to significant ice forces. Since the April 2011 concept analysis, further evaluation has been conducted. The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) conducted a study and provided recommendations. Based on CRREL's analysis, the upstream control structure has been changed from a riprap structure to a concrete structure. The draft report provided by CRREL is included as Attachment 1.

The CRREL evaluation estimated required riprap design configurations (rock size and layer thickness) and compared their estimates with the preliminary design provided by Omaha District. The comparison indicated that Omaha District designs were very similar to those estimated by CRREL. See Table 6 for the riprap comparison taken from the CRREL report (Attachment 1).

**Table 6 Riprap Design Comparison (source: Attachment 1, CRREL Draft report)**

| | Average Velocity | $D_{50}$ (inches) | | | $D_{100}$ (inches) | | | Layer Thickness (inches) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Structure | (ft/s) | Omaha District | Factored Isbash | Factored EM | Omaha District | Factored Isbash | Factored EM | Omaha District | Factored Isbash | Factored EM |
| Bypass Inlet Weir | 5.0 | 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Channel Plug | 6.2 | 20 | 12 | 8 | 30 | 24 | 16 | 45 | 36 | 24 |
| Bypass Bends | 7.0 | | 12 | 10 | 16 | 24 | 18 | 24-36 | 36 | 28 |
| Vertical Grade Control | 6.0 | 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Bypass Outlet Weir | 5.2 | 12 | 10 | 12 | | 20 | 24 | 27-40 | 30 | 36 |
| Downstream Lateral Stability Structure | 6.5 | 12 | 10 | 7 | 24 | 20 | 12 | 36 | 30 | 34 |
| Flow Augmentation Weir | 6.8 | CRREL recommendation: use 1.5-2.0-ft riprap where concrete wall ties into bank. | | | | | | | | |



Return to TOC

In addition to evaluating riprap design, the CRREL evaluation computed ice forces for use in structural design of concrete features. For the upstream concrete sill under a worst case scenario, an ice force of 5 kips/ft could act horizontally along the front edge. For the surface of the upstream sill and the downstream flow augmentation weir crests, a maximum horizontal ice force of 2 kips/$ft^2$ due to sliding ice is estimated. The concrete wall along the upstream edge of the flow augmentation weir is expected to experience high ice impacts. Here, an ice design load of 10 kips/ft is recommended.

The CRREL report suggested increasing rock size and layer thickness in two areas: the left hand side of the transition from the Yellowstone River into the upstream control structure and the right bank of the Yellowstone River immediately upstream of the flow augmentation structure.

### 6.6 Access to Dam (Right Abutment) and Left Bank of Bypass Channel

The current concept for access to the left bank of the bypass channel is to construct temporary crossings on an as-needed basis.

### 6.7 Impacts to Depth/Velocity at Proposed Dam Crest

A new, raised concrete dam is proposed just upstream from the existing dam. Two reasons exist for the proposed new dam:

- The new headworks structure requires additional head for diversion due to head losses through the new screens and
- Continued placement and loss of large rock on the dam may adversely impact the bypass channel entrance.

The current dam has required frequent maintenance (addition of large rock to crest) in order to provide the necessary head for diversion using the *old* headworks structure. Construction of the new headworks, substantially completed by March 2012, included the installation of fish screens to prevent entrainment of fish in the irrigation canal. Flow through the screens includes head losses, thus requiring additional head in order to divert the irrigation district's full water right during low flow periods on the Yellowstone River. The additional head (estimated to be approximately 0.5-0.7 ft by the screen manufacturer) will be gained by increasing the top elevation of the dam crest. Additionally, to prevent the need for annual placement of riprap on the crest as is currently done, a concrete crest is proposed. The proposed crest location is approximately 50 ft upstream from the existing crest.

With the new headworks requiring an estimated 0.7 ft of additional head, the addition of rock to the existing structure would likely increase not only initially but over time due to the higher potential for loss of protruding rocks on the crest to ice.

The amount of dam raise is not a set amount. The elevation of the current top of dam/top of rock is unknown; even if the current top was known, it has been established that the top changes annually depending on ice conditions, high flow events, and the irrigation district's placement of rock.



Return to TOC

The proposed top of dam elevation is 1990.5 ft NAVD88. This is likely similar to or slightly above the top of rock elevation just after the irrigation district places rock and perhaps 2 ft above top of rock just before rock placement.

Concerns have been raised over the impact to passability over a new crest structure for fish species that are currently able to pass the existing rock field and dam. A hydraulic model (HEC-RAS) was used to evaluate and compare existing and proposed conditions. Comparison of depths and velocities over the crest between existing and proposed conditions is difficult due to changing conditions and lack of data on the existing crest. For purposes of this analysis, the existing crest was assumed to be at 1989.5 ft NAVD88. **This is an assumed elevation and the crest is known to vary by at least 2 ft.**

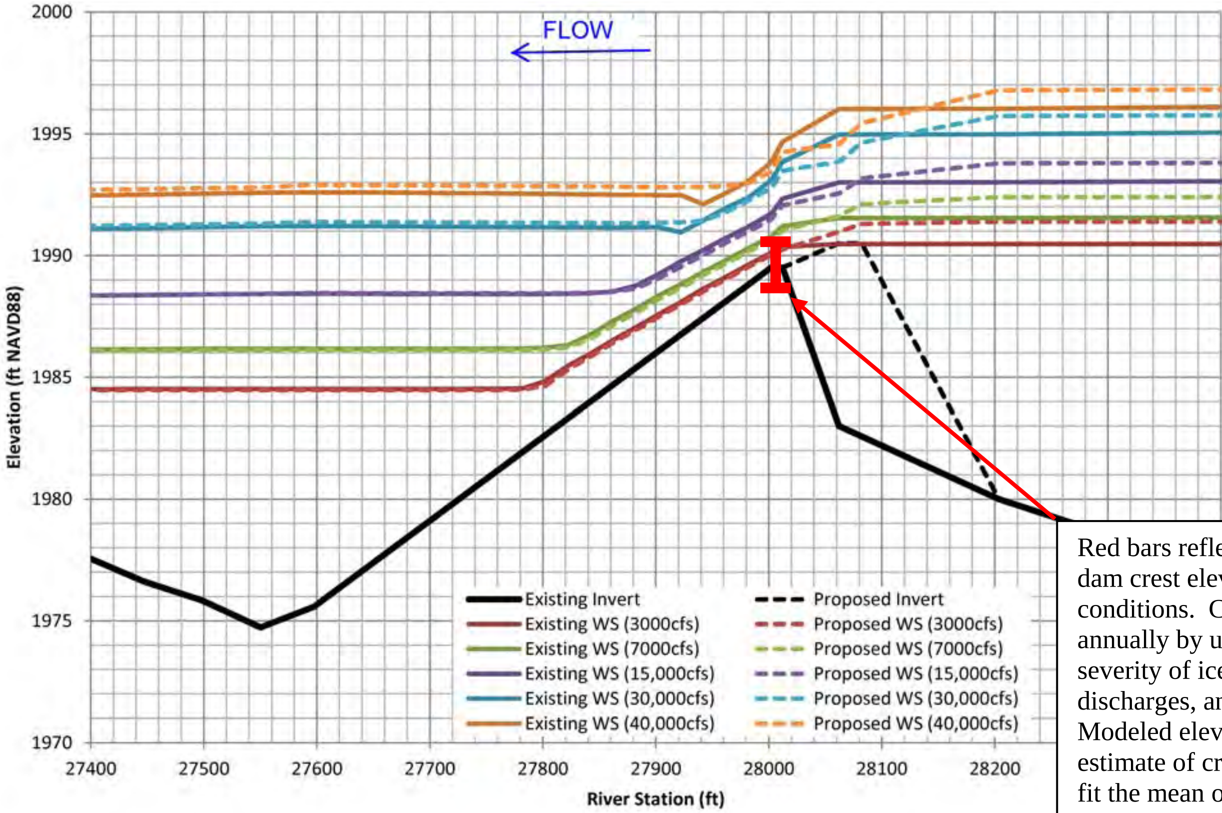
Existing conditions vs. proposed conditions water surface profiles and average channel velocities are shown in Figures 6 and 7, respectively. Note that in Figures 6 and 7, proposed conditions assume the bypass channel is diverting approximately 15% of total Yellowstone River flows. Therefore, proposed depths and velocities are slightly lower on the rock field due to the lower discharges.

Figures 8 and 9 show depths and velocities over the existing vs. proposed crests *not counting the bypass channel flow diversion*. Results indicate slightly longer lengths of higher velocities, but do not show higher overall velocities for the proposed crest structure.



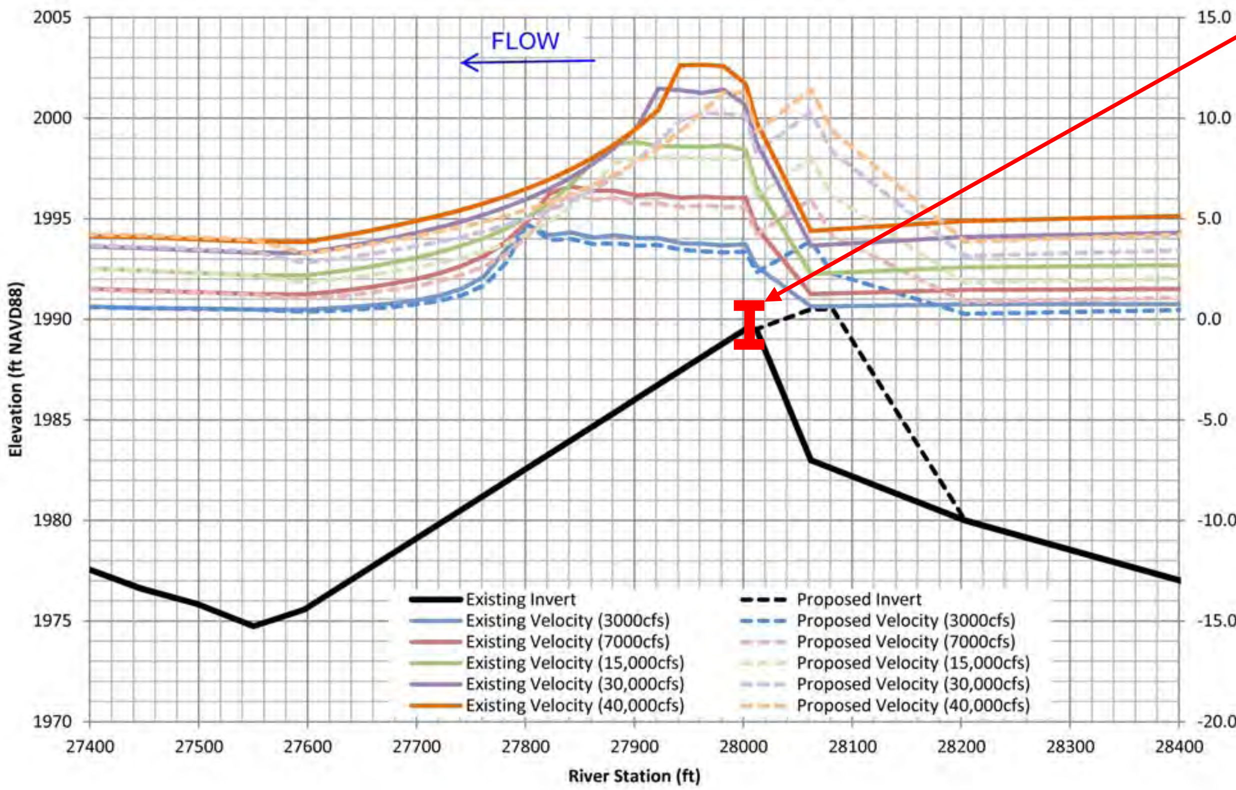
Return to TOC

**Figure 6 Dam Crest Water Surface Profiles, Existing vs. Proposed, with Bypass Channel**




Red bars reflect variable and uncertain dam crest elevation for existing conditions. Crest elevation varies annually by up to 2 ft depending on severity of ice runs, extreme discharges, and rock placement. Modeled elevation was based on best estimate of crest elevation required to fit the mean of the measured stage-discharge rating curve.

**Figure 7 Dam Crest Average Velocities, Existing vs. Proposed, with Bypass Channel**






Return to TOC

**Figure 8  Dam Crest Water Surface Profiles, Existing vs. Proposed, without Bypass Channel**

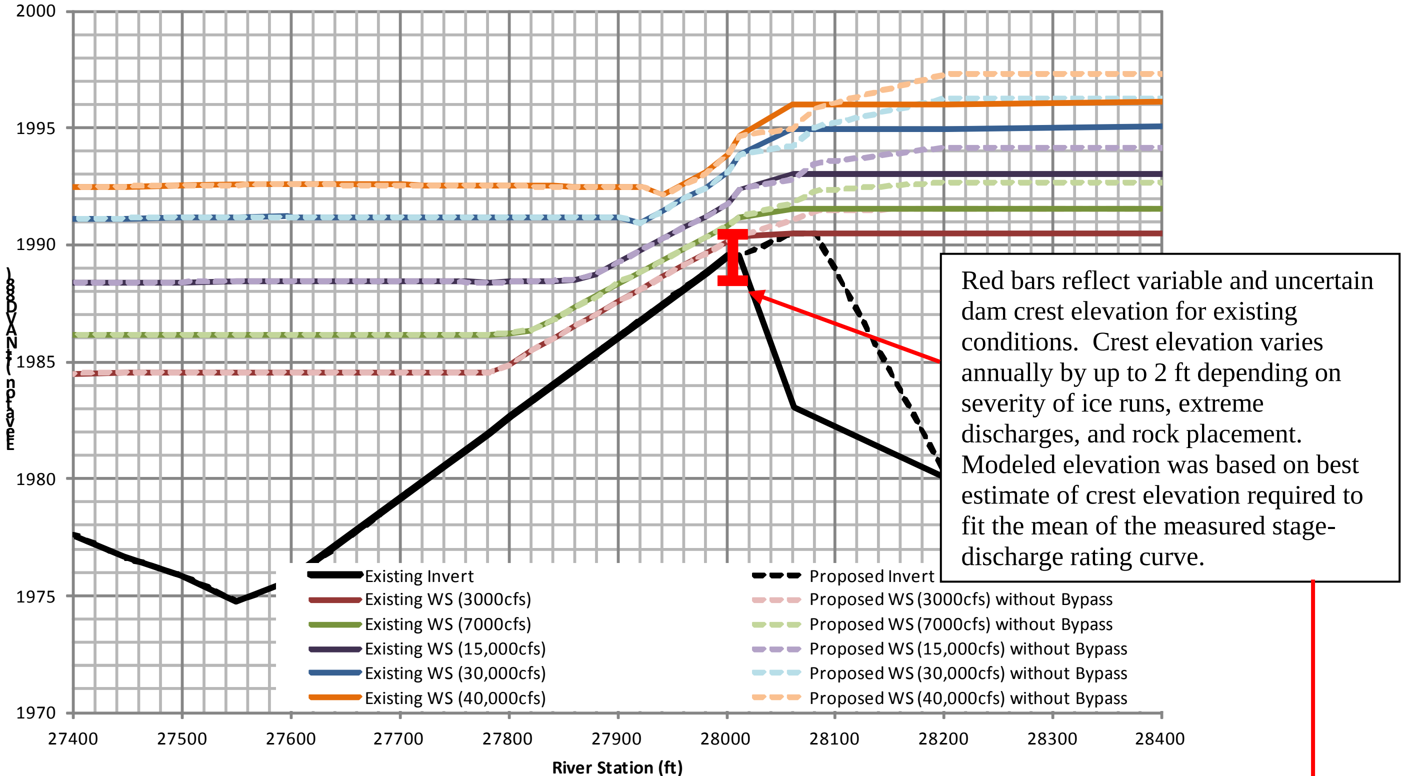
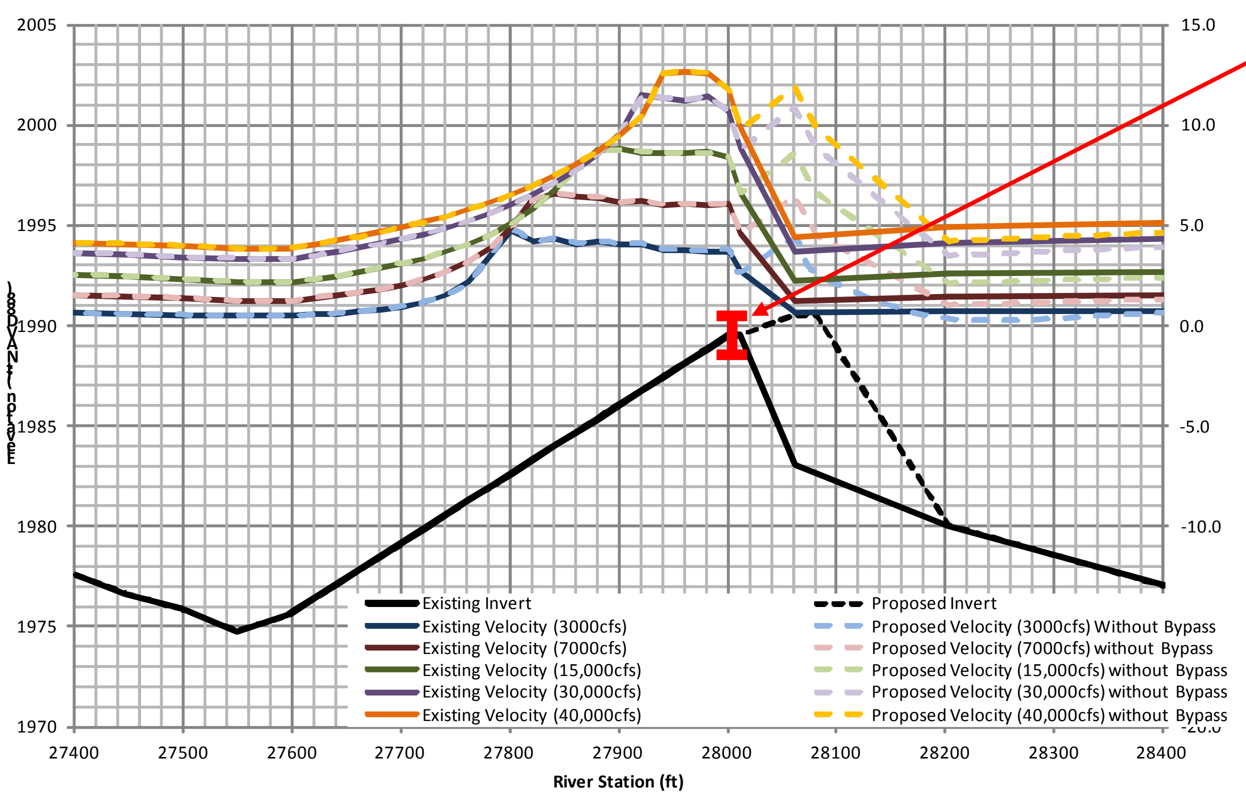



**Figure 9 Dam Crest Average Velocities, Existing vs. Proposed, without Bypass Channel**






Return to TOC

### 6.8 Future Design Work

Additional data needs and design work to carry this concept to final design would include:

- Collection of additional bathymetry data in the Yellowstone River in the vicinity of the fishway exit (upstream end)
- Collection of additional soil borings on the final alignment to assist in design of scour protection
- Further evaluation of optimal diversion discharge percentage
- Further evaluation of a longer channel
- Potential 2-dimensional evaluation of bypass channel
    - Compare depth/velocity to BRT criteria
    - Evaluate depth / velocity changes in detail at the diversion dam, comparing with and without bypass channel conditions
    - Determine scour protection requirements
    - Adjust inlet/outlet configuration
    - Adjust planform
    - Evaluate sediment transport within the chute and main Yellowstone River
    - Collect suspended and bedload sediment data in the Yellowstone River in the vicinity of the proposed fishway exit (upstream end of bypass channel)
- Detailed evaluation of island access crossing needs and requirements
- Geomorphologic assessment of existing right bank chute
- Sediment transport study of existing right bank chute

## 7. SUMMARY AND CONCLUSIONS

**Design Analysis.** The bypass channel design analysis consisted of the following evaluations:

- Yellowstone River-Hydraulic and sediment modeling was conducted to evaluate the maximum feasible flow split and associated sediment transport characteristics. Results indicate that the maximum feasible diversion percentage is in the range of 15%, with a 10% split preferred. Modeling indicates that diversion of more than 15% of total Yellowstone River flow would likely result in sediment deposition in the Yellowstone River, which is undesirable due to operation and maintenance challenges posed by working in the river. Note that no calibration data for the sediment modeling is available, limited sediment data and bed material data is available, and discharges for the simulation were based on flow records at Sidney and Glendive for the past 20 years. Additional sediment modeling and evaluation in the future design phase is required.
- Bypass Channel-Hydraulic and sediment modeling was conducted to evaluate flow/depth characteristics as well as sediment transport within the bypass channel. Results of the hydraulic modeling indicate that flow and depth criteria set forth by the BRT are met at all flows. Results of sediment modeling in the bypass channel indicate a slightly degradational trend, but the results are highly sensitive to several inherently uncertain input parameters to the model. Note that no calibration data for the sediment modeling is available, limited sediment data and bed material data is available, and discharges for the simulation were based on flow records at Sidney and Glendive for the past 20 years. Additional sediment modeling and evaluation in the future design phase is required.



Return to TOC

- Channel Stability Computations-In addition to the HEC-RAS sediment modeling completed on the bypass channel, stability computations were performed using various methods to evaluate channel stability (Shields stability analysis, critical shear stress, Copeland method). The evaluation indicates general agreement among the various methods for substrate material size required for channel stability, approximately 1-2 inches in diameter. As the design is refined in future evaluation, the stability analysis will also be updated. The requirement for an armor layer will be reviewed based on results from the stability analysis.
- Rock Sizing-Rock sizing for the bypass channel features was completed using HDC 712-1 (Isbash method) and guidance in EM 1110-2-1601. An evaluation by CRREL verified rock sizes were adequate considering ice effects.
- Geomorphologic Comparison of Similar Side Channels-A cursory evaluation was conducted to compare existing natural side channels on the Yellowstone River in the vicinity of Intake to the proposed bypass channel. The analysis indicates that general planform characteristics of the proposed bypass fall into the range of similar side channels.

**Bypass Passage Evaluation**

- Channel Section-The bypass chute design was performed with the goal of meeting passage objectives given the uncertainties in pallid sturgeon behavior. The channel section has compound bottom slopes to provide a range of depth and velocity diversity for a range of flows. The variation will optimize the potential for suitable habitat availability and also result in substrate size variability. The channel section still has normal side slopes with minimal impact to total quantity. The selected side slopes are compatible with long term sustainability to avoid bank failures.
- Flow depth-Flow depths were evaluated based on BRT criteria indicating preferred depths of greater than 1 meter with scaled passage ability with depths between 0.5 and 1 meter. During extreme low flows on the Yellowstone River (3000 cfs) most of the bypass channel has a depth of 0.5-1 meter, with the downstream end greater than a meter. When flows reach 7000 cfs (representative of April and August 50% exceeded by duration flows), bypass channel depths are greater than a meter (around 4ft or greater). At 15,000 cfs, representative of May and July 50% exceeded by duration flows, depths are in the 6-7ft range. At 30,000 cfs, representative of the June 50% exceeded by duration flow, depths are in the 8-10 ft range. Note that depths given are maximum depths in the thalweg; the actual depth would range from 0 to the maximum along the relatively flat sloped channels (1V:12H to 1V:3H).
- Flow velocity-Target flow velocities are lower than 4 ft/s for adult pallids and lower than 2 ft/s for juveniles based on BRT criteria. Because modeling to date is one-dimensional and considers a constant slope, uniform channel, average velocities throughout the bypass are fairly consistent. During extreme low flow periods on the Yellowstone River (3000cfs), bypass channel velocities are just under 2 ft/s. During 7,000-30,000cfs flows, bypass velocities are generally in the 2-4 ft/s range with areas in the 4-6 ft/s range (areas of 4-6 ft/s are located in the thalweg during 30,000 cfs flows; computed velocities outside of the thalweg are in the 2-4 ft/s range). Note that for all flows between 0-40,000cfs, models indicate areas with velocities less than 2 ft/s exist on the fringes (i.e. outside of the thalweg along the flat slope areas).



Return to TOC

- Turbulence-Minimal turbulence is expected in the majority of the bypass channel due to the relative uniformity of the cross section. Areas of concern are the exit and entrance where bypass and Yellowstone River flows converge and diverge. Of particular interest is the bypass channel entrance (downstream end) due to the potential for excessive turbulence and shear zones to disrupt upstream pallid migration. Additional numerical modeling and potentially physical modeling would be utilized to further evaluate turbulence in the critical areas to maximize passage ability based on input from the biological community. Additionally, monitoring of the project would be expected to identify potential areas of high turbulence preventing passage. Adaptive management techniques, including movement/manipulation of riprap or addition of training structures (especially at the bypass entrance) have been identified as having potential to minimize turbulence concerns.

**Bypass Stability Features**

A number of stability features are included in the bypass channel to maximize the potential for a long term, sustainable fish passage project.

- Stable Channel Design-The design follows standard stable channel design principles that use a variable bottom slope and meander pattern. Past projects have illustrated that a straight alignment or flat bottom channel is not stable which would create a passage risk as the chute develops a stable planform. Stability features in the chute are not optional if we want to provide a long term sustainable project that meets the objective of providing both passage and irrigation diversion.
- Upstream Control-Riprap with a concrete sill, designed to provide stability during extreme events. The structure would be backfilled with natural river size rock to give the appearance of a seamless channel invert.
- Channel Plug-Rock-lined earthen embankment at point where proposed bypass channel diverges from existing high flow chute, designed to keep flows in bypass during low flows. A low-level discharge pipe allows for normal flows to pass into the existing chute while the rock lining allows for overtopping during extreme events in order for the existing chute to maintain its current functionality.
- Riprap at Bends-Standard bank stabilization techniques at critical locations to prevent major loss of channel planform during extreme events. Some channel movement is expected and desired to attain the appearance of a natural channel.
- Vertical Control-Two riprap sills are proposed for maintaining channel slope during extreme events and for early identification of channel movement. The sills would be overexcavated and backfilled with natural river size rock similar to the upstream control structure.
- Downstream Control-Both vertical and horizontal riprap control structures would be constructed on the downstream end of the bypass channel. The horizontal control is intended to prevent downstream migration of the bypass while the vertical control is intended to maintain channel elevation.
- Armor layer-Bypass channel sediment modeling and stability computations indicate that substrate material in the 1-2 inch size range is required for channel stability (i.e. armor layer). Based on available field data, a natural armor layer with this approximate material size would be expected to form over time. However, while this size of material is apparently available along the alignment (based on limited field data), it is outside the



Return to TOC

ability of current sediment modeling practices to predict with the required precision the amount of degradation that would occur prior to formation of a stable armor layer. Additional field data collection along the final chute alignment and evaluation in future design is required to further evaluate the armor layer.

**New Dam**

A new, raised concrete dam is proposed just upstream from the existing dam. Two reasons exist for the proposed new dam:

- The new headworks structure requires additional head for diversion due to head losses through the new screens.
- Continued placement and loss of large rock on the dam may adversely impact the bypass channel entrance which is located immediately downstream of the dam.
- The raised dam alters depth and flow velocities in the dam crest vicinity. Since the bypass chute is taking more flow than the current condition, the depth and velocity change comparison at the dam crest is complex.

The current dam has required frequent maintenance (addition of large rock to crest) in order to provide the necessary head for diversion using the *old* headworks structure. With the new headworks requiring an estimated 0.7 ft of additional head, the addition of rock to the existing structure would likely increase not only initially but over time due to the higher potential for loss of protruding rocks on the crest to ice.

The amount of dam raise is not a set amount. The elevation of the current top of dam/top of rock is unknown; even if the current top was known, it has been established that the top of rock elevation changes annually depending on ice conditions, high flow events, and the irrigation district's placement of rock. The proposed top of dam elevation is 1990.5 ft NAVD88. This is likely similar to or slightly above the top of rock elevation just after the irrigation district places rock and perhaps 2 feet above top of rock just before rock placement during normal maintenance activities.

Comparison of depths and velocities over the crest between existing and proposed conditions is difficult due to changing conditions and lack of data on the existing crest. For comparison purposes, the top of existing dam was assumed to be 1989.5 ft NAVD88. Results of the comparison are presented in section 6.7 above. With the bypass channel, the diversion of 15% of total Yellowstone River flow results in lower velocities and depths over the crest for the same recurrence interval event. Without the bypass channel diversion (i.e. assuming no bypass channel), results generally indicate slightly longer lengths of higher velocities, but do not show higher overall velocities for the proposed crest structure.

**Ice Impacts**

The Yellowstone River is subject to heavy ice formation with dynamic ice breakups and ice jams. The upstream control structure is likely the most critical structure in terms of vulnerability to ice as its upstream approach lies on the outside bend and will be exposed to the full impact of ice runs on the main river. For this reason, the invert portion of this structure includes a concrete sill. Riprap ties the sill into the side slopes. Due to the exposure of this structure to large ice



Return to TOC

forces, O&M for the riprap portion has been estimated at a 5% replacement per year, essentially giving the structure a 20-year design life.

The remaining structures in the bypass channel consist of riprap and will likely be subject to far fewer ice breakup impacts than the upstream control structure.

The new dam crest will be subject to large ice forces. The CRREL analysis indicates a preference for a sloped upstream face, but does not allow for a reduction in ice forces for structural computations. The proposed crest uses a large riprap wedge in front of the concrete weir to minimize damage to the upstream concrete face.

**Operation and Maintenance**

Operation and Maintenance (O&M) quantities and costs were developed based on experience with past projects and assumptions involving frequency of riprap replacement and costs. Additional O&M costs were estimated for removal of sediment in front of the headworks. Note that the current design and modeling efforts do not indicate that sediment will deposit in front of the headworks; however, the limited available data, modeling uncertainties, and natural variability limit the accuracy of computations. Total annual O&M costs for the bypass channel (not including O&M of the newly constructed headworks) and new dam crest are estimated at approximately $140,000 per year.

**Adaptive Management**

The following adaptive management features were considered for post-construction enhancement of the bypass channel on an as-needed basis:

- Flow augmentation structure. The flow augmentation structure would be located on the right bank of the Yellowstone River near the proposed dam. The purpose of the structure would be to increase attractive flow at the bypass entrance (downstream end) by 5-7%.
- Localized repairs of high turbulence areas if found to be affecting fish passage.
- Modifications to the configuration of the bypass entrance (downstream end) to increase attraction to the bypass channel. These modifications would consist of movement and manipulation of riprap and the existing rock field material in the main channel of the Yellowstone River and a short distance upstream into the bypass channel.
- Intake diversion weir revisions (new dam crest). Modifications to the hydraulic characteristics of the proposed new dam crest may be required if passage of other native species (besides pallids) is found to be negatively impacted by the new crest. Modifications to the proposed concrete crest would likely not be feasible, so the AM proposal would be to manipulate the riprap between the proposed new crest and the existing dam crest in order to improve depth/velocity diversity at the proposed crest.

**Future Work**

Additional data collection and analyses are required to finalize design of the bypass channel, including:

- Collection of additional sediment data in the vicinity of the bypass exit (upstream end). The measured sediment load at the site is nearly an order of magnitude lower than that reported at the Sidney gage. While sediment data naturally varies, the measured data at



Return to TOC

sediment modeling will require additional sediment data collection in order to decrease the range of input parameters used for sensitivity analysis.

- Collection of additional soil borings along the final bypass channel alignment. Additional soil borings will be used as input to the armor layer analysis. Also, more soil borings will help alleviate concerns with potential excavation constructability issues (e.g. shallow bedrock).
- Detailed modeling of the bypass entrance (downstream end). The bypass channel entrance (downstream end) is critical to passage success. Detailed modeling (likely 2-dimensional) of the entrance will be required to assess flow conditions and various configurations to increase the likelihood of fish finding and using the bypass channel.
- Detailed modeling of the bypass exit (upstream end). The bypass exit is critical to sediment continuity and stability of the entire bypass channel. Detailed modeling of the flow and sediment split will be required to analyze stability of the bypass channel.
- Detailed modeling of the system. The entire bypass channel system, including the bypass entrance, bypass exit, bypass channel, remaining existing high flow channel and Yellowstone River from upstream of the exit to downstream of the existing high flow channel will be required to assess overall stability of the system.
- Collection of water surface elevations related to irrigation diversion. Design of the headworks included assumptions on head loss through the new fish screens. Measured water surfaces in the Yellowstone River along with diverted discharge into the canal will allow for fine tuning of the proposed dam crest elevation.
- Modeling of the proposed dam and irrigation diversion headworks. Data measured during the first season of headworks operation will be used to assess the proposed dam crest elevation and configuration needed to meet irrigation diversion requirements as well as to evaluate flow conditions over the proposed and existing dam for passage of species that currently pass the rock field.



Return to TOC

Attachment 6  Bypass Channel

# Appendix A

Sediment Analysis-Main Channel Yellowstone River

19March2012

Return to TOC

US Army Corps of Engineers ®
Omaha District

# Intake Dam
# Lower Yellowstone Irrigation Project Modifications
# Bypass Main Channel Sediment Impacts Analysis
# CENWO-ED-HF
# December 22, 2011

Return to TOC

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF FIGURES



Return to TOC

# Intake Dam – Main Channel Sediment Analysis

## 1. INTRODUCTION

A technical analysis was performed to evaluate potential impacts of the creation of a bypass channel around the dam at Intake, MT as it relates to the sediment processes in the main channel. The goal of the analysis was to determine if removing a percentage of flow from the main channel would cause deposition to occur beyond background levels behind the weir currently present at the site. This summary report discusses the evaluation and presents results of the analysis.

## 2. PROJECT DESCRIPTION

### 2.1 EXISTING CONDITION

The project at Intake consists of a low head diversion dam and headworks located on the Yellowstone River. Under current conditions, sediment deposition in the main channel does not impact operations of the structure. It is assumed that while some deposition may occur behind the structure under low flows, flood events serve to pass any entrained sediment over the diversion dam and down the Yellowstone River.

### 2.2 PROPOSED CONDITION

In order to facilitate fish passage around the diversion weir at Intake, it has been proposed that a bypass be constructed. The bypass would outlet just downstream of the existing diversion dam and have an upstream entrance at the location of an existing high flow chute several miles upstream from the diversion structure. Attractive flow is an issue with the bypass proposal, so flow diversions ranging from approximately 5 to 30% of total Yellowstone River flow have been evaluated. It is the goal of this evaluation to determine if the reduction in stream power of the Yellowstone River resultant from the bypass alternative will alter the existing sediment processes at the diversion site.

## 3. SEDIMENT DATA

Sediment data for the purpose of this evaluation was procured from two separate sources. The first being on-site samples collected by the USGS in 2008 and 2011. The second being gage data obtained from the USGS gaging station at Sidney, MT. Additional details on sediment data used can be found in the reference "Lower Yellowstone Project Fish Passage and Screening, Preliminary Design Report, Appendix A-2, Hydraulics."

### 3.1SUSPENDED SEDIMENT DATA

Two sources of suspended data were run through the analysis to establish an upper and lower bound for the sediment loading at the project site. On-site samples collected in 2011by the USGS provided the lower bound for the simulation, while data collected from the USGS gaging station provided the upper bound. The USGS also collected sediment samples in 2008; however, the focus of the 2008 sampling effort was to evaluate sediment entering the canal through the headworks. Further details pertaining to the 2008 sampling effort can be found in the Hydraulic Appendix to the original EA.

There is a significant difference in magnitude between the two curves despite the lack of any major tributaries between the project site and the gaging station at Sidney. However, loading curves established from the on-site sediment collection efforts fall in the lower ranges of data taken from the gaging station at Sidney. Potential causes of the discrepancy include timing of collection of the on-site data (data was most often collected on the falling limb of event hydrographs) and differences in sampling



Return to TOC

methodologies. Also, as with any set of sediment data, there is great variability in the concentrations measured given a certain flow. The large selection of data points available from the Sidney gage provides greater certainty in the estimation of average sediment loadings in this portion of the Yellowstone.

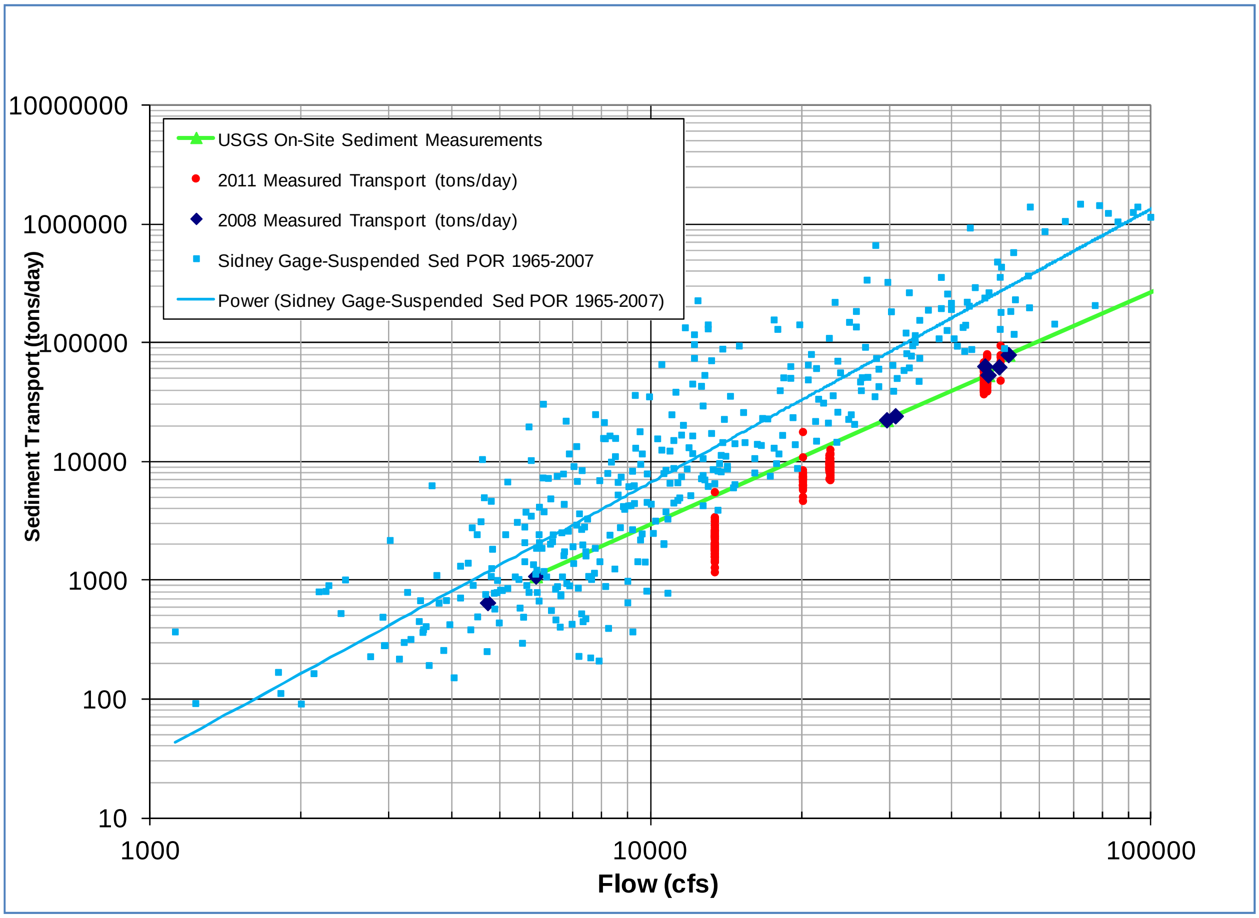



**Figure 1 - Suspended Sediment Rating Curve**

### 3.2 BED DATA

Makeup of the bed was determined from on-site samples taken in 2008 from multiple locations throughout the project site. For the purposes of the model, results from Wohlman counts were used to represent the bed in the HEC-RAS model. This bed makeup would be the most likely to resist degradation and represents the most conservative configuration.

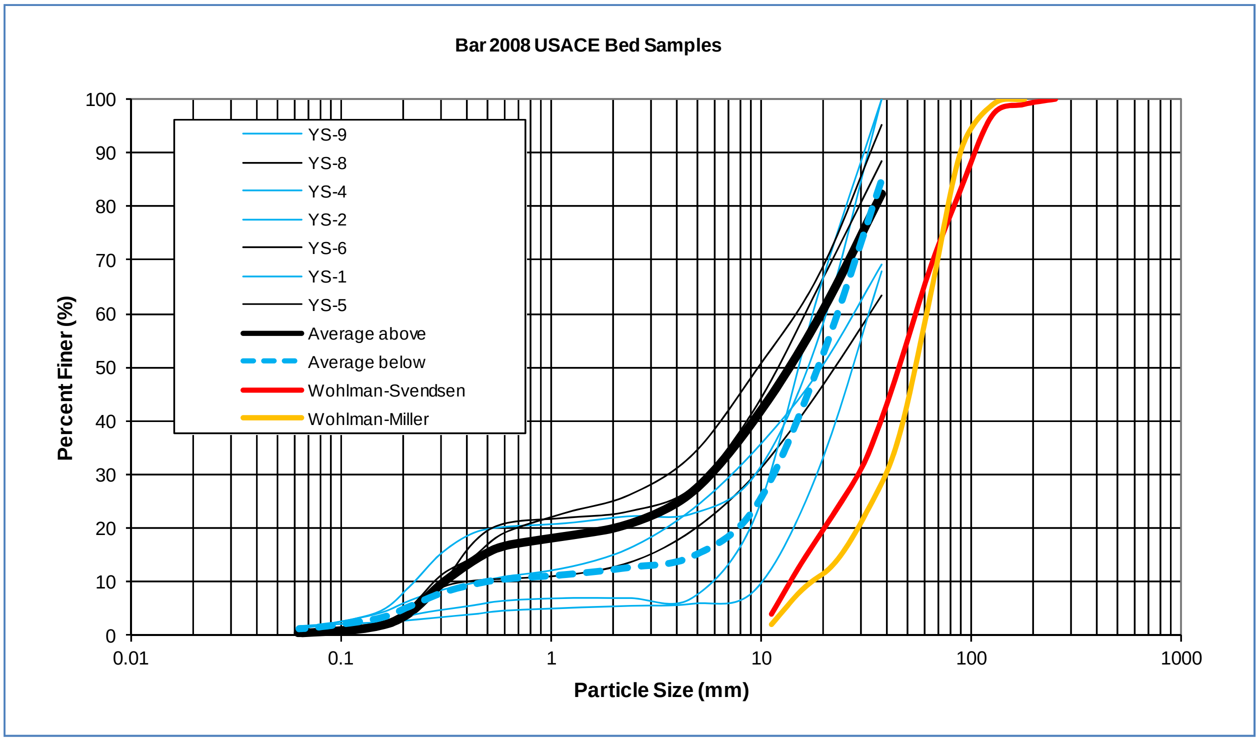



**Figure 2 - Bed Gradation Curves**

## 4. HEC-RAS MODELING

Analysis was performed to evaluate potential impacts of the creation of a bypass channel around the dam at Intake, MT as it relates to the sediment processes in the main channel. The analysis used HEC-RAS version 4.1.0 dated January 2010. A previously created existing conditions model was used as the base model. In order to facilitate use of the sediment transport function in HEC-RAS, the existing model was modified by removing all split flow junctions and removing sections to improve stability of transport simulations.

## 5. SEDIMENT TRANSPORT MODELING

Calibration data was not available for this modeling simulation. The approach was to simulate conditions that would most likely promote aggradation behind the dam. The bed layer was selected on the coarser side of the data available and two sources of suspended data were utilized to form upper and lower bounds of the expected loading at the project site.

### 5.1 Quasi-Unsteady Flow

Current sediment capabilities in HEC-RAS are based on quasi-unsteady hydraulics. The quasi-unsteady approach approximates a flow hydrograph by a series of steady flow profiles associated with corresponding flow durations.

A 20-year simulation was used to evaluate long term trends in the project reach. Daily flow data from the USGS Sidney gage were downloaded, covering the time period from 27Sep1991 to 27Sep2011. An absence of major tributaries makes the Sidney gage a fair approximation of flow conditions at the project site.

Computation increments (CIs) between 0.1 hours and 24 hours were evaluated and varied based on the flow encountered at a given time step. Using a computation interval of 0.1 hours provided the best indication of model stability, but resulted in unacceptable run times when utilized over the entire flow range.

In order to simulate the installation of the bypass, flows from the Sidney gage were reduced by a flat percentage ranging from 5 to 30% for the various alternatives.

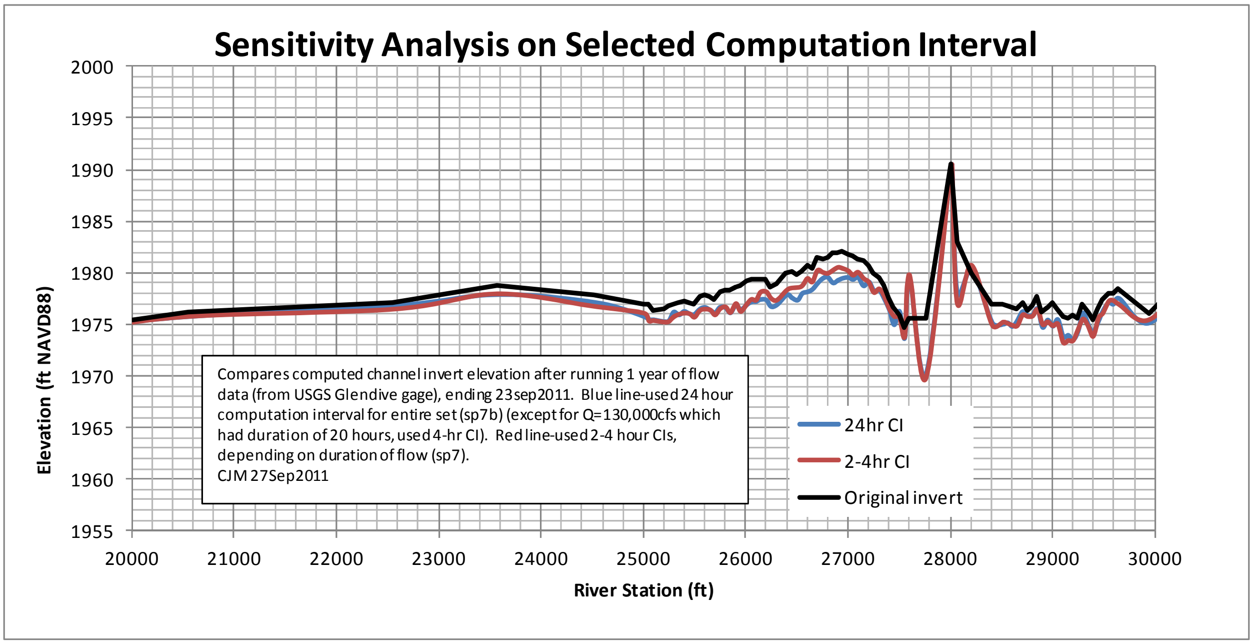



**Figure 3- Sensitivity Analysis on Selected Computation Interval**

### 5.2 Bed Gradation

Several sources of data were employed to determine the expected range of bed material gradations including bed and bank samples collected in 2008. During calibration runs, all bed materials resulted in a general degradational trend for the existing conditions. Wohlman counts from the 2008 samples were selected as the preferred gradation as they represented the most conservative condition with the goal in mind to identify aggradational potential.



Return to TOC

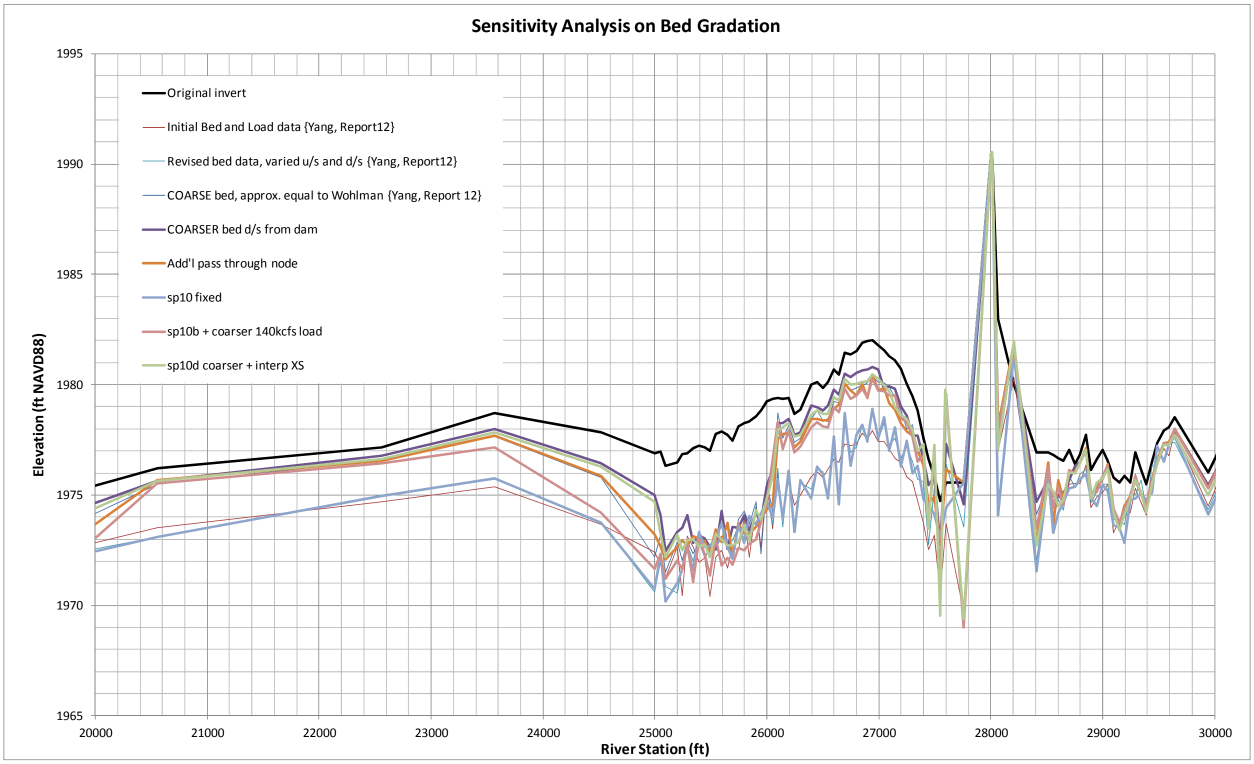



**Figure 4 - Sensitivity Analysis on Bed Gradation**

### 5.3 SEDIMENT LOADING

The suspended sediment load was input into the model utilizing a rating curve correlating total load to flow encountered. Two rating curves were used to define the upper and lower bound of expected load. Gradations for the two curves were assumed to be similar.

In order to simulate the installation of the bypass, the rating curve flows were shifted by the percentage of reduction in flow while total tons per day remained static. The assumption that no sediment load was diverted to the bypass was made to provide a conservative estimate of the effects of the bypass on sediment processes in the main channel.

**Table 1 - USGS On-Site Sediment Rating Curve**

| | | | | | |
|---|---|---|---|---|---|
| Flow | 5890 | 29600 | 47200 | 51800 | 140000 |
| tons/day | 1090 | 22470 | 53680 | 79650 | 500000 |
| Clay | | | | | |
| VFM | | | | | |
| FM | | | | | |
| MM | | | | | |
| CM | 0.82 | 0.78 | 0.76 | 0.67 | 0.55 |
| VFS | 0.06 | 0.07 | 0.08 | 0.12 | 0.15 |
| FS | 0.1 | 0.11 | 0.13 | 0.15 | 0.17 |
| MS | 0.02 | 0.03 | 0.03 | 0.06 | 0.08 |
| CS | | | | | 0.05 |

**Table 2 - Sidney Gage Sediment Rating Curve**

| | | | | | |
|---|---|---|---|---|---|
| Flow | 5000 | 20000 | 40000 | 50000 | 140000 |



Return to TOC

| tons/day | 1344.945 | 32756.46 | 161656.5 | 270261.9 | 2894847 |
|---|---|---|---|---|---|
| Clay | | | | | |
| VFM | | | | | |
| FM | | | | | |
| MM | | | | | |
| CM | 0.82 | 0.78 | 0.76 | 0.67 | 0.55 |
| VFS | 0.06 | 0.07 | 0.08 | 0.12 | 0.15 |
| FS | 0.1 | 0.11 | 0.13 | 0.15 | 0.17 |
| MS | 0.02 | 0.03 | 0.03 | 0.06 | 0.08 |
| CS | | | | | 0.05 |

### 5.4 Transport Function

The Laursen-Copeland transport function was selected because of its applicability to sediments in the silt range. Both the 2011 measured data and the Sidney data show over 60-90% of the material in suspension is finer than sand. Yang, Toffaleti, England-Hansen, and Achers-White also give reasonable results. Meyer-Peter Muller computes fairly significant aggradation, which is expected due to its tendency to underpredict the transport potential of finer materials.

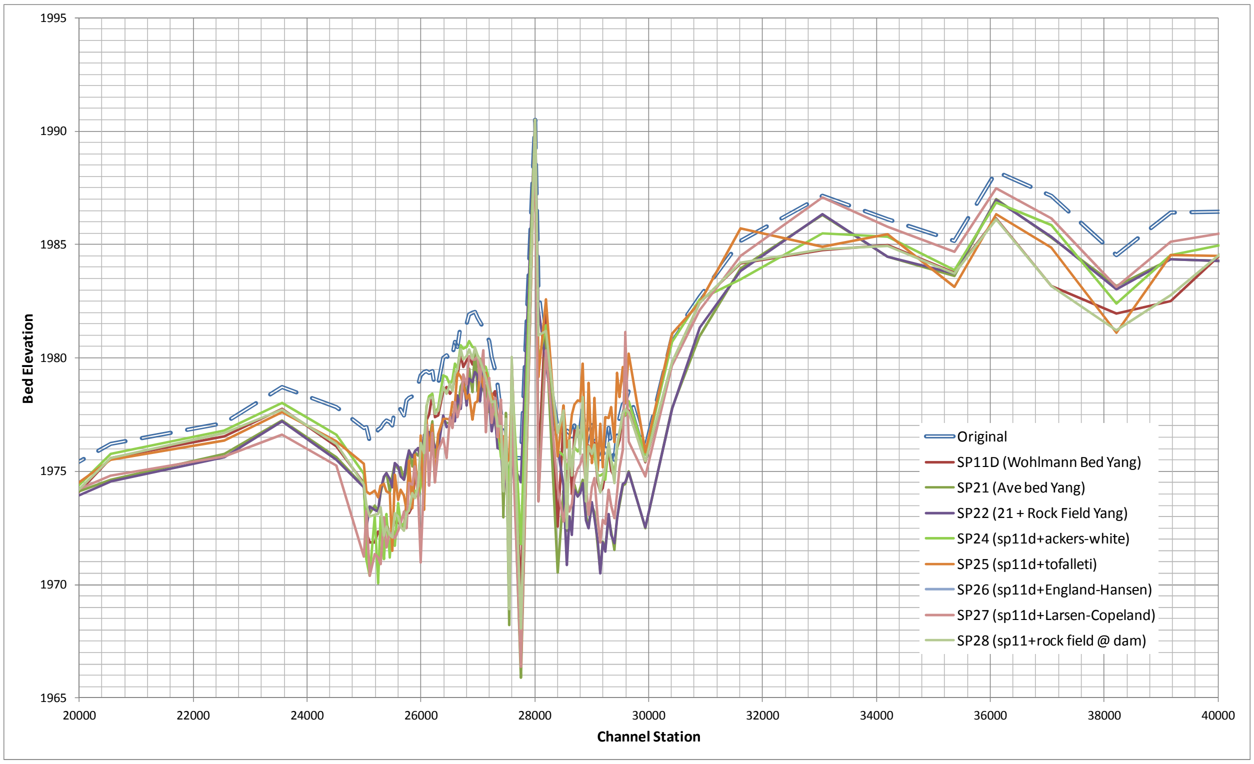



**Figure 5 - Sensitivity to Transport Function**

### 5.5 Sorting Method and Fall Velocity

The default methods for sorting and fall velocity were selected for this analysis. HEC-RAS does provide an alternative sorting method to the default; however it is intended only with use of the Wilcock transport method which was not utilized in this simulation.

Several methods are available for computing fall velocity as well. The default method in HEC-6 (Report 12) was selected for this simulation. A sensitivity analysis was not performed.



Return to TOC

## 6. RESULTS

Results varied greatly between use of the two sediment loading curves.

Using on-site sediment data, the channel showed little change in its transport potential up to a 30% reduction in total flow in the main channel. Reductions above the 30% threshold showed significant aggradation behind the diversion structure, though the channel remained stable as little as one-mile upstream from the diversion site. The diversion is located at approximate station 28000 on the plots.

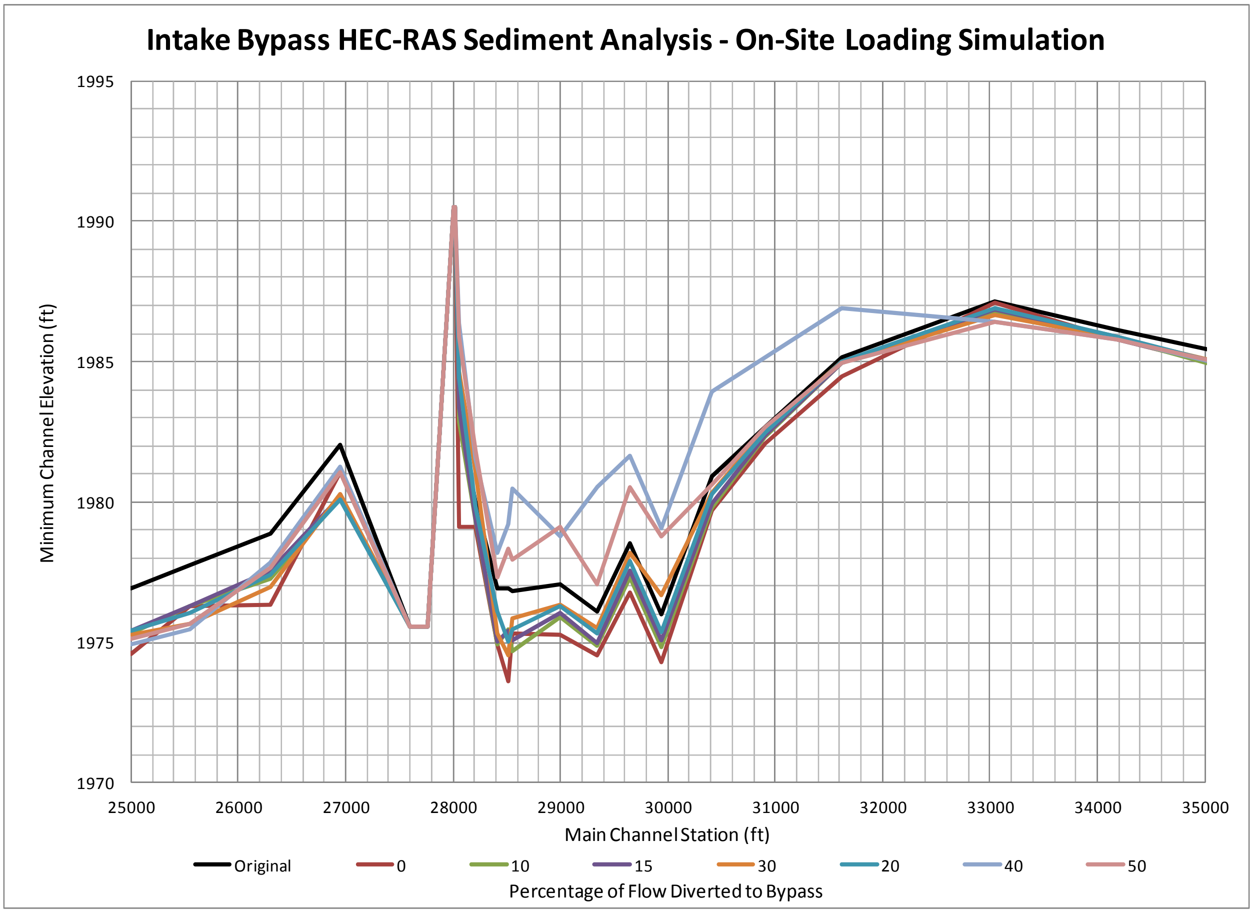



**Figure 6 - Minimum Channel Elevation (On-Site Data Simulations)**

When applying the Sidney gage sediment loading to the simulation, results showed slight aggradational potential even under existing conditions. However, this rate accelerated greatly once flows were reduced by 20%, leading to the conclusion that the 15% reduction should be the upper limit for targeted diversions.



Return to TOC

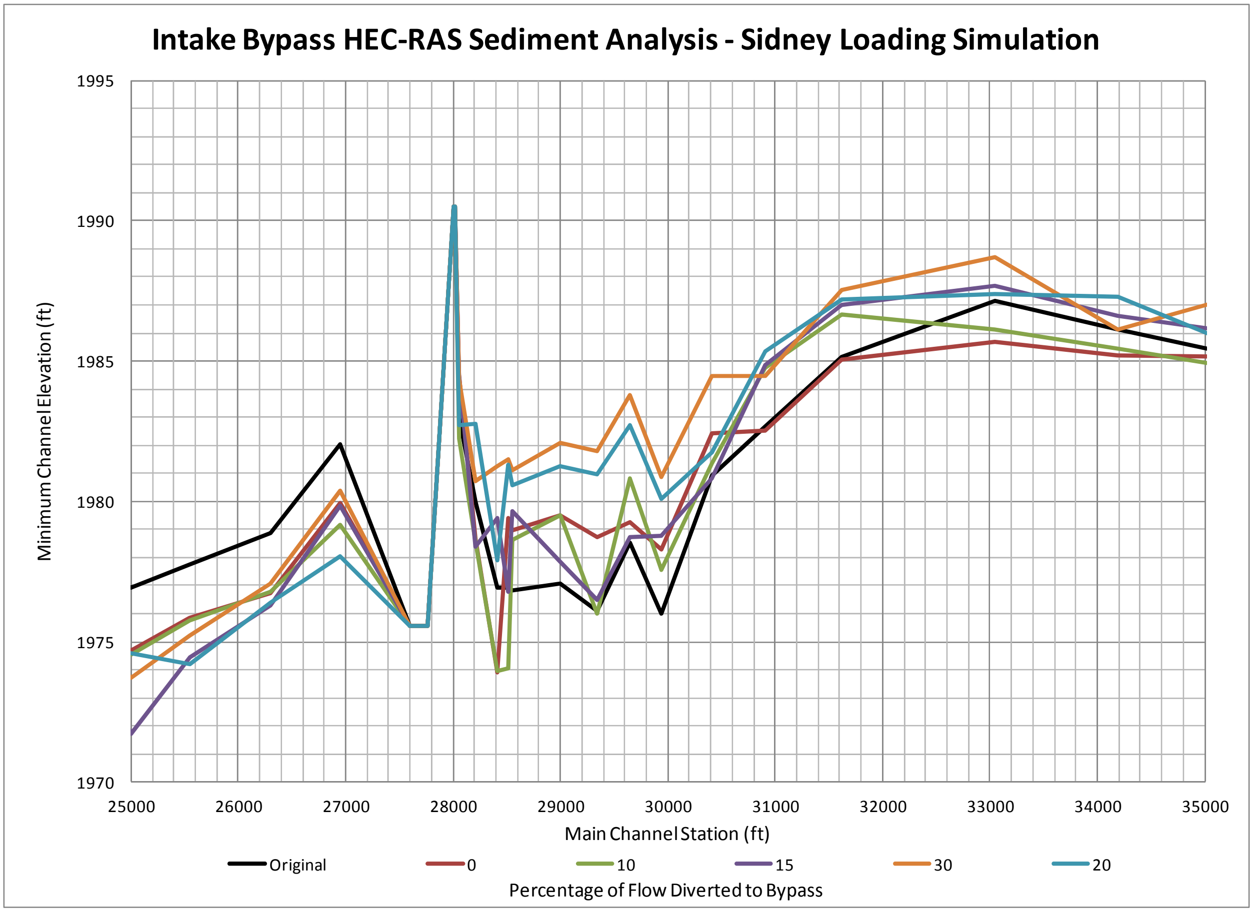



**Figure 7 - Minimum Channel Elevation (Sidney Data Simulations)**

## 7. RECOMMENDATIONS

It is paramount that the sediment dynamics of the diversion at Intake be unaltered from existing conditions following construction of the proposed bypass. Currently, the dam requires no in channel management of sediments.

If stream power were reduced to a point where sediments began to regularly accumulate in the vicinity of the headworks operations of the fish screens could be impeded, resulting in continued entrainment of fish species within the canal. Efforts to remove any sediments that accumulate would result in significant increases in annual O&M costs that the project is subject to.

Given the results of the two sediment loading analysis and the potential implications of any major alterations to the sediment processes at the site, it is recommended that a conservative approach be taken. Therefore, based upon the analysis utilizing Sidney gage suspended sediment loadings, a diversion of greater than 15% would present a risk to alter the sediment transport dynamics currently present in the Yellowstone River at the Intake Diversion project and should be the maximum amount of diversion for the proposed bypass.



Return to TOC

## 8. REFERENCES


U.S. Army Corps of Engineer. CPD-68 “HEC-RAS, River Analysis System, User’s Manual, Version 4.1.” 2010.

U.S. Army Corps of Engineers. EM 1110-2-1601 “Hydraulic Design of Flood Control Channels.” 1994.

U.S. Army Corps of Engineers, Omaha District. “Lower Yellowstone Project Fish Passage and Screening, Preliminary Design Report, Appendix A-2, Hydraulics.” October 2009.

U.S. Army Corps of Engineers, Omaha District. “Trip Report 26-28August2008.”

Attachment 6  Bypass Channel

# Appendix B

Sediment Analysis-Bypass Channel

19March2012

Return to TOC

# Intake Dam
Lower Yellowstone Irrigation Project Modifications

**Bypass Channel-Sediment Analysis**
**30% Design-Hydraulics**

**U.S. Army Corps of Engineers**
**Omaha District**
**DRAFT FEB2012**

Return to TOC

# Table of Contents



## List of Figures





Return to TOC

## List of Tables

## 1. INTRODUCTION

This report describes sediment evaluation and HEC-RAS modeling used in support of the design of a bypass channel at the Bureau of Reclamation's Lower Yellowstone Irrigation Project (commonly referred to as Intake). This report focuses on sediment modeling of the bypass channel itself; concurrent modeling of the main Yellowstone River is being conducted by USACE Omaha District Sediment and Channel Stabilization Section. The purpose of the bypass channel is to allow Pallid sturgeon (as well as other native species) to pass from downstream of the low head (≈8-10ft) structure to upstream.

The intent of this analysis is to reach approximately a 30% design level for the bypass channel. The bypass channel is one of two remaining alternatives currently being considered; the other is a flat slope (≈0.5%) rock ramp. The 30% design of the bypass channel is intended to allow for a fair comparison of cost estimates between the bypass channel and rock ramp. This report does not discuss the rock ramp alternative further.

## 2. BACKGROUND

Passage of the Pallid sturgeon around Intake Dam by means of a bypass channel has been discussed and evaluated for over a decade. This analysis uses best available information along with suggestions from U.S. Department of Interior, Bureau of Reclamation (Reclamation) to evaluate several bypass alternatives.

Criteria used to develop and evaluate the alternatives are based on suggestions from the Biological Review Team (BRT). The criteria used to develop alternatives include:

- A range of percentage of flow diverted from 10% to 35%
- Similar to previous evaluations of both the rock ramp and bypass channel, flow and depth ranges as shown in Table 1 were used based on BRT passage criteria. The preferred range for Pallid passage is depths greater than a meter with velocities lower than 4 ft/s.

**Table 1 Depth and Velocity Ranges used for Evaluation**

| Depth range | | Velocity range (ft/sec) | | | | |
|---|---|---|---|---|---|---|
| (m) | (ft) | *0-2* | *2-4* | *4-6* | *6-8* | *>8* |
| *0-0.5* | *0-1.64* | | | | | |
| *0.5-1.0* | *1.64-3.28* | | | | | |
| *>1.0* | *>3.28* | | | | | |

The above criteria were used to evaluate numerous alternatives based solely on hydraulics (i.e. no sediment modeling included). Three alternatives were selected representing 10%, 15%, and 30% diversion. Table 2 summarizes these three alternatives. Additional details on the initial evaluation were presented in a concept analysis in April 2011 (see Reference 5.)



Return to TOC

**Table 2 ORIGINAL Bypass Channel Flow Splits and Configurations**

| Recurrence interval (annual, post-Yellowtail flows) | Total Yellowstone River discharge | Flow Splits for Base and Alternatives: BASE (existing right bank chute assuming new headworks with existing dam) | | 10% Diversion | | 15% Diversion | | 30% Diversion | |
|---|---|---|---|---|---|---|---|---|---|
| | (cfs) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) |
| <2-yr | 3000 | 0 | 0 | 210 | 7 | 570 | 19 | 830 | 28 |
| <2-yr | 7000 | 0 | 0 | 750 | 11 | 1260 | 18 | 2540 | 36 |
| <2-yr | 15000 | 0 | 0 | 1600 | 11 | 2280 | 15 | 5280 | 35 |
| <2-yr | 20000 | 0 | 0 | 2120 | 11 | 2850 | 14 | 6930 | 35 |
| <2-yr | 25000 | 190 | 1 | 2640 | 11 | 3420 | 14 | 8410 | 34 |
| <2-yr | 30000 | 790 | 3 | 3170 | 11 | 3990 | 13 | 9840 | 33 |
| 2-yr | 45300 | 2280 | 5 | 4970 | 11 | 5910 | 13 | 14210 | 31 |
| 5-yr | 60600 | 4050 | 7 | 7190 | 12 | 7920 | 13 | 18540 | 31 |
| 10-yr | 70100 | 5220 | 7 | 8670 | 12 | 8740 | 12 | 21110 | 30 |
| 20-yr | 78700 | 6090 | 8 | 9830 | 12 | 10460 | 13 | 23520 | 30 |
| 50-yr | 89400 | 7280 | 8 | 11410 | 13 | 11830 | 13 | 26480 | 30 |
| 100-yr | 97200 | 8090 | 8 | 12600 | 13 | 12950 | 13 | 28480 | 29 |
| 500-yr | 114000 | 9920 | 9 | 15620 | 14 | 15870 | 14 | 32710 | 29 |

| Pertinent Bypass Channel Parameters | **10% Diversion** | **15% Diversion** | **30% Diversion** |
|---|---|---|---|
| Alignment | 2 | 1 | 2 |
| Bypass Channel Length (ft) | 13550 | 15650 | 13550 |
| Bypass Channel Longitudinal Slope | 0.00059 | 0.00045 | 0.00059 |
| Low Flow Channel Depth (ft) | 2 | N/A | 2 |
| Low Flow Channel Bottom Width (ft) | 10 | N/A | 10 |
| Low Flow Channel Side Slopes | 1V:3H | N/A | 1V:3H |
| Main Bypass Channel Bottom Width | 50 | 61 | 300 |
| Main Bypass Channel Side Slopes | 1V:5H | 1V:4H | 1V:5H |
| Approximate Excavation Quantity (cubic yards) | 650,000 | 950,000 | 2,460,000 |

## 3. HYDRAULIC MODELING

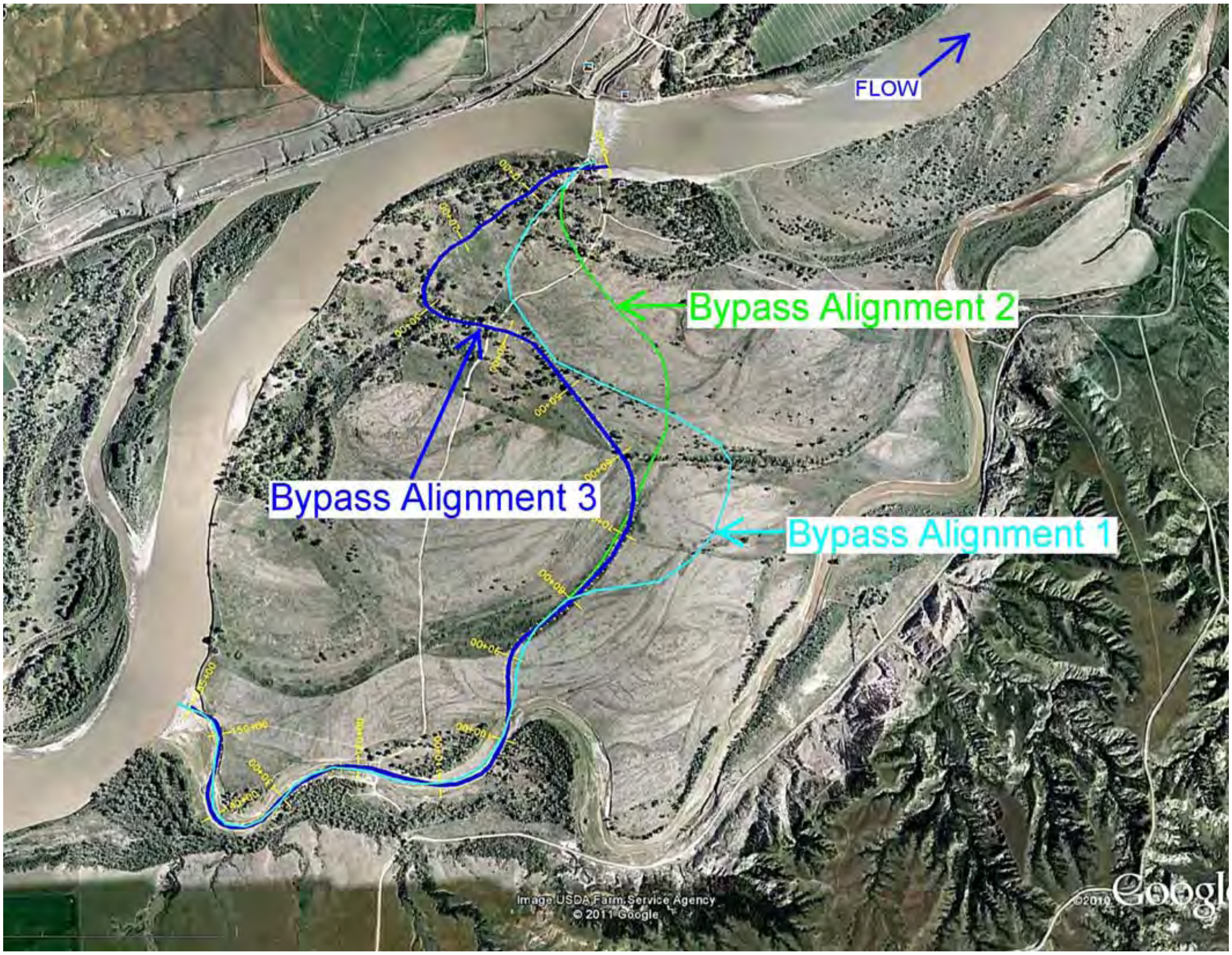
The analysis used HEC-RAS version 4.1.0 dated January 2010. A previously created existing conditions model was used as the base model. Using three different alignments, new cross sections were extracted from a LiDAR based digital terrain model (DTM) using Bentley's Microstation/InRoads software package.



Return to TOC

The three alignments were developed based on length required to obtain the desired channel slope as well as to minimize excavation quantities. The alignments are shown in Figure 1 and are hereafter referred to as Alignments 1, 2, and 3. Alignments 1 and 3 have similar lengths (≈15,500ft) and alignment 2 is slightly shorter (≈13,500ft). Alignment 3 was developed to maximize the use of historic channel scars and swales following a site visit in August 2011. Figure 1 shows Alignments 1 and 2 discussed in the original concept evaluation as well as the currently selected Alignment 3.

**Figure 1 Potential Alignments**



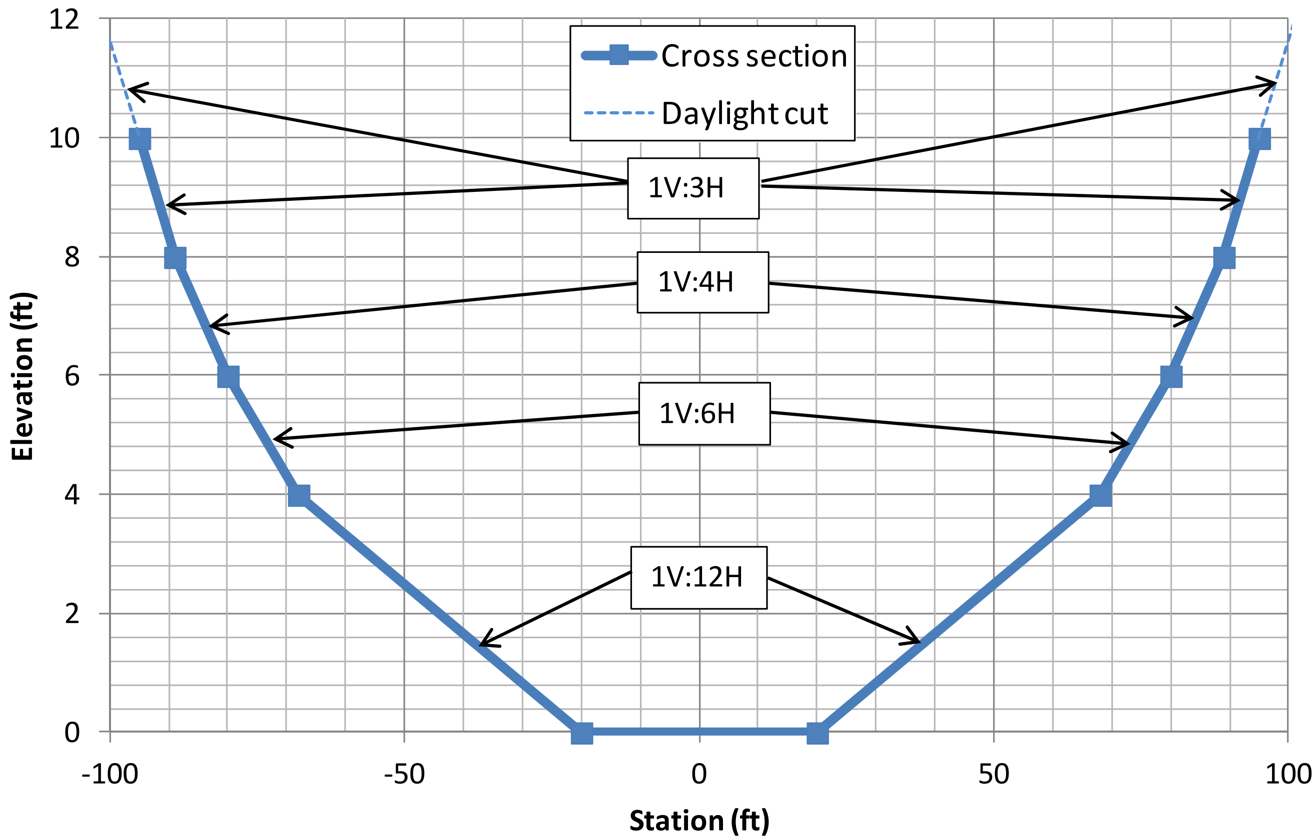



Return to TOC

A large number of alternatives were developed to roughly determine flow splits between the Yellowstone River and the bypass channel. Three that were originally selected for further evaluation in April 2011 are summarized and compared in Table 2.

Following the concept analysis in April 2011, further coordination with Reclamation and the BRT led to a channel section with a 40 ft bottom width, side slopes varying between 1V:12H and 1V:3H with a longitudinal slope of 0.0006 ft/ft. This channel section is shown in Figure 2.

**Figure 2 Channel Section**




The channel configuration using Alignment 3 and the section shown in Figure 2 will hereinafter be referred to as the **15% base bypass alternative**. It diverts 10%-17% of Yellowstone River flows and is considered the 15% diversion alternative. Also evaluated were 10% and 30% diversion alternatives.

The 10% diversion alternative utilizes a cross section similar to that shown in Figure 2, but half the width (i.e. bottom width is 20ft, each side slope section only half as wide). The 30% diversion utilizes the same side slopes as those shown in Figure 2 with a 200ft bottom width.

Table 3 summarizes the current bypass alternatives in the same format as Table 2 presented the original alternatives.

**Table 3 Current Bypass Channel Flow Splits and Configurations**

| | | Flow Splits for Base and Alternatives | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Recurrence interval (annual, post-Yellowtail flows) | Total Yellowstone River discharge | **BASE** (existing right bank chute assuming new headworks with existing dam) | | **10% Diversion** | | **15% Diversion** | | **30% Diversion** | |
| | (cfs) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) | (cfs) | (%) |
| <2-yr | 3000 | 0 | 0 | 220 | 7 | 310 | 10 | 890 | 30 |
| <2-yr | 7000 | 0 | 0 | 650 | 9 | 860 | 12 | 2220 | 32 |
| <2-yr | 15000 | 0 | 0 | 1550 | 10 | 2140 | 14 | 4770 | 32 |
| <2-yr | 30000 | 790 | 3 | 3220 | 11 | 4510 | 15 | 9290 | 31 |
| 2-yr | 45300 | 2280 | 5 | 5180 | 11 | 7170 | 16 | 13720 | 30 |
| 5-yr | 60600 | 4050 | 7 | 7340 | 12 | 9900 | 16 | 18130 | 30 |
| 10-yr | 70100 | 5220 | 7 | 8770 | 13 | 11690 | 17 | 20780 | 30 |
| 20-yr | 78700 | 6090 | 8 | 9990 | 13 | 13210 | 17 | 23240 | 30 |
| 50-yr | 89400 | 7280 | 8 | 11540 | 13 | 14940 | 17 | 26260 | 29 |
| 100-yr | 97200 | 8090 | 8 | 12650 | 13 | 16280 | 17 | 28170 | 29 |
| 500-yr | 114000 | 9920 | 9 | 15570 | 14 | 19290 | 17 | 32490 | 29 |

| Pertinent Bypass Channel Parameters | **10% Diversion** | **15% Diversion** | **30% Diversion** |
|---|---|---|---|
| Alignment | 3 | 3 | 3 |
| Bypass Channel Length (ft) | 15500 | 15500 | 15500 |
| Bypass Channel Longitudinal Slope | 0.00060 | 0.00060 | 0.00060 |
| Bypass Channel Bottom Width | 20 | 40 | 200 |
| Bypass Channel Side Slopes | Vary from 1V:12H to 1V:3H | | |
| Approximate Excavation Quantity (cubic yards) | 800,000 | 1,200,000 | 2,600,000 |

## 4. SEDIMENT DATA

Two sediment data collection efforts have been completed by the USGS as requested by USACE. The first effort occurred in 2008 and consisted of four sampling runs between 24June2008 and 28August2008. Each of these runs gathered suspended and bedload data at three locations: just upstream of Intake Dam, just downstream of Intake Dam, and in the irrigation canal just downstream from the old headworks. The intent of the 2008 effort was to provide increased knowledge of sedimentation processes in the immediate vicinity of the dam. More details concerning the 2008 sediment data can be found in section 2.8 of Reference 6. Reference 6 also provides some information on the sediment data available from the USGS gage (06329500) on the Yellowstone River at Sidney, MT (42 miles downstream). In addition to the

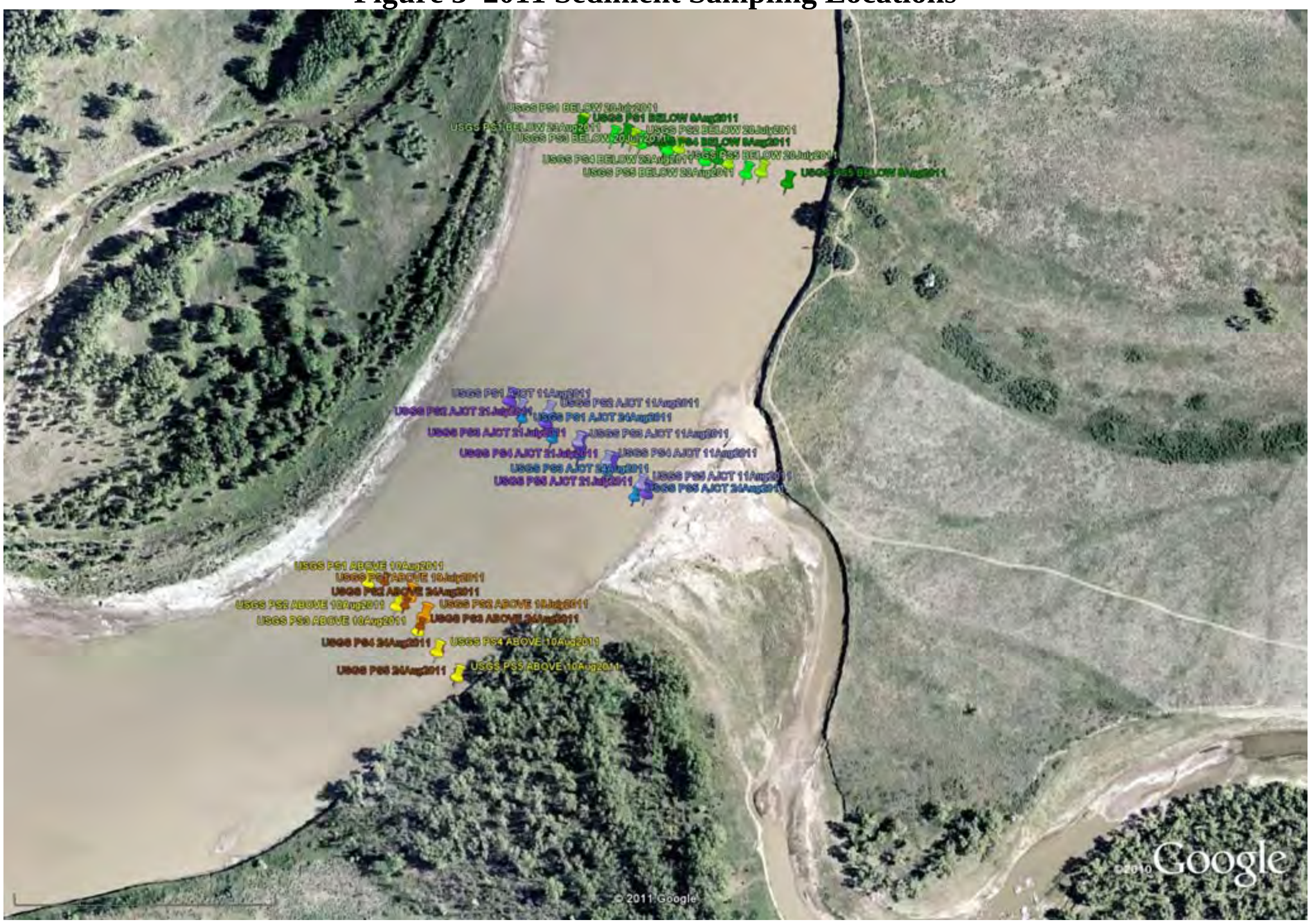


Return to TOC

USGS data gathered in 2008, USACE gathered several grab samples from both the banks and in-channel bars. These grab samples were sent to the USGS lab for analysis. Details on these samples can be found in reference 7.

The second sediment data collection effort occurred in 2011, with three sampling runs occurring in July and August (19-21July, 9-11August, and 23-24August). Three locations were sampled during each run: adjacent to the upstream end of the existing high flow chute as well as just above and below (see Figure 3 for sample locations). The intent of the 2011 effort was to provide increased knowledge of the size and concentration of sediment, especially as it relates to vertical distribution. As such, point samples were taken at each cross section. Six point samples were taken in each of the five equal-discharge-increment verticals for a total of 30 point samples at each cross section during each sampling run.

**Figure 3 2011 Sediment Sampling Locations**




During the July sampling effort, flow was entering the existing right bank chute. However, because of equipment malfunction during collection of the upstream data and the limited number of samples, it is difficult to make conclusions on the impact of the existing chute on sediment transport.

Figures 4-6 show the suspended sediment concentration and $D_{90}$ for the three cross sections based on the USGS data.
Figure 7 compares suspended transport for the Sidney gage with the measured data.

Figures 8 and 9 show the suspended load particle size distributions for the 2008 and 2011 data as well as the Sidney data.

**Figure 4 Relative Concentration and $D_{90}$ Upstream from High Flow Channel**

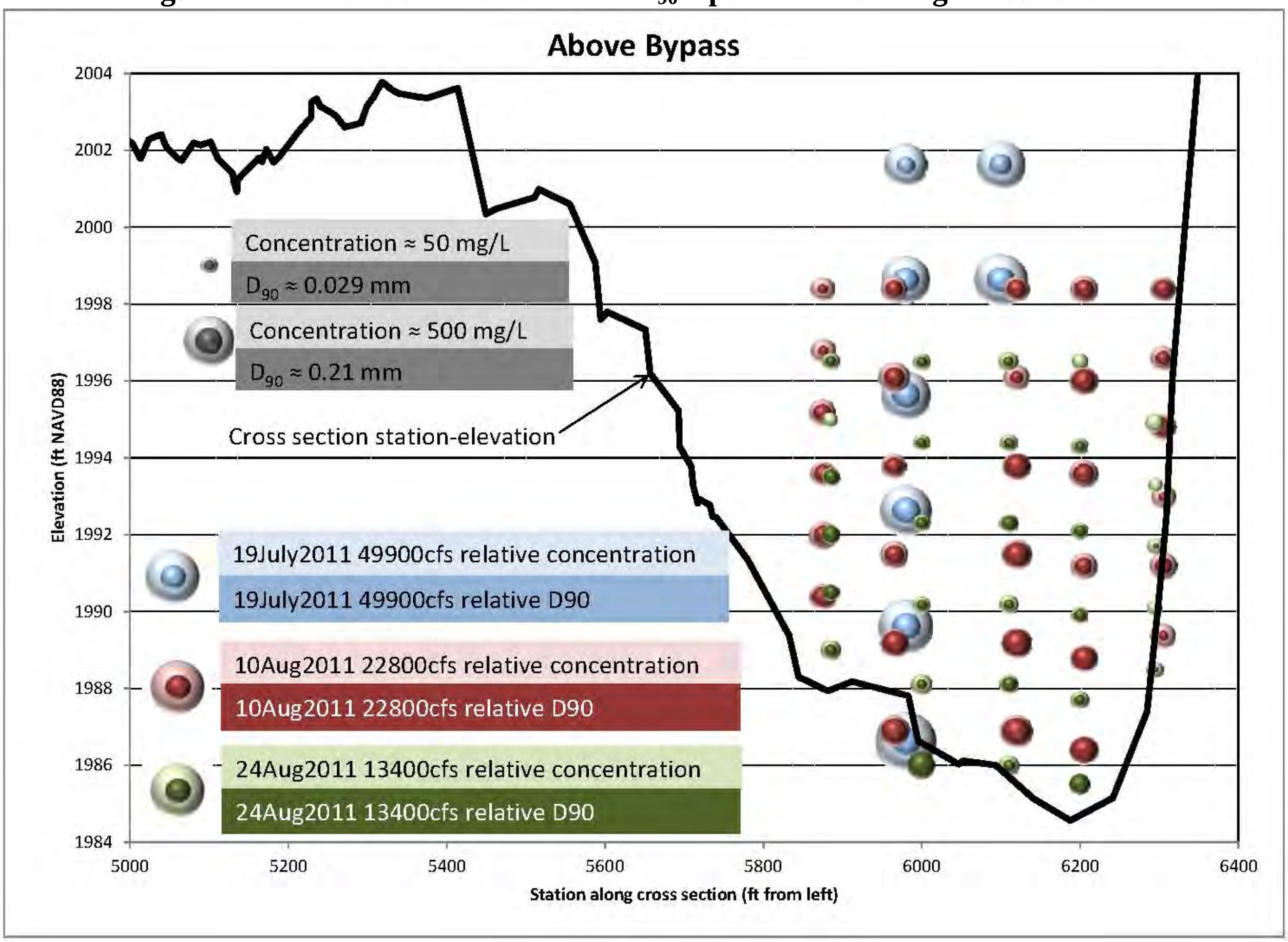
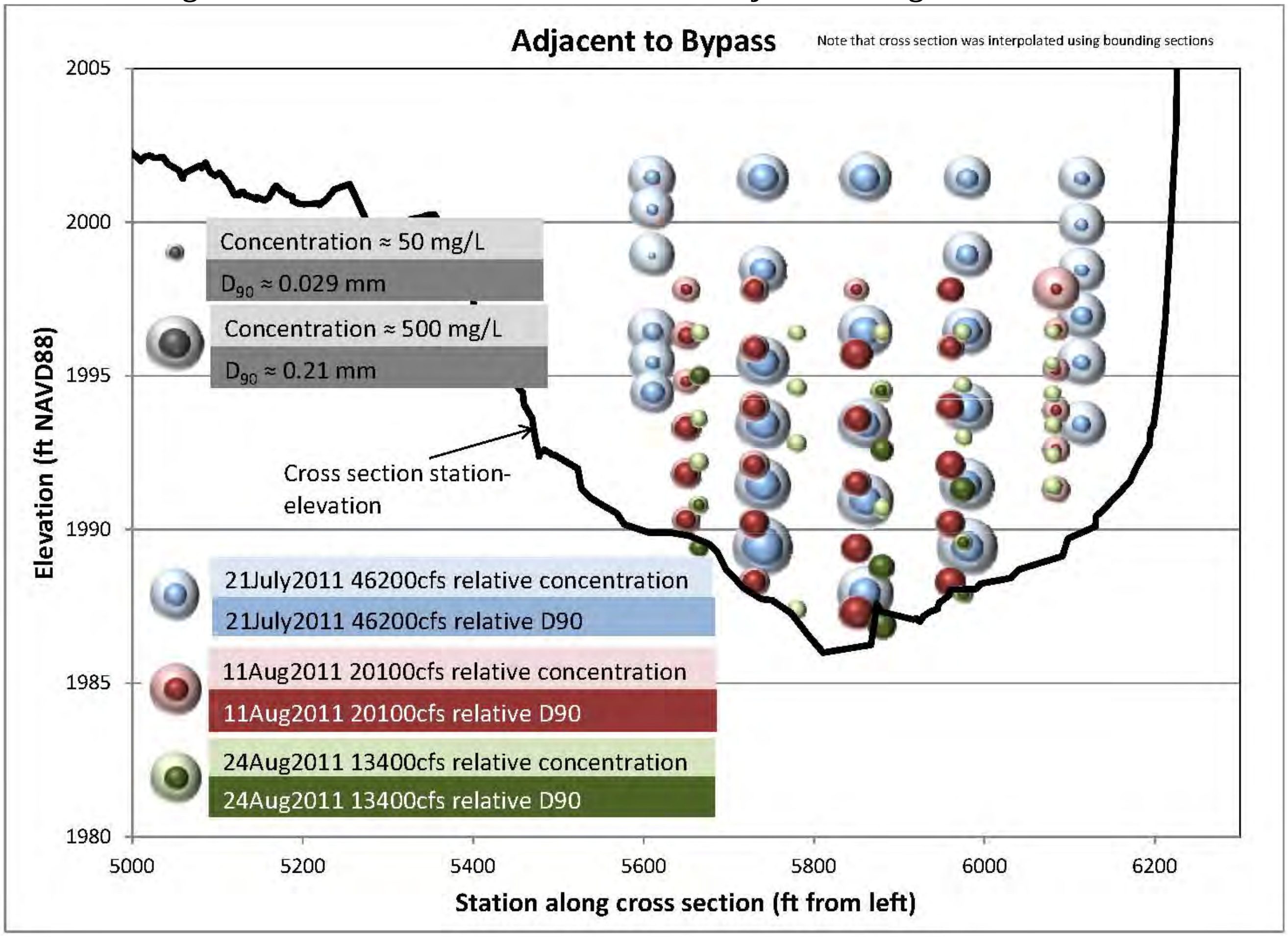


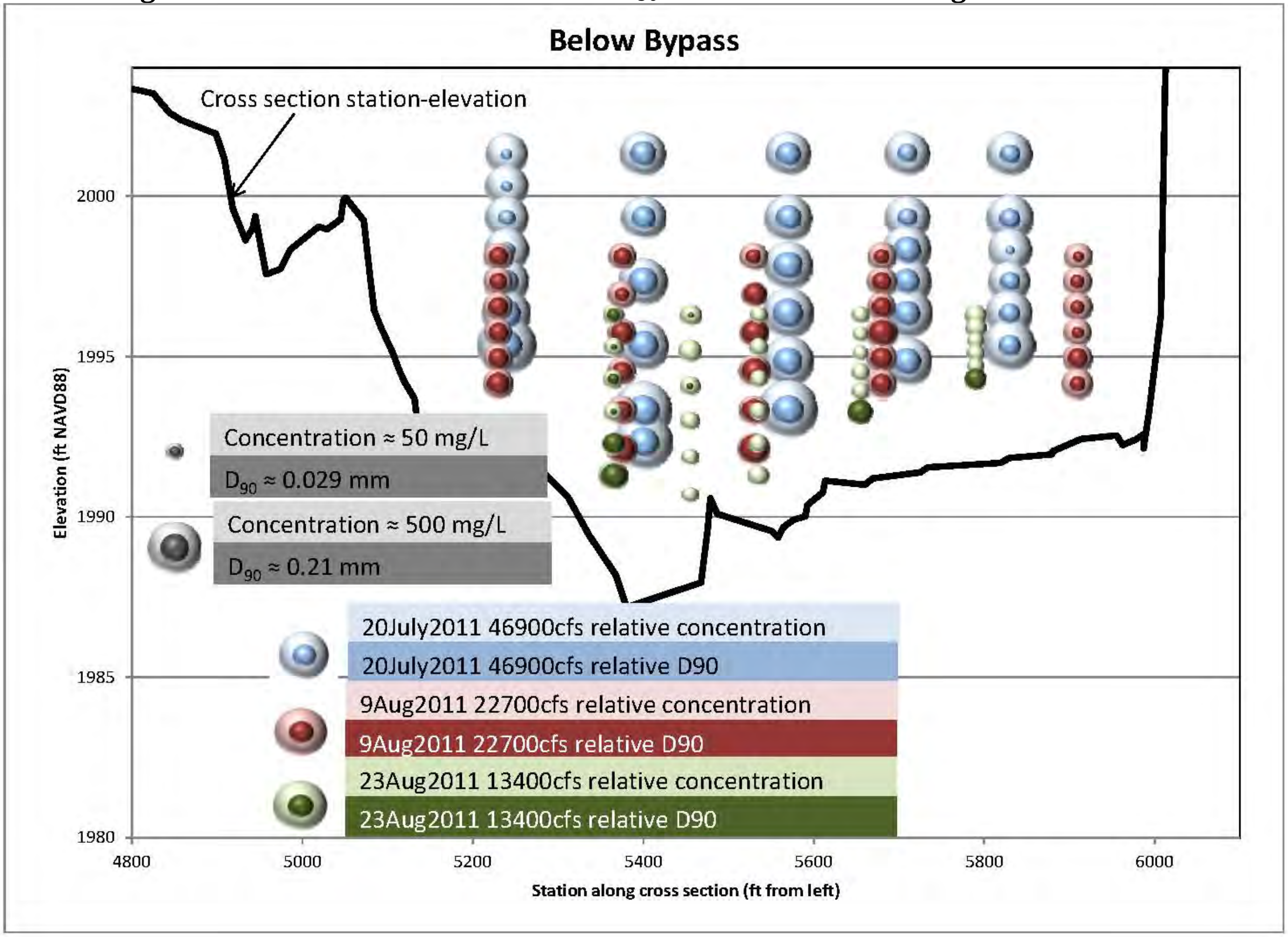
**Figure 5 Relative Concentration and $D_{90}$ Adjacent to High Flow Channel**






Return to TOC

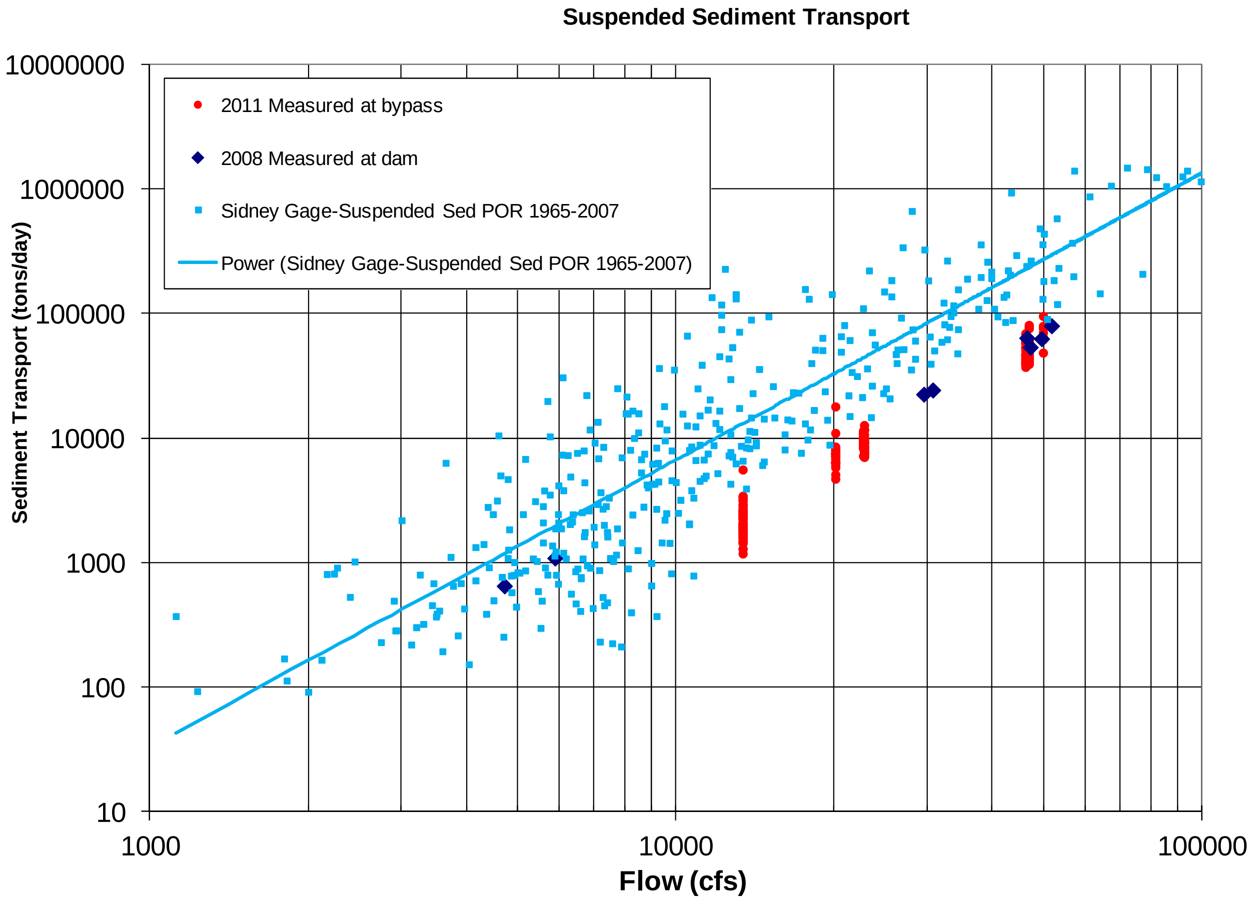
**Figure 6 Relative Concentration and $D_{90}$ Downstream from High Flow Channel**






Return to TOC

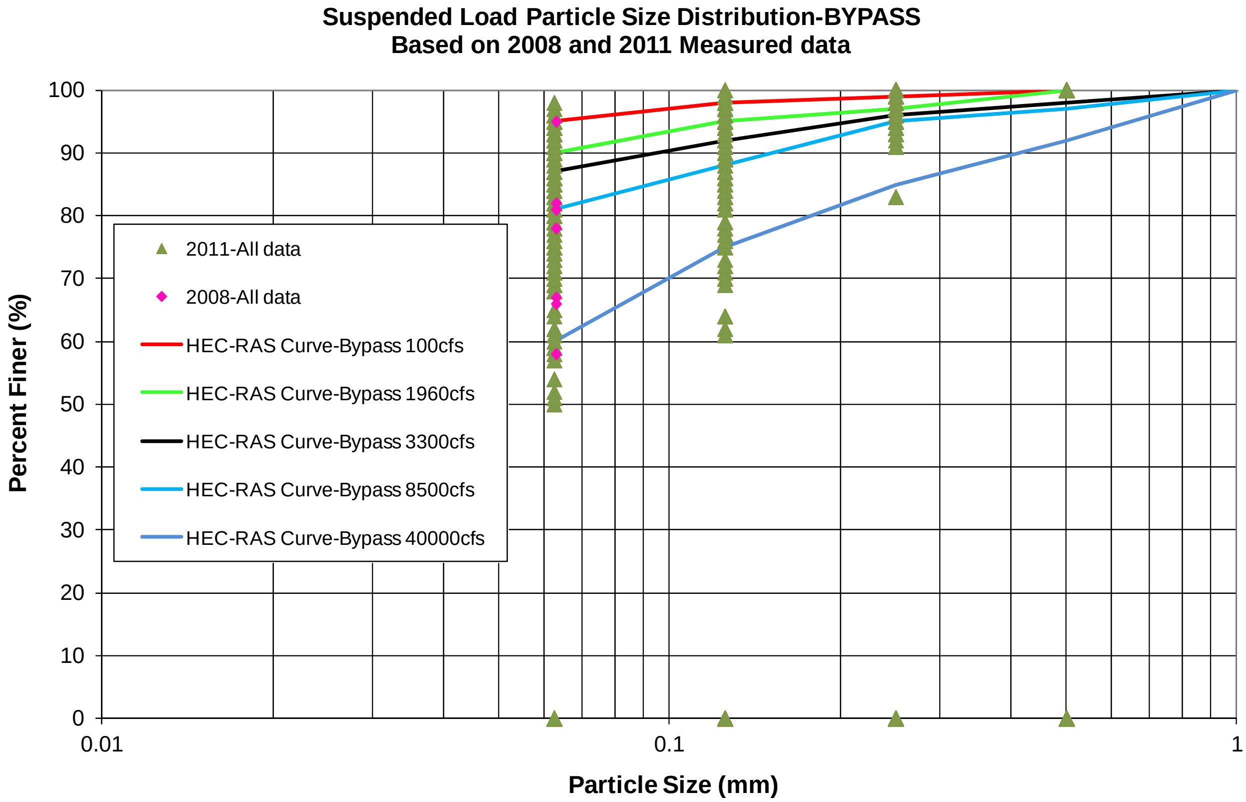
## Figure 7 Suspended Sediment Transport






Return to TOC

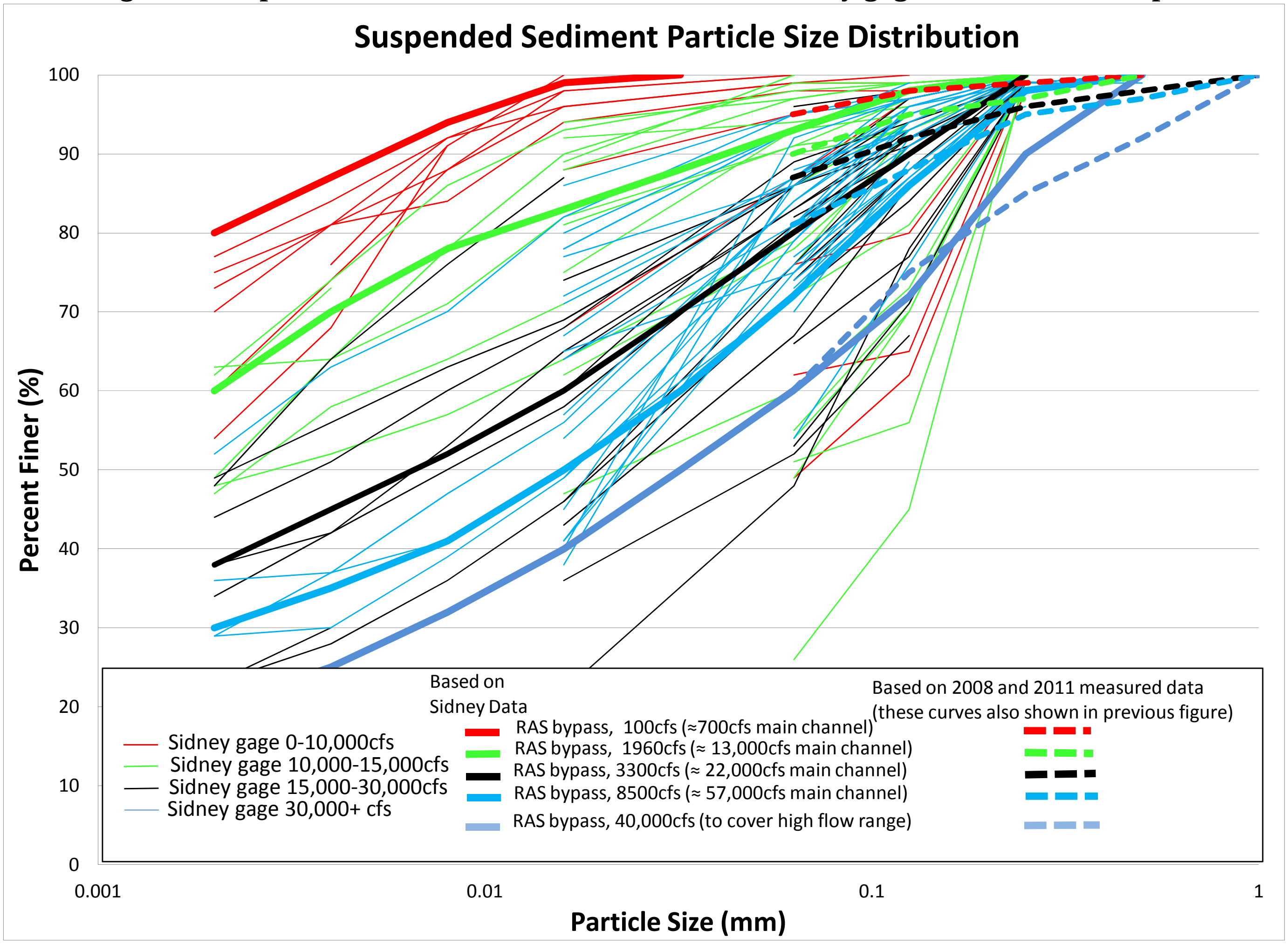
## Figure 8 Suspended Load Particle Size Distribution, Measured Data






Return to TOC

**Figure 9 Suspended Load Particle Size Distribution, Sidney gage, for HEC-RAS Input**




In addition to the point samples, the USGS gathered bedload data during each of the sampling runs. Total bedload as reported by the USGS is given in Table 4. Measured bedload gradation from 2008, 2011, and the Sidney gage are compared in Figure 10.

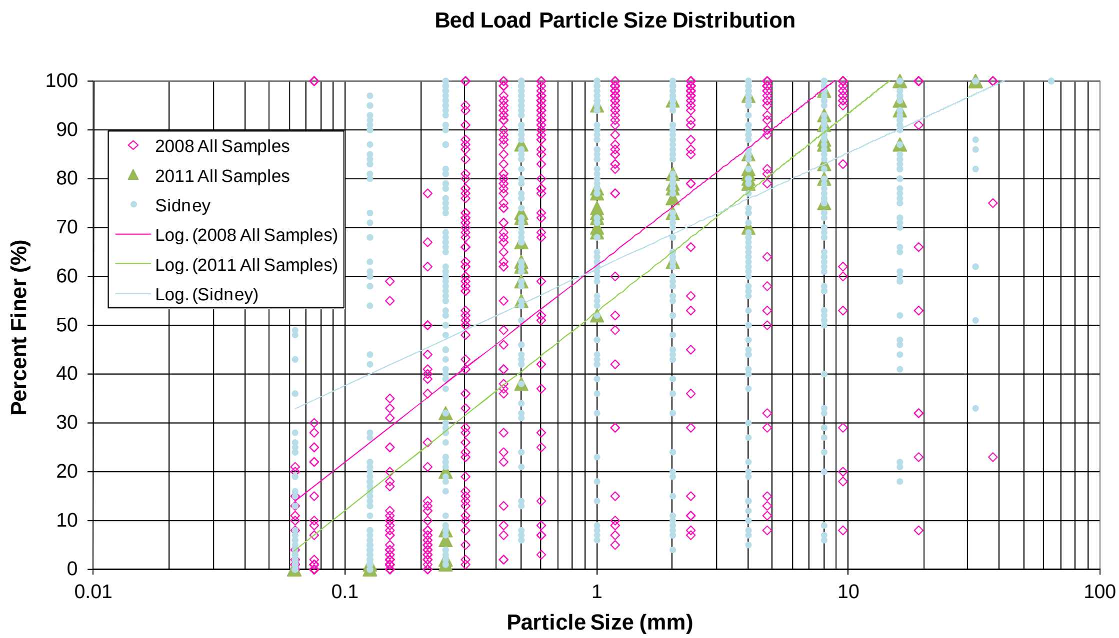


Return to TOC

## Table 4 Bedload Transport

| Location | DATE | Discharge (cfs) | Bedload (tons/day) |
|---|---|---|---|
| Above upstream end of high flow channel | 7/19/2011 | 49900 | 254 |
| | 8/10/2011 | 22800 | 36 |
| | 8/24/2011 | 13400 | 5 |
| Adjacent to upstream end of high flow channel | 7/21/2011 | 46200 | 255 |
| | 8/11/2011 | 20100 | 53 |
| | 8/24/2011 | 13400 | 20 |
| Below upstream end of high flow channel | 7/20/2011 | 46900 | 301 |
| | 8/9/2011 | 22700 | 96 |
| | 8/23/2011 | 13400 | 55 |
| | | | |
| Just upstream from dam | 6/18/2008 | 29600 | 829 |
| | 6/25/2008 | 51800 | 836 |
| | 7/9/2008 | 47200 | 738 |
| | 8/27/2008 | 5890 | 3 |
| Just downstream from dam | 6/17/2008 | 30800 | 571 |
| | 6/24/2008 | 49600 | 0 |
| | 7/8/2008 | 46500 | 1524 |
| | 8/26/2008 | 4720 | 36 |
| Irrigation canal just below headworks | 6/19/2008 | 1130 | 1 |
| | 6/26/2008 | 1310 | 0 |
| | 7/10/2008 | 1350 | 1 |
| | 8/28/2008 | 1050 | 0 |

## Figure 10 Bed Load Particle Size Distribution






Return to TOC

Test pits and borings were also gathered from the island area in the vicinity of the proposed alignments in order to provide increased knowledge about the potential bed material to be encountered upon excavation.

Figure 11 shows test pit (TP) locations.

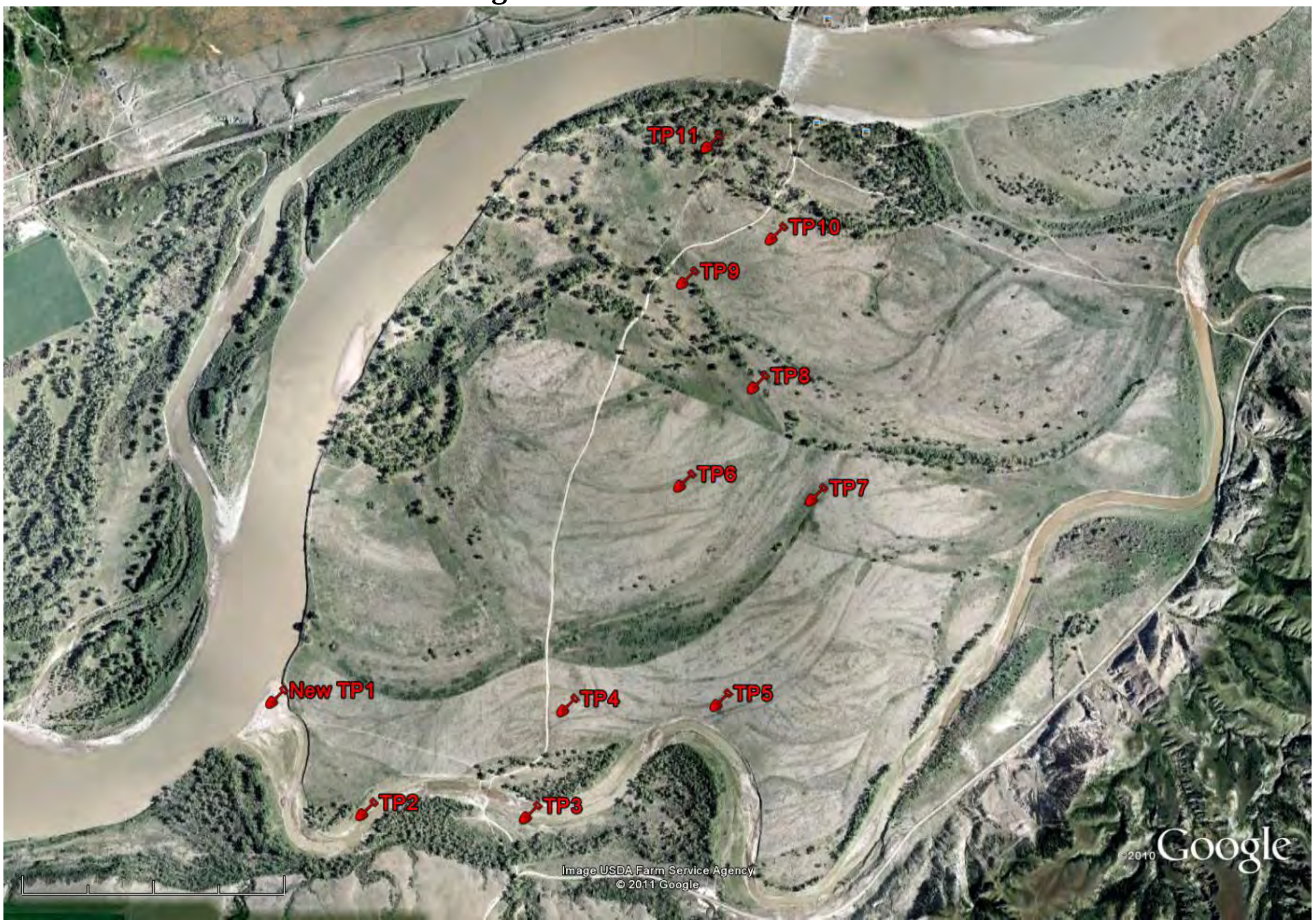
A narrative describing the test pit digging follows (per email from hole logger, John Hartley):

> Lithology
>
> An upper zone 3-8+ ft thick comprising silt to silt with very fine sand to very fine sand. This layer was not present in TP-1. Occasionally stringers or thin beds of coarser sands would be observed in the side wall but 1.5cy bucket sampling just doesn't capture nuance. Also some clay both in the matrix and accessional as blobs in the bucket..lens or thin layer? Walls stand up until undermined at which time they fall down fairly rapidly. Essentially no cohesion. Overbank flood deposits
>
> Underlying the silty layer was a unit of very rounded river gravel and cobbles (1-5 inches diameter with 2-3 inches being predominant). Usually the matrix was silt to very fine sand, usually mostly silt. Bimodal distribution of the very coarse and very fine. Other zones had a well graded matrix with silt to very coarse sand and the gravels. Gravel was anywhere from about 40% est of the unit to > probably 80%. All could be generalized as channel gravel with a fine grained non-cohesive matrix. It may take drag lines to effectively excavate I'm afraid.
>
> Tim was 100% correct in predicting that test pits would rapidly turn into sink holes once they got past the water table. TP 5 for some strange reason was dry and we got close to 25 ft out of it. In the units with higher percentages of gravel the material was usually saturated and basically flowed when dumped from the bucket resulting in pure gravel and useless samples. Got some pictures. In most places the water poured in, in a few...I believe tp7 it came in slower but it still came. In TP1 head was sufficient to cause boils during excavation and the backfilled excavation was quick. We added trees to the surface because until that settles a person walking into would not get out without help. When the water poured in the matrix washed out, the gravel collapsed, and the sink hole gr. Usually after 2-3 ft below the water table additional excavation was just an exercise in keeping up with caving so most holes terminated around 12-15 ft
>
> The entrance to the channel adjacent to the Yellowstone is armored with imbricate cobbles in the 3-5 inch range with smaller clasts infilling the voids. The same material was found throughout the TP-1 section but with matrix material included. Probably a case of the river bedload during flood being the very coarse material (the reason why we didn't get anything in the sediment sampling bedload samples, they didn't fit??) with the finer material being contributed over the years during lower flow or lesser flood stages.
>
> Bottom line. Lower coarse grained highly permeable saturated channel deposits overlain by overbank and flood deposits. Need to check the elevations once the "logs" get plotted to see how thinks line out but gut check says the top of the gravel layer was around the same place over the whole island suggesting the Yellowstone is happy with it's channel bottom elevation there. On the downside all measurements were pure eyeball due to excavation safety. On the upside the operator and I usually saw things the same or within a foot so we should be somewhat close.



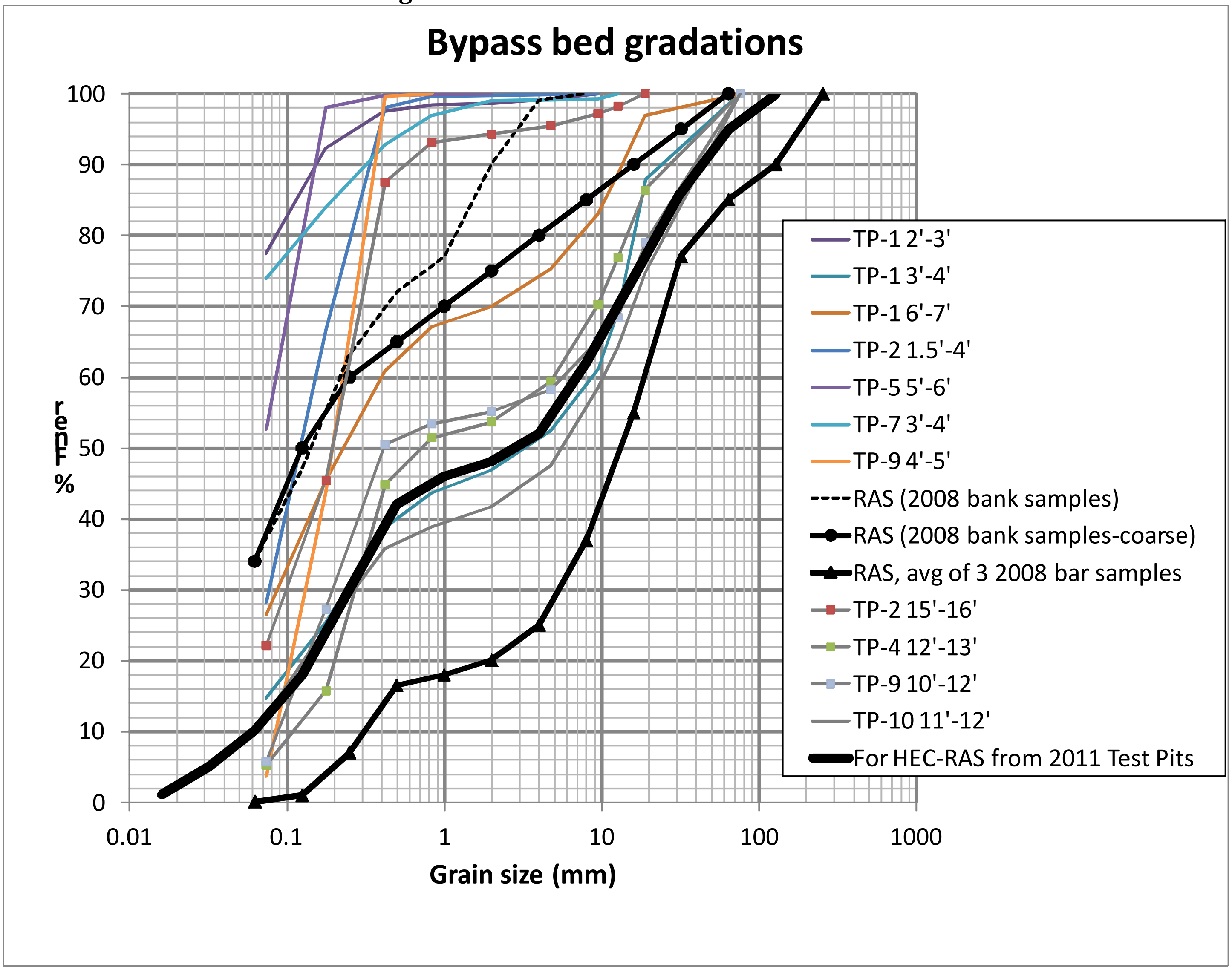
Return to TOC

**Figure 11  Test Pit Locations**




Test pit particle size distributions are plotted in Figure 12 along with bar and bank particle size distributions from samples gathered in 2008. Details pertaining to the 2008 sampling effort are included in Reference 7.

**Figure 12 Bed Particle Size Distributions**




## 5. SEDIMENT MODELING OF SELECTED BYPASS CHANNEL

### 5.1 Quasi-Unsteady Flow

A 20-year simulation was used to evaluate long term trends in the bypass channel. Daily flow data from the USGS Sidney gage were downloaded, covering the time period from 27Sep1991 to 27Sep2011. The flow data from the Sidney gage was then reduced according to the flow splits given in Table 3. These reduced flows were then entered into the quasi-unsteady flow file using a flow duration of 24 hours.



Return to TOC

The downstream boundary condition was set to a rating curve based on a separate split flow HEC-RAS model that contains the Yellowstone River and bypass channel.

### 5.2 Bed Gradation

Because the future bed material of the proposed bypass channel is largely unknown, a range of bed material gradations was analyzed.
Several sources of data were employed to determine the expected range of bed material gradations including bed and bank samples collected in 2008 and test pit data collected in 2011. Section 4 and Figure 12 give details on sample data. Figure 12 shows average values from the 2008 bank and bar data as well as a user-generated curve with the lower end loosely based on the bank samples (labeled “RAS (2008 bank samples-coarse)”.

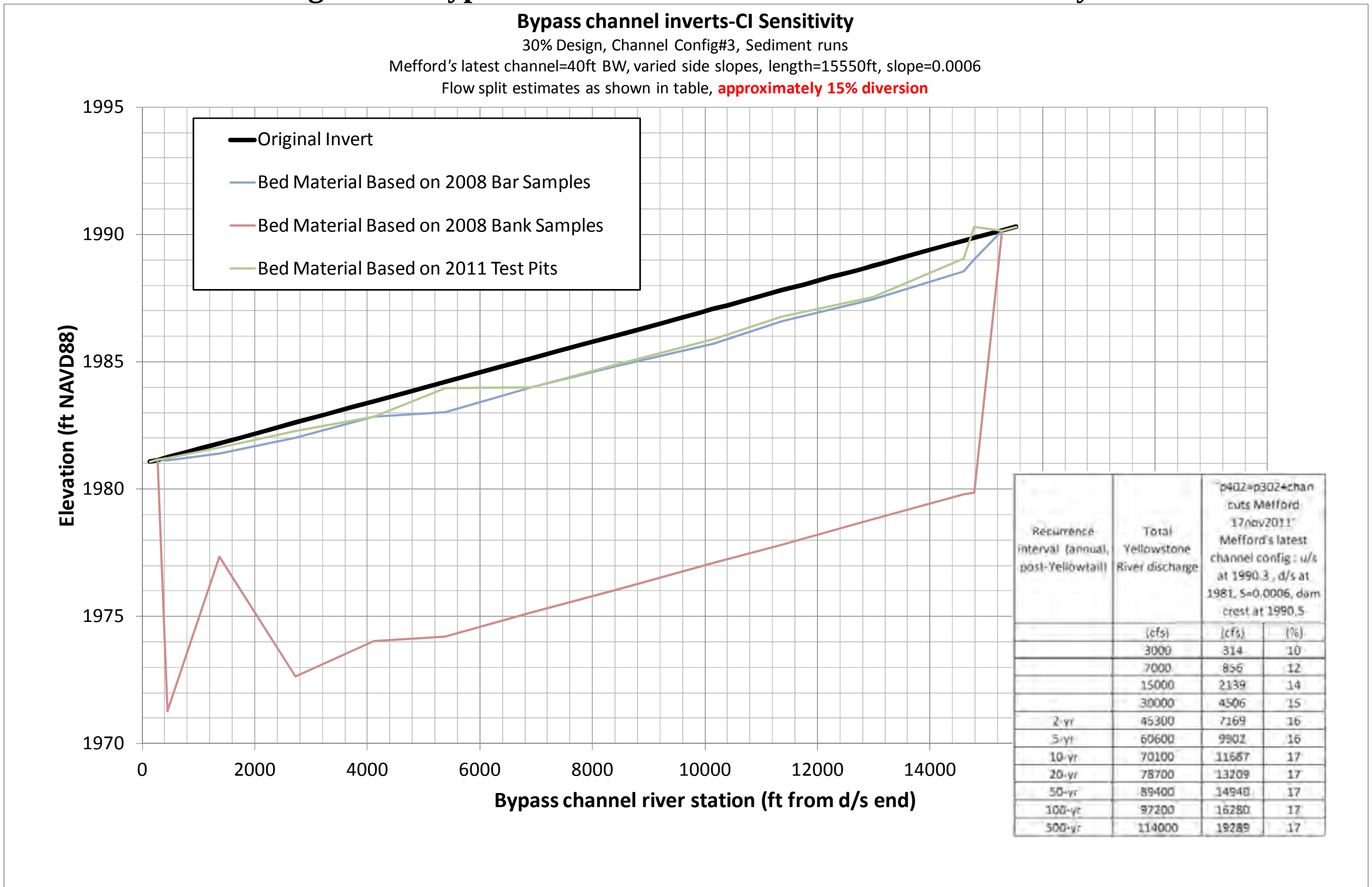
The selected bed material gradation is based on the 2011 test pit data since the samples were collected in the vicinity (both horizontal and vertical) of the proposed bypass channel bed. The selected curve is labeled “For HEC-RAS from 2011 Test Pits” in Figure 12.

Figure 14 summarizes a sensitivity analysis on bed material gradation by showing bypass channel invert profiles at the end of the 20 year simulation. Note that the maximum depth of degradation is set to 10 ft for all cross sections. The sensitivity indicates low sensitivity at coarser gradations (between the test pits and bar samples) but high sensitivity if the specified bed material is finer than the test pit data. The threshold where the bed turns significantly degradational is highly uncertain.



Return to TOC

**Figure 13 Bypass Channel Inverts-Bed Material Sensitivity**




| Recurrence interval (annual, post-Yellowtail) | Total Yellowstone River discharge | "p402=p302+chan cuts Mefford 17nov2011" Mefford's latest channel config : u/s at 1990.3 , d/s at 1981, S=0.0006, dam crest at 1990.5 | |
|---|---|---|---|
| | (cfs) | (cfs) | (%) |
| | 3000 | 314 | 10 |
| | 7000 | 856 | 12 |
| | 15000 | 2139 | 14 |
| | 30000 | 4506 | 15 |
| 2-yr | 45300 | 7169 | 16 |
| 5-yr | 60600 | 9902 | 16 |
| 10-yr | 70100 | 11687 | 17 |
| 20-yr | 78700 | 13209 | 17 |
| 50-yr | 89400 | 14940 | 17 |
| 100-yr | 97200 | 16280 | 17 |
| 500-yr | 114000 | 19289 | 17 |

## 5.3 Incoming Sediment

Available suspended sediment data is discussed in Section 4 and Reference 6. The selected incoming sediment is based on engineering judgment considering both the 2011 sample data and the Sidney USGS gage data and is shown in Figure 9.

### 5.3.1 Total Load

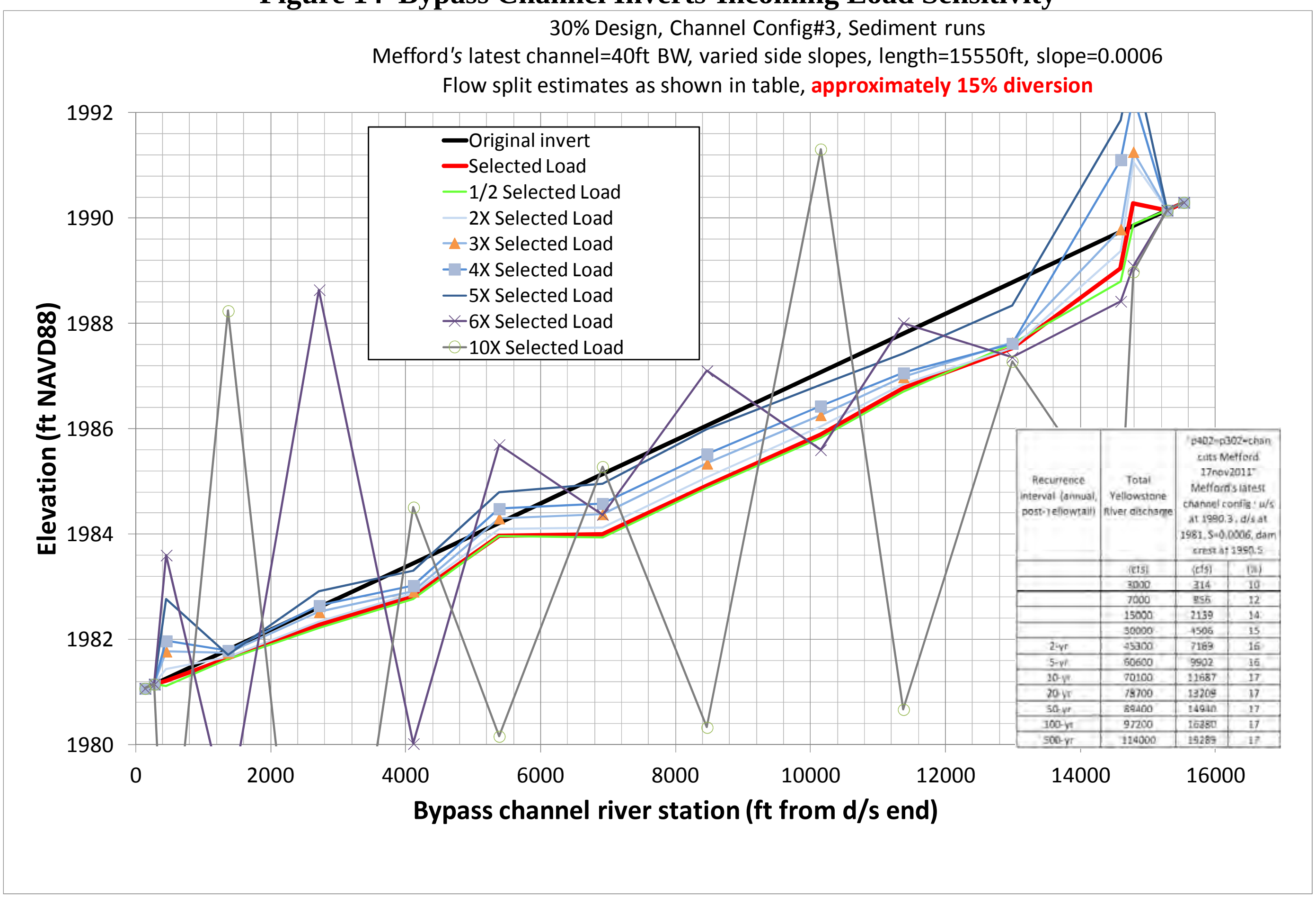
Total load for a range of bypass discharges was computed based on estimated concentration of sediment entering the bypass (see Table 5).

**Table 5 Total Load**

| Discharge (bypass) | Conc | Total load |
|---|---|---|
| (cfs) | (mg/l) | (tons/day) |
| 100 | 320 | 86 |
| 1960 | 65 | 344 |
| 3300 | 150 | 1337 |
| 8500 | 320 | 7344 |
| 40000 | 320 | 34560 |

Because of the high level of uncertainty associated with the incoming total sediment load, a sensitivity analysis was conducted. Figure 15 summarizes the sensitivity analysis by showing bypass channel inverts at the end of the 20 year simulation. Model instability occurs when the selected load is increased by a factor of approximately 6.

**Figure 14 Bypass Channel Inverts-Incoming Load Sensitivity**






Return to TOC

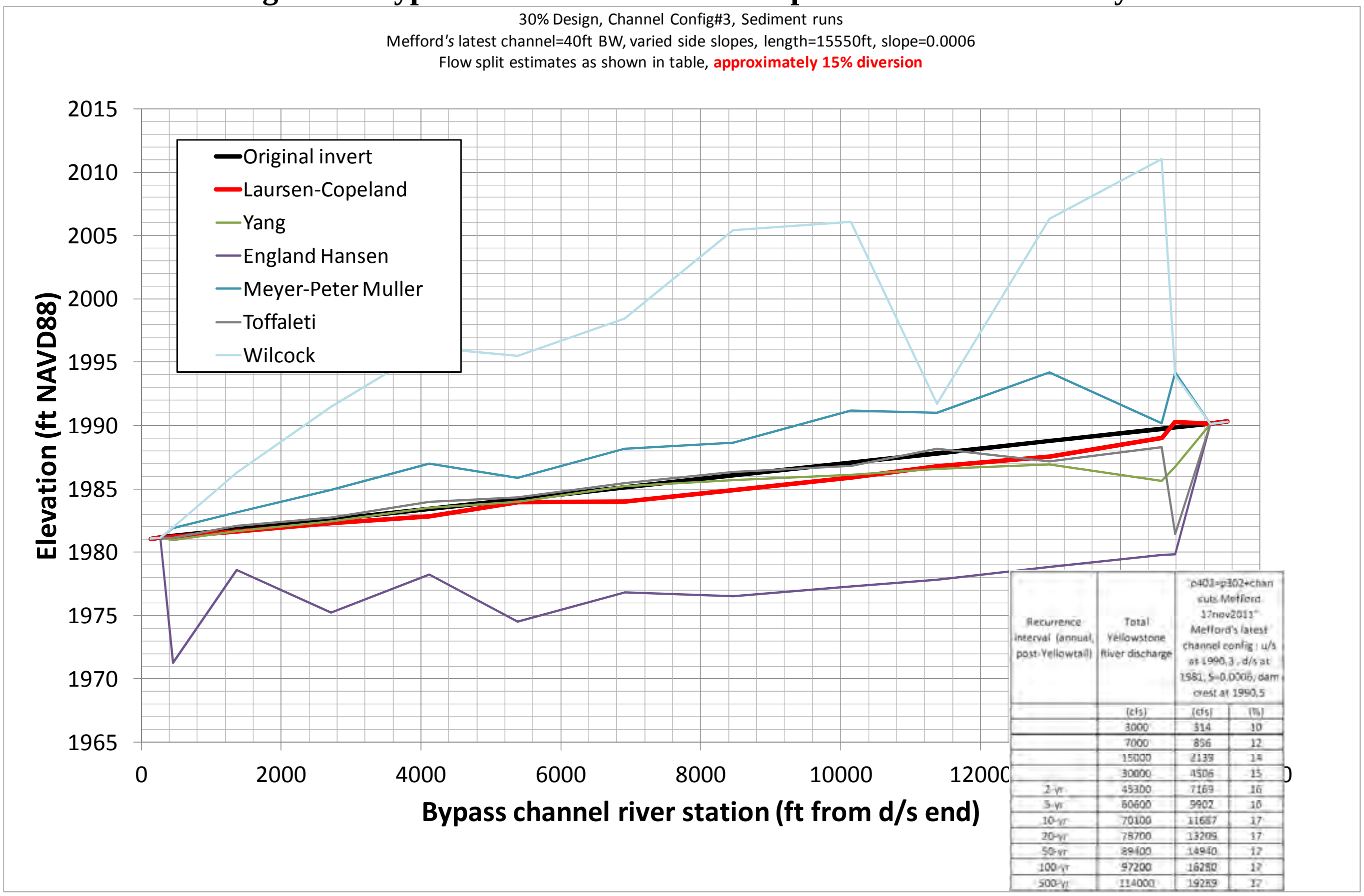
### 5.3.2 Particle Size Distribution

The incoming sediment particle size distribution is based on the 2011 sample data and Sidney gage data as shown in Figure 9.

## 5.4 Transport Function

The Laursen-Copeland transport function was selected because of its applicability to sediments in the silt range. Both the 2011 measured data and the Sidney data show over 60-90% of the material in suspension is finer than sand. Yang and Toffaleti also give reasonable results. Meter-Peter Muller computes fairly significant aggradation, which is expected due to its tendency to underpredict the transport potential of finer materials. Figure 16 shows results of the sensitivity analysis conducted on the selected transport function.

**Figure 15 Bypass Channel Inverts-Transport Function Sensitivity**




| Recurrence interval (annual, post-Yellowtail) | Total Yellowstone River discharge | "p401=p302+chan cuts Mefford 17nov2011" Mefford's latest channel config: u/s at 1990.3, d/s at 1981, S=0.0006, dam crest at 1990.5 | |
|---|---|---|---|
| | (cfs) | (cfs) | (%) |
| | 3000 | 314 | 10 |
| | 7000 | 856 | 12 |
| | 15000 | 2139 | 14 |
| | 30000 | 4506 | 15 |
| 2-yr | 45300 | 7169 | 16 |
| 5-yr | 60600 | 9902 | 16 |
| 10-yr | 70100 | 11667 | 17 |
| 20-yr | 78700 | 13209 | 17 |
| 50-yr | 89400 | 14940 | 17 |
| 100-yr | 97200 | 16250 | 17 |
| 500-yr | 114000 | 19289 | 17 |



Return to TOC

## 6. CONCLUSIONS AND RECOMMENDATIONS

The HEC-RAS sediment routine was used to evaluate the bypass channel. Because of the nature of the proposed channel, calibration is not possible. Therefore, the results of the model are highly uncertain and should not be construed as providing quantitative estimates of aggradation/degradation.

Simulations conducted using the best estimates of all parameters and most applicable transport function indicate a slightly degradational trend. However, as shown in section 5, varying the transport functions or estimated parameters can result in a range of anywhere from 10+ ft of degradation to 10+ ft of aggradation over the 20-year period of simulation.

It is recommended that for the currently proposed channel configuration, a channel armor layer be constructed to prevent excessive vertical movement of the channel. The channel armor layer should be constructed of material with a $D_{50}$ in the range of 37 to 45 mm (1.4” to 1.8”) based on an analysis conducted to determine the armor layer characteristics (see Reference 8).

# REFERENCES

1. **U.S. Army Corps of Engineers.** EM 1110-2-1601 “Hydraulic Design of Flood Control Channels.” 1994.

2. **U.S. Army Corps of Engineers.** EM 1110-2-1602 “Hydraulic Design of Reservoir Outlet Works.” 1980.

3. **U.S. Army Corps of Engineers.** EM 1110-2-1603 “Hydraulic Design of Spillways.” 1990.

4. Chow, Ven T. “Open Channel Hydraulics.” McGraw-Hill Inc. 1959.

5. **U.S. Army Corps of Engineer, Omaha District.** “Bypass Channel Concept Evaluation.” April2011

6. **U.S. Army Corps of Engineers, Omaha District.** “Lower Yellowstone Project Fish Passage and Screening, Preliminary Design Report, Appendix A-2, Hydraulics.” October 2009.

7. **U.S. Army Corps of Engineers, Omaha District.** “Trip Report 26-28August2008.”

8. **U.S. Army Corps of Engineers, Omaha District.** “Intake Dam Fish Bypass Channel Stable Channel Material Analysis.” March 2012.

Return to TOC

Attachment 6 Bypass Channel

# Appendix C

30% Design Features

19March2012
Updated 6JULY2012

NOTE:
FOR CONSISTENCY, FIGURES AND DESCRIPTIONS WILL BE UPDATED UPON COMPLETION OF PLANS AND SPECS.

Return to TOC

US Army Corps of Engineers
Omaha District

| Project: | Lower Yellowstone Irrigation Project-Intake | | | | | Sheet No. | 1/9 |
|---|---|---|---|---|---|---|---|
| Subject: | Bypass Channel 30% Design Features | | | | | | |
| Computed by: | CJM | Date: | 6JULY2012 | Checked by: | | Date: | |

**EXECUTIVE SUMMARY**

A bypass channel for fish passage is being evaluated and compared to the previously analyzed rock ramp. This document summarizes the current configuration of the bypass channel.

The design effort for the proposed bypass channel is scheduled to be at approximately 30% by May 2012. Therefore, the data contained herein is between concept level and 30%, and should not be construed as a final design. Features are subject to change and input from the BRT is critical to understanding areas of concern as well as locations where adaptive management techniques are most likely to be successfully applied in the future.

The channel and associated features were designed using criteria developed by the BRT. The focus of the design effort was percentage of flow diverted and depths/velocities in the bypass channel. Considerable time was spent evaluating the appropriate percentage of flow to be diverted through the bypass channel. Sediment and flow data were collected around the upstream end of the bypass, hydraulic and sediment models were created, and empirical equations were consulted to determine the response not only to the bypass, but to the main channel of the Yellowstone River. A range of diversion flow between 10% and 35% was considered.

Sediment modeling indicates that diversion of greater than approximately 15% of the total flow leads to depositional tendencies in the main channel of the Yellowstone River. This is undesirable due to the impact to irrigation diversion in addition to maintenance issues in the vicinity of the fish screens on the newly constructed headworks.

Past BRT discussions indicated that the chances of pallid sturgeon using the bypass increase with percentage of flow diverted. To address attractive flow at the mouth of the bypass channel, the alternative being evaluated is a flow augmentation structure (FAS). The FAS would consist of a weir (essentially an extension of the proposed dam crest) that would discharge into the bypass channel near the downstream end (see Plates 1 and 15-16). The FAS would increase flows in the bypass channel entrance (downstream end) by around 4-6% in the May-June timeframe. While an FAS configuration is presented herein, final design would include physical modeling and additional numerical modeling to attain the most desirable flow patterns in and around the bypass channel entrance.

A number of channel configurations were modeled by Reclamation and USACE evaluating varying side slopes, channel widths, and channel slopes. The selected alternative meets design objectives (with respect to depth and velocity) with the exception of depth at the exit (upstream end) for a river flow of 10,000 ft$^3$/s. This was considered acceptable as the exit depth is similar to downstream river thalweg depths and exceeds the target depth prior to river flows reaching 20,000 ft$^3$/s. Reclamation's "Lower

Yellowstone Intake Diversion Dam, Fish Bypass Channel Entrance and Exit Pre-appraisal Study, Progress Report," dated January 2012, contains additional details and is attached.

The following proposed features are described in this document and are shown in Plate 1. Note: Several rock spanning structures are proposed. These structures are at grade and do not protrude into the flowline. The rock structures consist of larger material for stability that will be backfilled with natural river size rock during construction. The intent would be to provide a more natural substrate for fish passage with the underlying large rock to provide stability when needed.

1. **Bypass channel excavation-**A bypass channel would be excavated from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. The proposed alignment is approximately 15,500 ft long at a slope of 0.0006ft/ft (natural Yellowstone River slope in the project area is approximately .0004ft/ft to .0007ft/ft) and excavation is currently estimated at approximately 1.2 million cubic yards. The channel cross section has a 40ft bottom width and side slopes varying from 1V:12H to 1V:3H. The bypass channel would divert approximately 15% of total Yellowstone River flows.
2. **Upstream control structure**-A structure designed to control discharge into the bypass channel would be situated on the upstream end of the channel. The structure will be composed of either all riprap or riprap with a concrete sill. With either construction material, the control structure would be backfilled with natural river size rock to give the appearance of a seamless channel invert. The purpose of the structure is to provide stability during extreme events to prevent excessive flow through the bypass.
3. **Channel plug**-A channel "plug" would be constructed approximately 1 mile downstream from the upstream end of the bypass in the existing high flow chute to keep normal flows in the proposed bypass. The channel plug would be an earthen embankment with rock riprap armor. The channel plug would have a low-level discharge pipe and would be designed for overtopping during larger events to maintain the existing chute's current functionality.
4. **Riprap at bends for lateral stability**-Bank riprap is proposed at two outside bends to minimize the risk of losing the bypass channel planform.
5. **Vertical control structures**-Two vertical control structures (riprap sills) are proposed for maintaining channel slope and allowing for early identification of channel movement. Similar to the upstream control structure, these would be overexcavated and backfilled with natural river size rock to give the appearance of a seamless channel invert while providing stability during extreme events.
6. **Downstream vertical control structure**-A riprap sill is proposed at the downstream end of the channel to maintain channel elevations (similar to vertical control structures).

7. **Downstream lateral stability structure**-A riprap bank stabilization feature would be constructed on the descending right bank of the bypass channel to prevent downstream migration (relative to the Yellowstone River) of the downstream end of the bypass channel.
8. **New dam**-In order to maintain irrigation diversion capabilities without impacting the bypass channel, a new dam is proposed. The new dam would preclude the necessity of adding large rock to the crest of the existing dam to maintain diversion capabilities (as is currently done). The proposed dam configuration is a concrete crest placed underwater in sheet pile "cells" with approximate dimensions of 24 ft (in the direction of flow) by 40 ft. See Attachment 7 for additional details on the proposed crest.
9. **Flow augmentation structure-POTENTIAL ADAPTIVE MANAGEMENT FEATURE-**A weir constructed using roller compacted concrete would be constructed near the tie-in between the downstream end of the bypass channel and Yellowstone River. The weir would increase attractive flow in the bypass channel when Yellowstone River discharges are above approximately 7,000cfs. The flow augmentation structure would only be constructed as a response to lack of passage and is not included in the proposed bypass channel configuration.
10. **Armor Layer**-Evaluation is currently underway to determine the necessity of artificially constructing an armor layer. The proposed armor layer would be similar to naturally formed armor layers found in the Yellowstone River on bars. The intent would be to minimize bypass channel degradation while providing substrate similar to reaches upstream and downstream from the project.

US Army Corps of Engineers
Omaha District

| Project: | Lower Yellowstone Irrigation Project-Intake | | | | | Sheet No. | 4/9 |
|---|---|---|---|---|---|---|---|
| Subject: | Bypass Channel 30% Design Features | | | | | | |
| Computed by: | CJM | Date: | 6JULY2012 | Checked by: | | Date: | |

**PURPOSE**
This document describes the features required for the proposed bypass channel at Reclamation's Lower Yellowstone Irrigation Project (Intake). The intent of this document is to provide enough detail to allow for a 30% level of design cost estimate. Geotechnical and structural personnel will use this information to provide quantities to cost estimating.

**FEATURES**
The following features are described in this document:

1. Bypass channel excavation
2. Upstream control structure (referred to as "exit" from fish perspective)
3. Channel plug
4. Riprap at bends for lateral stability
5. Vertical control structures
6. Downstream vertical control structure (referred to as "entrance" from fish perspective)
7. Downstream lateral stability structure
8. New dam
9. Flow augmentation structure
10. Armor Layer

Each of these features is shown on Plate 1 and described in the following sections. All elevations are referenced to NAVD88 vertical datum.

**1. BYPASS CHANNEL EXCAVATION**
The main element of the bypass alternative is channel excavation. As shown in Plate 1, the upstream 1/3 of the proposed channel uses the existing high flow chute. Approximately 5000ft from the upstream end, the proposed channel diverges from the existing chute and continues across Joe's Island for the remaining 10,000ft where it flows back into the river just below the existing dam and rock field.

The upstream invert elevation is 1990.3 ft NAVD88 and the downstream invert elevation is 1981.0 ft NAVD88 for a total drop of 9.3 ft over a length of 15,500 ft (slope=0.0006 ft/ft).

The proposed channel section has a 40ft bottom width with side slopes varying from 1V:12H to 1V:3H. The section shape was developed with input from the BRT and is shown in Plate 2. Plates 3-8 compare existing ground to the proposed channel cuts at select locations. The river station (RS) shown on Plates 3-8 can be correlated to location using the stationing shown in Plate 1.

## 2. UPSTREAM CONTROL STRUCTURE

The upstream control structure is located at approximate station 15+250 on the proposed alignment, just downstream of where the existing high flow channel inlets. The purpose of the upstream control structure is to maintain the designed rate of diversion into the proposed bypass. The structure is centered around a 60' wide concrete sill inverted at elevation 1990.3. The concrete sill will be 15' long in the direction of flow. Loose rock riprap will protect the sideslopes of the structure. In the downstream direction, the riprap will slope at 10H:1V for a distance of 35'. In the upstream direction, the riprap will slope at 3.5H:1V for a distance of 12.25' followed by a 25' long horizontal blanket. A width of 60' will be maintained throughout the structure. The structure will be backfilled to the proposed grade of the channel. The embankments of the structure will be sloped at a 5:1 rate and rock lined up to the projected 10 year water surface elevation. Plates 9-10 show the plan, profile, and cross section of the proposed control structure.

## 3. CHANNEL PLUG

The channel plug is located in the existing high flow chute just downstream from where the proposed channel diverges (see Plate 1). The purpose of the channel plug is to prevent water from leaving the proposed bypass channel during low to normal flows. The channel plug would be constructed as an earthen embankment with rock riprap armor.

The top elevation of the plug is 2000ft NAVD88, just above the 5-year water surface elevation of 1999.8 ft NAVD88 and nearly a foot below the 10-year water surface elevation of 2000.9 ft NAVD88. Plate 11 shows the plan, profile, and cross section of the proposed channel plug. Water surface elevations were taken adjacent to the channel plug structure in the proposed bypass channel.

The plug is designed as an overtopping section to allow flow into the existing high flow chute during higher Yellowstone River flows so that the existing chute retains its functionality. The high flow chute currently begins carrying water during a Yellowstone River discharge of approximately 25,000-30,000 cfs. With-project conditions would allow flow into the remaining existing high flow chute at a discharge of approximately 60,000cfs.

To accommodate overtopping flows, the crest is 15 ft wide and the downstream face of the plug is on a 1V:6H slope with riprap as described in the bullets below:

- $D_{100}$=30 inches
- $D_{50}$=20 inches
- Layer thickness=45 inches (=1.5*$D_{100}$)

The downstream toe should transition to a horizontal blanket approximately 50 ft long, then should extend on a 1V:3H slope into native ground two layer thicknesses or approximately 7.5 ft.

The upstream face is on a 1V:3H slope and should include riprap toed into existing ground two layer thicknesses (7.5ft).
See Plate 11 for plan, profile, and cross section views of the proposed channel plug.
A low level output pipe is proposed to allow small flows through the plug at a Yellowstone River flow of approximately 7000 cfs and above. The proposed low level outlet pipe would be 18” in diameter and would have an upstream invert elevation of approximately 1991 ft NAVD88, a length of approximately 130 ft, and a downstream invert elevation of 1990 ft NAVD88. A rock-lined preformed scour hole would dissipate energy on the downstream end of the pipe (see Plate 12).

## 4. RIPRAP AT BENDS FOR LATERAL STABILITY

Riprap is proposed at two outside bends to prevent significant lateral movement. The upstream bend riprap section is approximately 2000 ft long and the downstream section is approximately 1500ft long. Some lateral movement of the bypass channel is expected and may inadvertently enhance depth/velocity diversity in the bypass channel. The proposed riprap locations were selected due to the potential for significant adverse consequences of lateral channel movement. The upstream bend riprap location is in the vicinity of an existing swale created by an old channel scar. Loss of the bend in this area could result in bypass channel avulsion. The downstream bend riprap location is located where the bypass channel comes within 700 ft of the Yellowstone River. Significant lateral channel movement in this area would put the bypass channel and Yellowstone River at risk.

The riprap section would consist of rock with a $D_{100}$ of 16 inches and a layer thickness of 24 inches (based on Isbash using velocity of $1.25*V_{avg}=1.25*7=8.75$ft/s). The section would be placed on a 1V:3H slope, such that the bottom portion would be buried by the channel’s flatter slopes. The section would extend from the channel invert to approximately 15ft above the invert (approximate 10yr depth). The section includes a weighted toe along the invert. The area of the weighted toe is 1.5 times the area required to extend the 24 inch layer on a 1V:3H slope down two layer thicknesses (4 ft). (Note- the area was multiplied by 1.5 to account for self-launching of the weighted toe).

See Plate 13 for additional details on the riprap section.

Rough quantity computations indicate a volume of approximately 25,000 tons:

$$3500\text{ft} * 60\text{ft} * 2\text{ft} / 27\text{ft}^3/\text{yd}^3 * 1.55\text{ton/yd}^3 = 24{,}111\text{tons}$$

## 5. VERTICAL CONTROL STRUCTURES

Two buried riprap sections are proposed at approximately stations 4800 and 9400 with the intention of monitoring vertical movement within the channel.

The sections would be over excavated, then a bedding and riprap section would be constructed with a top elevation approximately 1-2 ft below the final invert. Material similar to that composing the rest of the excavated channel would be used to bring the section up to final grade.
Following high flow events or long durations of low flow, the indicator sections could be evaluated to determine channel performance and stability. Adaptive management measures could be taken if necessary.

Plate 14 shows a typical plan view and section for the indicator sections.

## 6. DOWNSTREAM VERTICAL CONTROL STRUCTURE

The downstream vertical control structure is configured similar to the vertical control structures described in section 5 and Plate 14. It is shown on Plate 15 in relation to the other downstream features (lateral stability structure and flow augmentation structure).

## 7. DOWNSTREAM LATERAL STABILITY STRUCTURE

The downstream lateral stability structure consists of a riprap revetment designed to allow for a smooth transition from the main channel of the Yellowstone River to the bypass channel. Additionally, the structure is intended to prevent the downstream end of the bypass channel from migrating eastward (downstream).

The upstream end of the structure conforms to the typical channel section side slopes (see Plate 2). Downstream from the vertical control structure, the side slopes transition to a 3H:1V slope (see Plate 15).

The riprap section should consist of 24 inch $D_{100}$ material with a layer thickness of 36 inches.

The upstream end of the structure is keyed into the bank using a riprap filled trench that is 20ft wide and 10ft deep extending 100ft into the bank at a 45 degree angle (see Plate 15). The trench size was determined using a post-launch section of 45ft by 3ft, factored by 1.5 to account for stone lost during launching.

## 8. NEW DAM

A new dam is proposed just upstream from the existing dam for the following reasons:

- Installation of fish screens increased required head for diversion
- Continued placement of rock on the existing dam crest is not desirable from a fish passage perspective or from a bypass channel maintenance perspective

The proposed dam configuration is a concrete crest placed underwater in sheet pile “cells” with approximate dimensions of 24 ft (in the direction of flow) by 40 ft. See Attachment 7 for additional details on the proposed crest.The new dam will be located approximately 50 ft upstream from the existing dam. The area between the old and new dams will be partially filled with riprap similar to the material that composes the existing rubble field.

## 9. FLOW AUGMENTATION STRUCTURE

The flow augmentation structure concept, developed by Reclamation, is intended as a potential adaptive management feature to increase attractive flow in the bypass channel. The structure would function as a weir once Yellowstone River discharges reached approximately 7000 cfs. The structure location is shown in Plate 15. This structure would ONLY be constructed as a response to lack of passage and is not included in the preferred alternative. It is include here to provide information on one potential AM feature.

The structure would consist of a roller compacted concrete weir crest followed by a 50ft horizontal riprap blanket. The riprap blanket terminates on the relatively flat side slopes of the proposed bypass channel. Details are shown in Plates 16-18. Table 1 shows the increase in bypass channel flow due to the flow augmentation structure (weir).

**Table 1 Bypass Channel and Weir Flows**

| River Flow | Bypass Flow | Weir Flow | Canal Flow | Bypass Flow as % of River Flow | Weir Flow as % of River Flow | Bypass and Weir Flow as % or River Flow |
|---|---|---|---|---|---|---|
| $ft^3/s$ | $ft^3/s$ | $ft^3/s$ | $ft^3/s$ | | | |
| 5000 | 560 | 0 | 1400 | 15.6% | 0.0% | 15.6% |
| 10000 | 1300 | 150 | 1400 | 15.1% | 1.7% | 16.9% |
| 20000 | 2880 | 840 | 1400 | 15.5% | 4.5% | 20.0% |
| 30000 | 4430 | 1610 | 1400 | 15.5% | 5.6% | 21.1% |
| 40000 | 6040 | 2400 | 1400 | 15.6% | 6.2% | 21.9% |
| 70000 | 11050 | 4760 | 1400 | 16.1% | 6.9% | 23.0% |

## 10. ARMOR LAYER

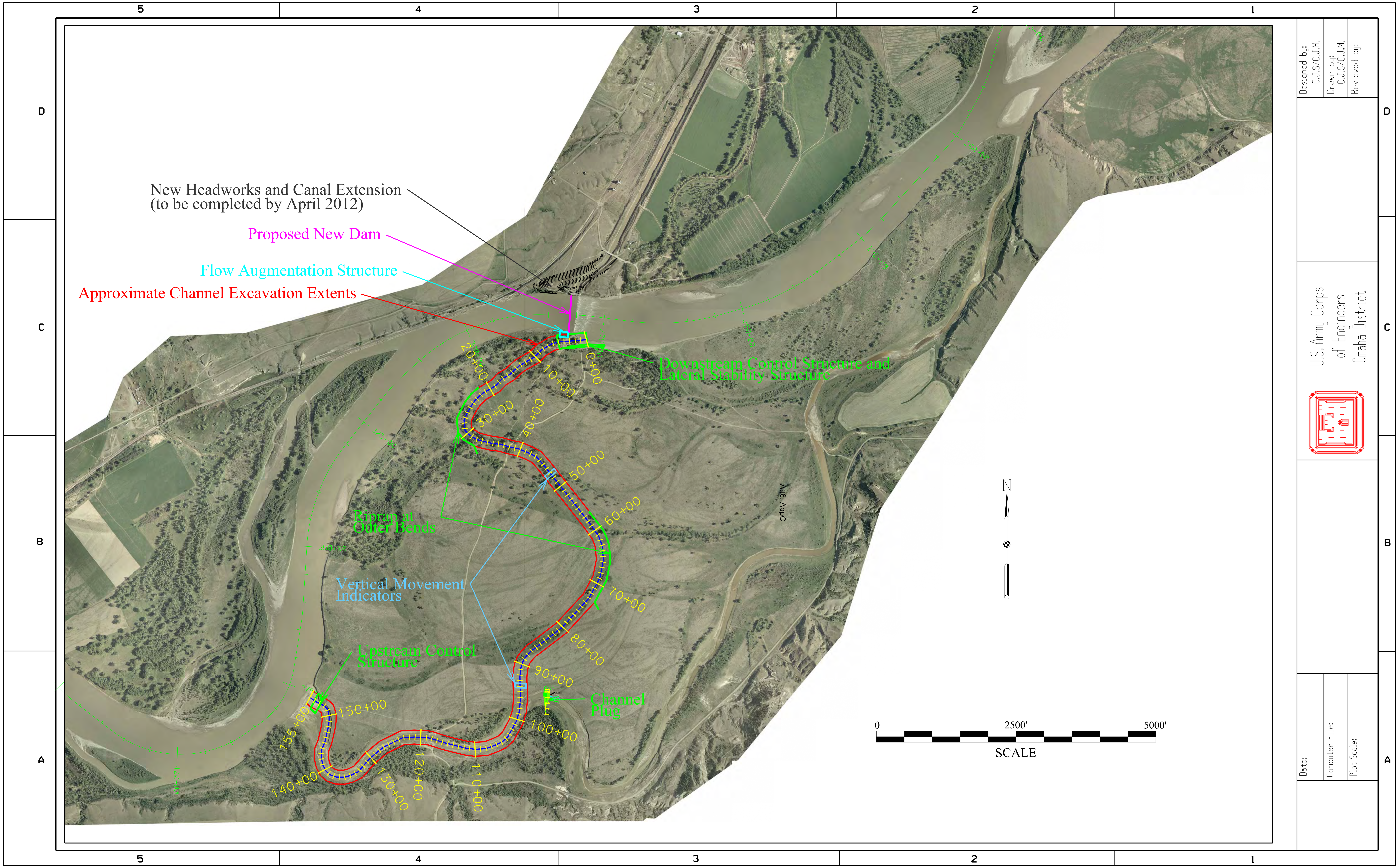
Evaluation is currently underway to determine the necessity of artificially constructing an armor layer. Preliminary sediment transport modeling of the proposed bypass channel indicates a slightly degradational tendency, highly dependent on the bed material inputs to the model. The proposed armor layer would be similar to naturally formed armor layers found in the Yellowstone River on bars and would represent what would be expected were the newly excavated channel be allowed to form the layer naturally.

The intent of the armor layer would be to prevent degradation of the channel leading to poor fish passage performance as well as diverting too much water into the bypass.

The alternative to constructing an artificial armor layer is to underexcavate the channel and allow the armor layer to develop over time. Risks associated with this method include the potential for too little or not enough degradation prior to attaining a stable armor layer.

The armor layer gradation would be similar to available measured data from 2008 Yellowstone River bar samples (see Photo 1) in the vicinity of Intake Dam ($D_{50}$≈16mm, $D_{90}$≈128mm). The armor layer would be continuous from upstream to downstream (i.e. the vertical control structures would be covered with the armor layer so as to minimize flow discontinuities).

**Photograph 1 Mid-channel bar downstream from Intake Dam**

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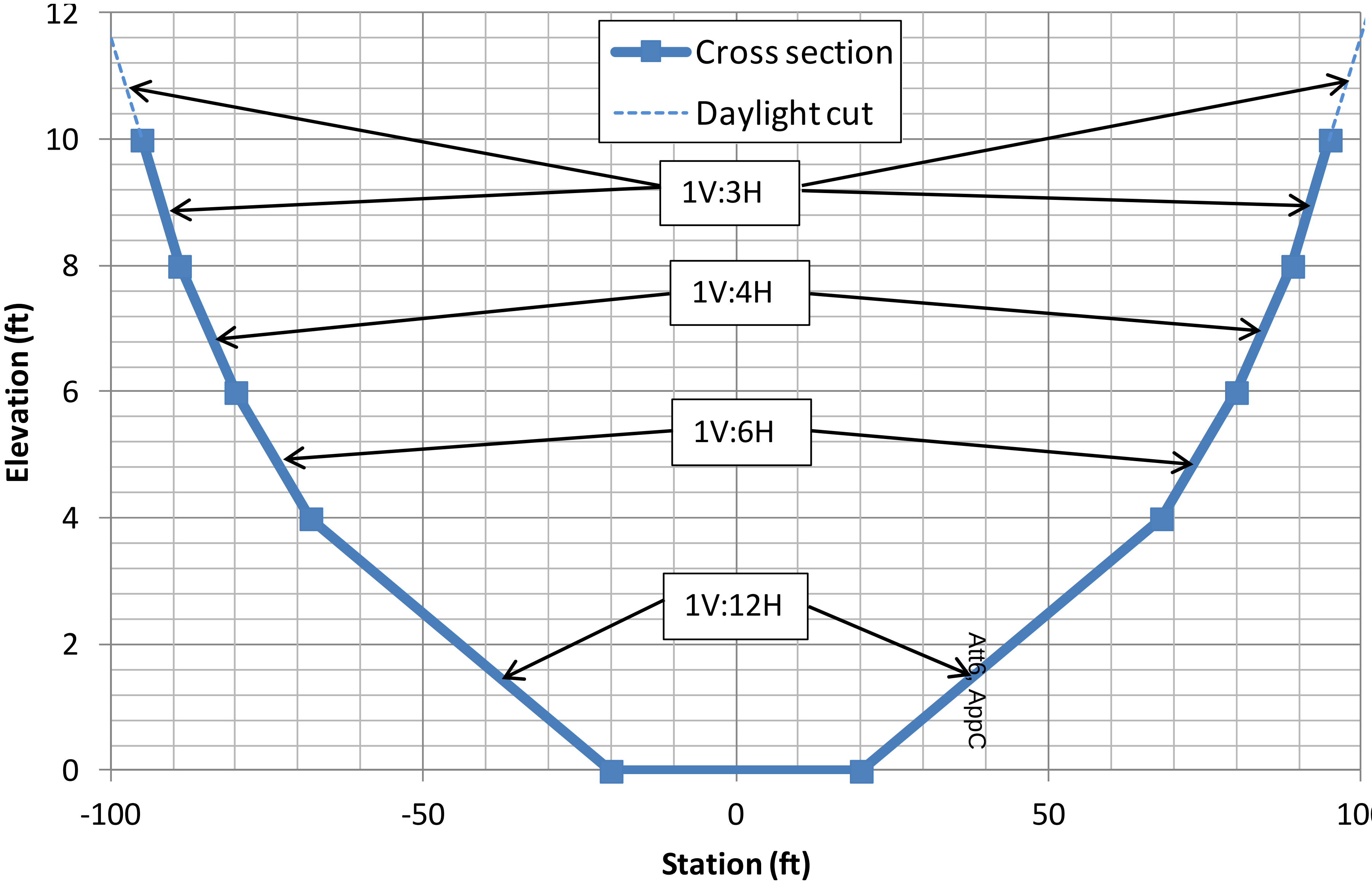


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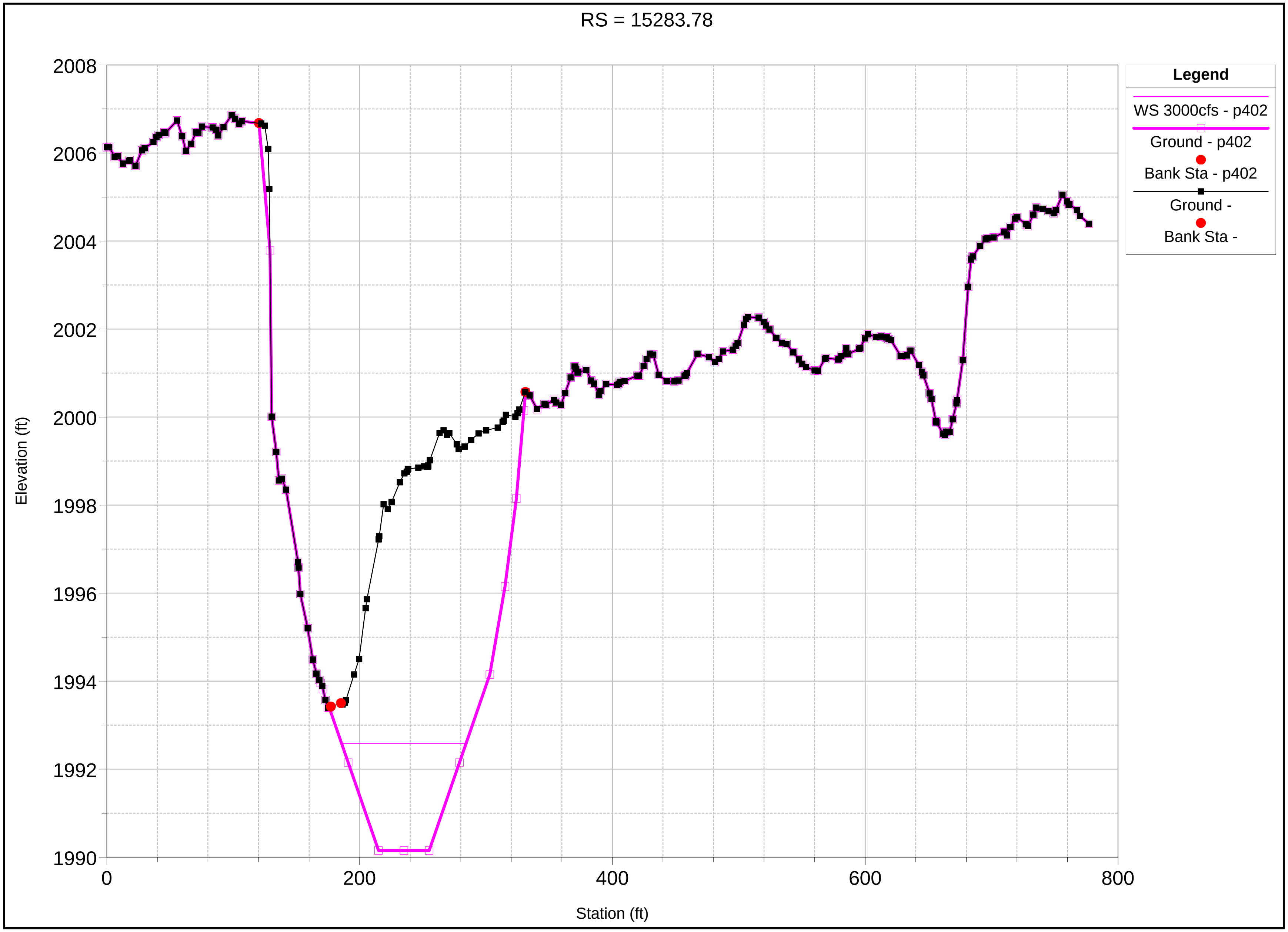
Plate 2

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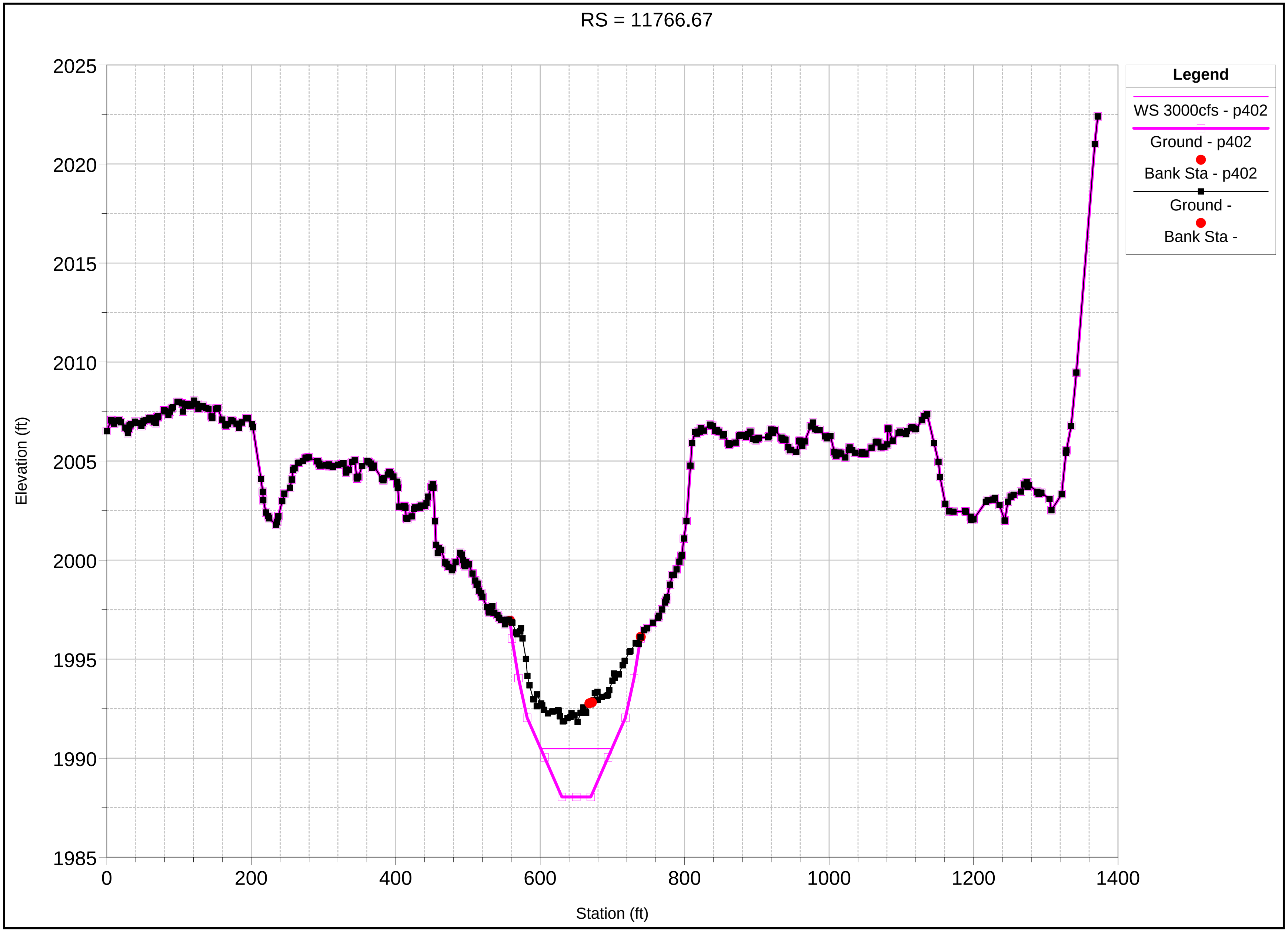


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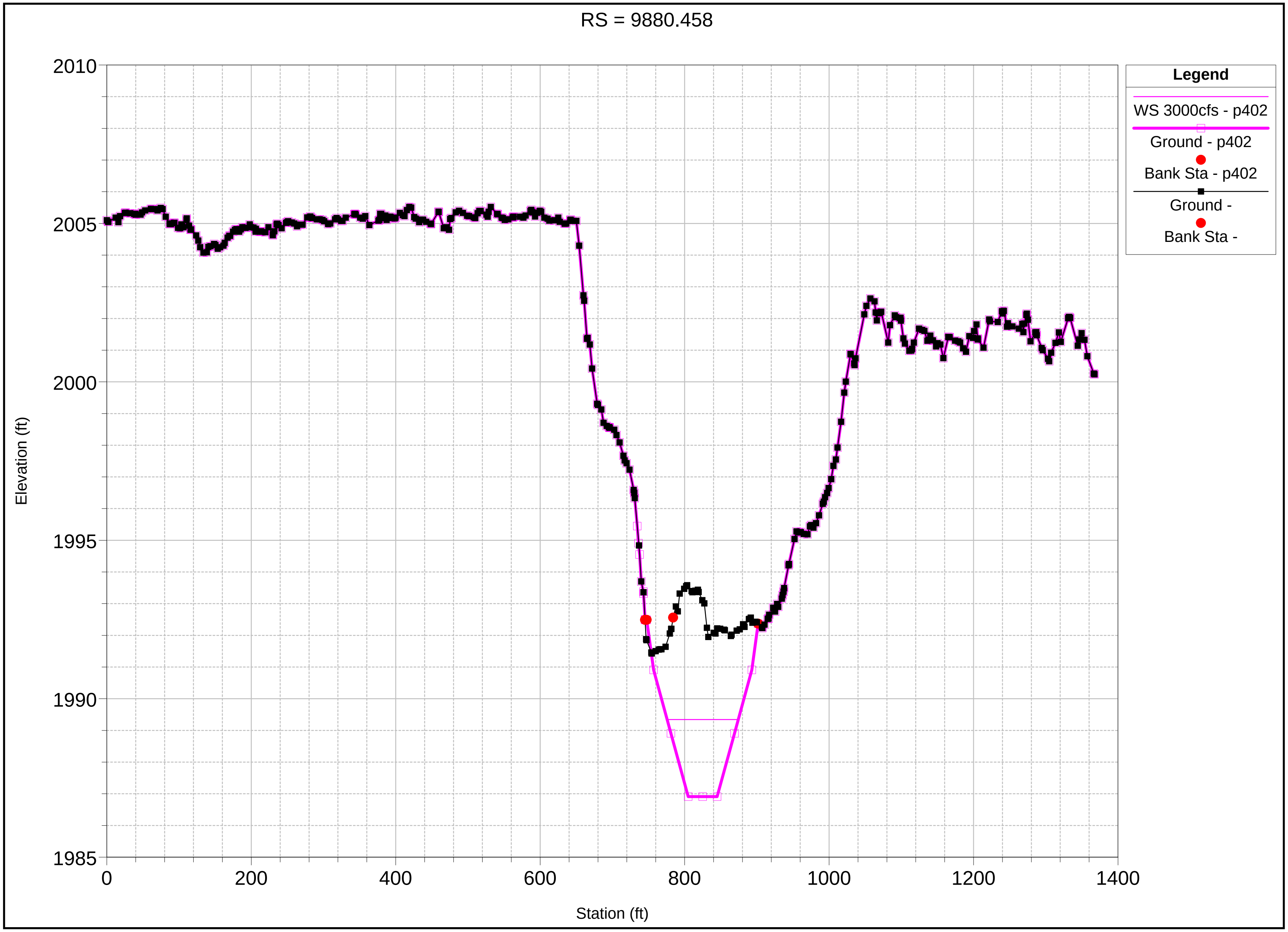
Plate 4

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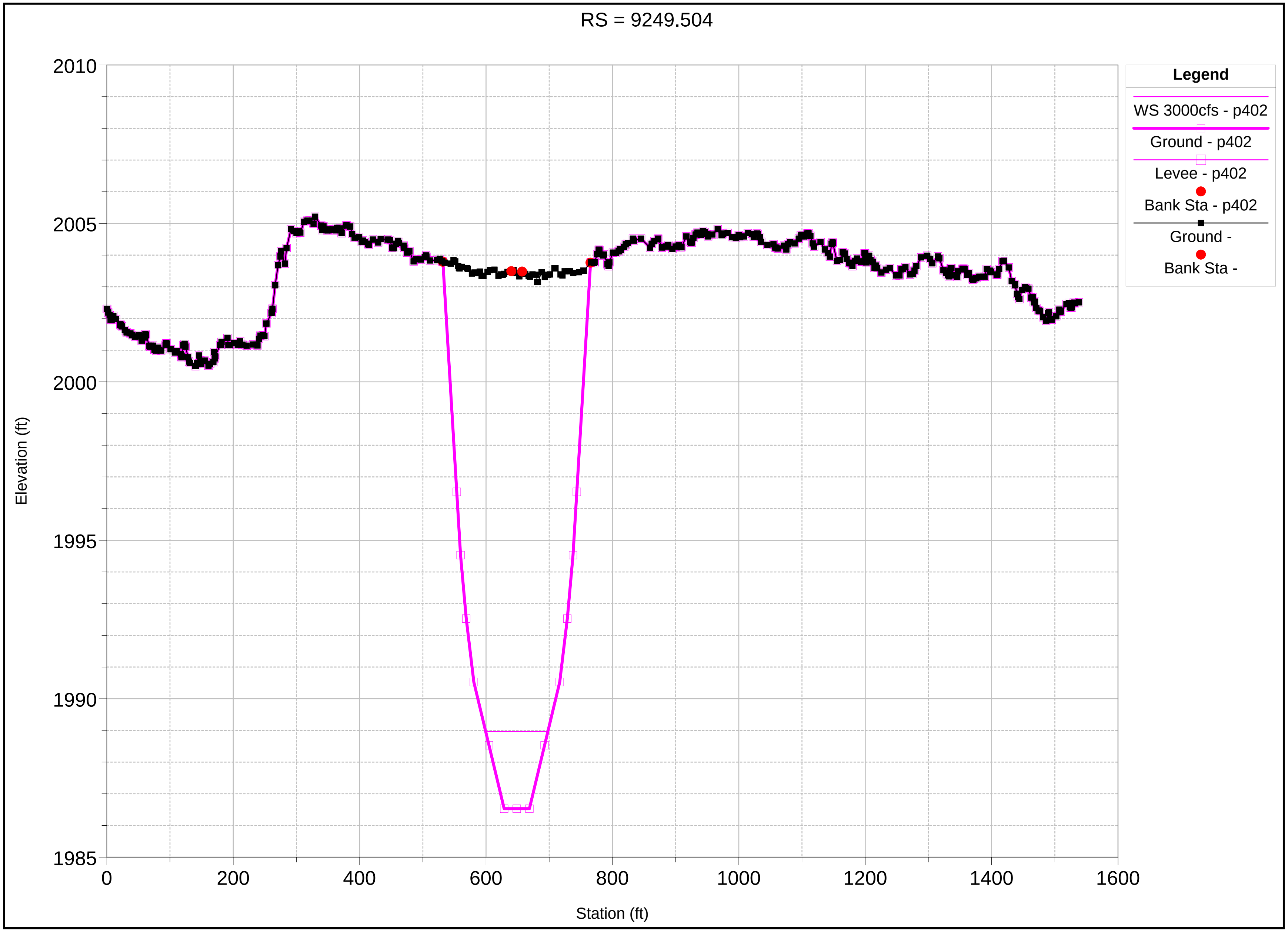


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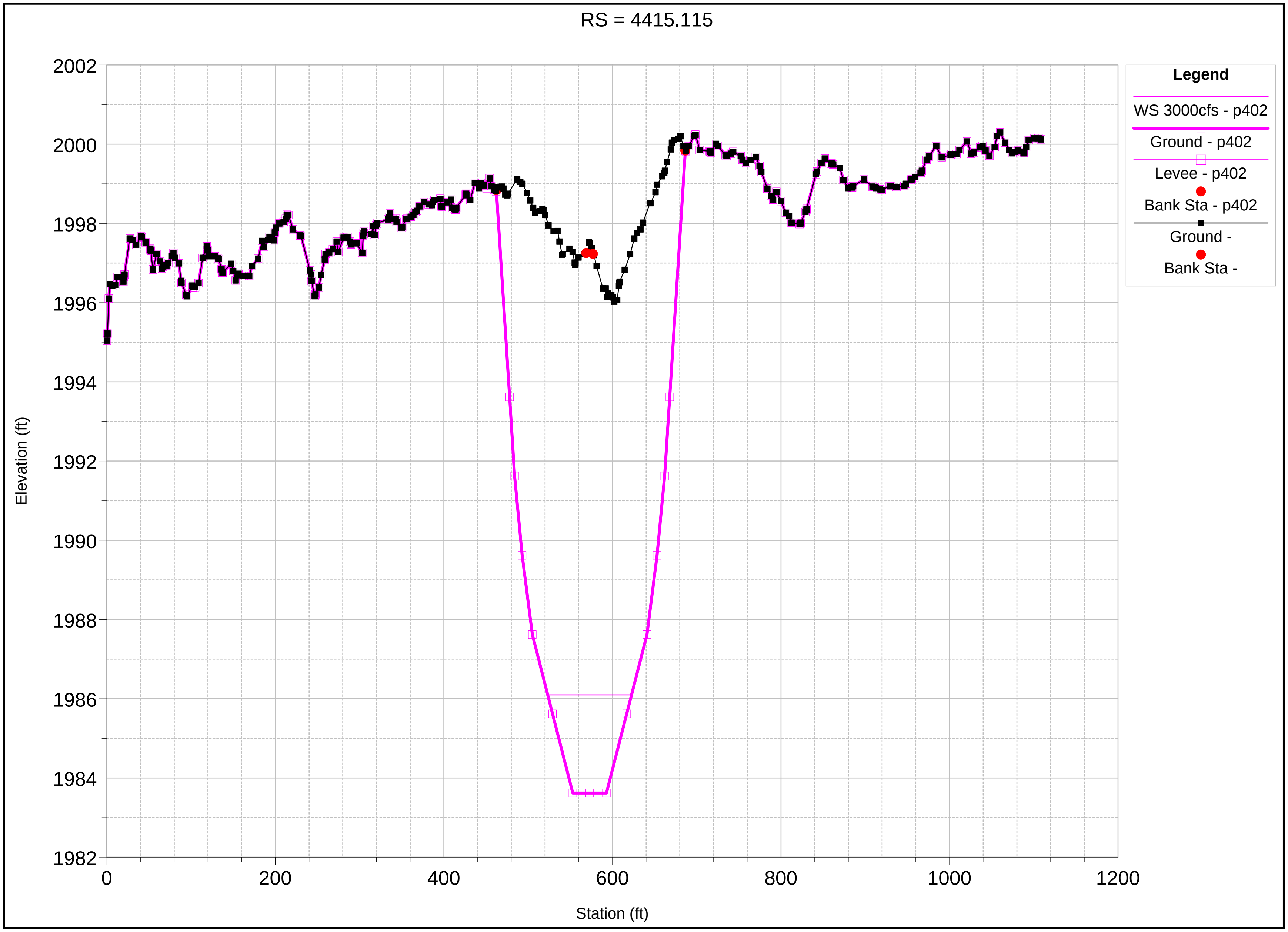


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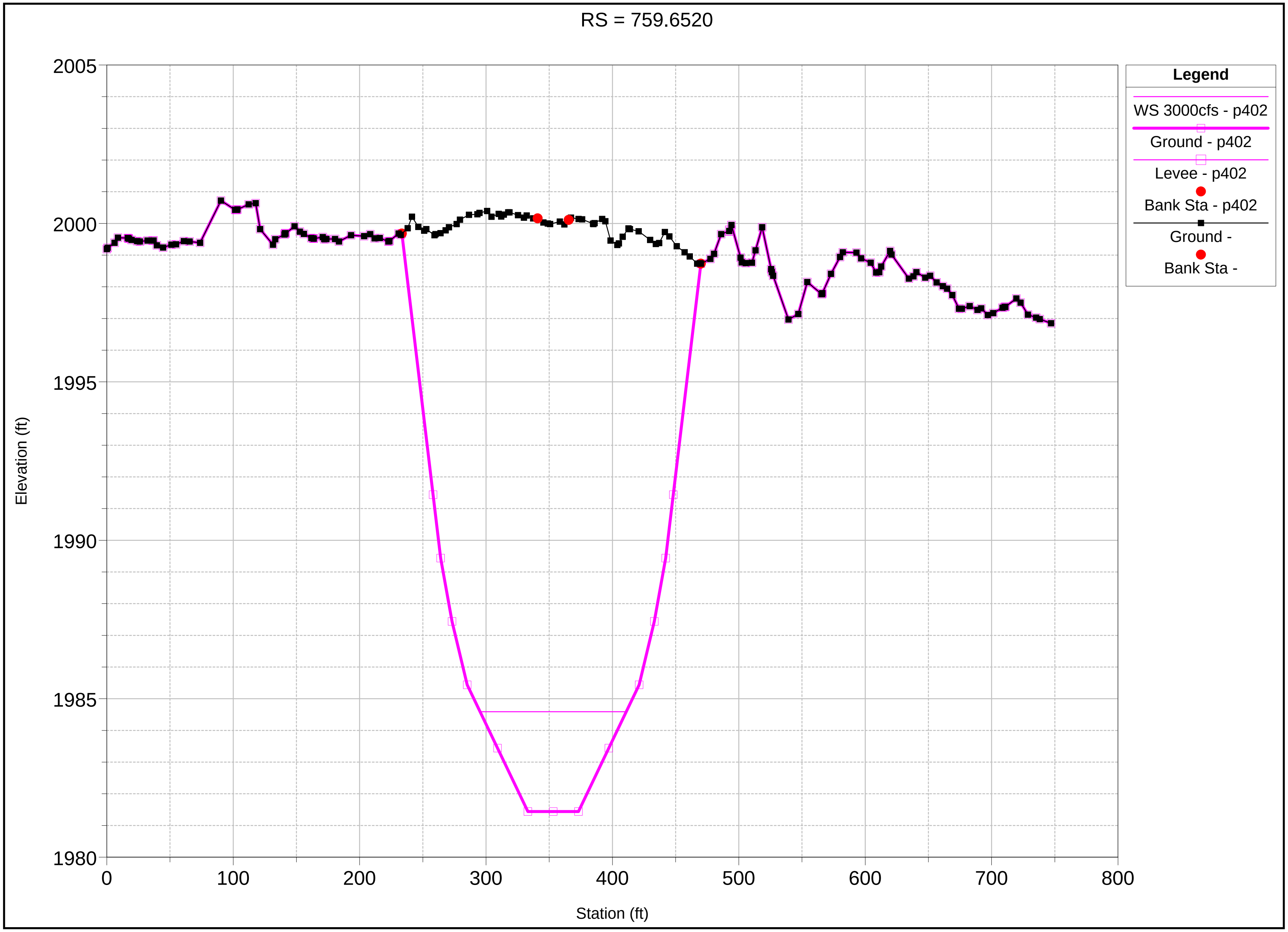


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Plate 8


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| SYMBOL | DESCRIPTION | DATE | APPROVED |
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ENGINEERING DIVISION, CHF.
DATE:

| | | |
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| DESIGNED BY: C.J.S. | DATE: DEC 16, 2011 | REV. — |
| DWN BY: C.J.S. / CKD BY: | DESIGN FILE NO. | SPEC. NO. XXXXX-XX-X-XXXX |
| REVIEWED BY: | PLOT SCALE RATIO: | CONTRACT NO. |
| SUBMITTED BY: CHIEF: CHAN. STAB. & SED. SECTION | DRAWING CODE: X | TASK ORDER #XX |

INTAKE FISH PASSAGE BYPASS
YELLOWSTONE RIVER MONTANA
UPSTREAM GRADE CONTROL STRUCTURE
PLAN VIEW

SHEET
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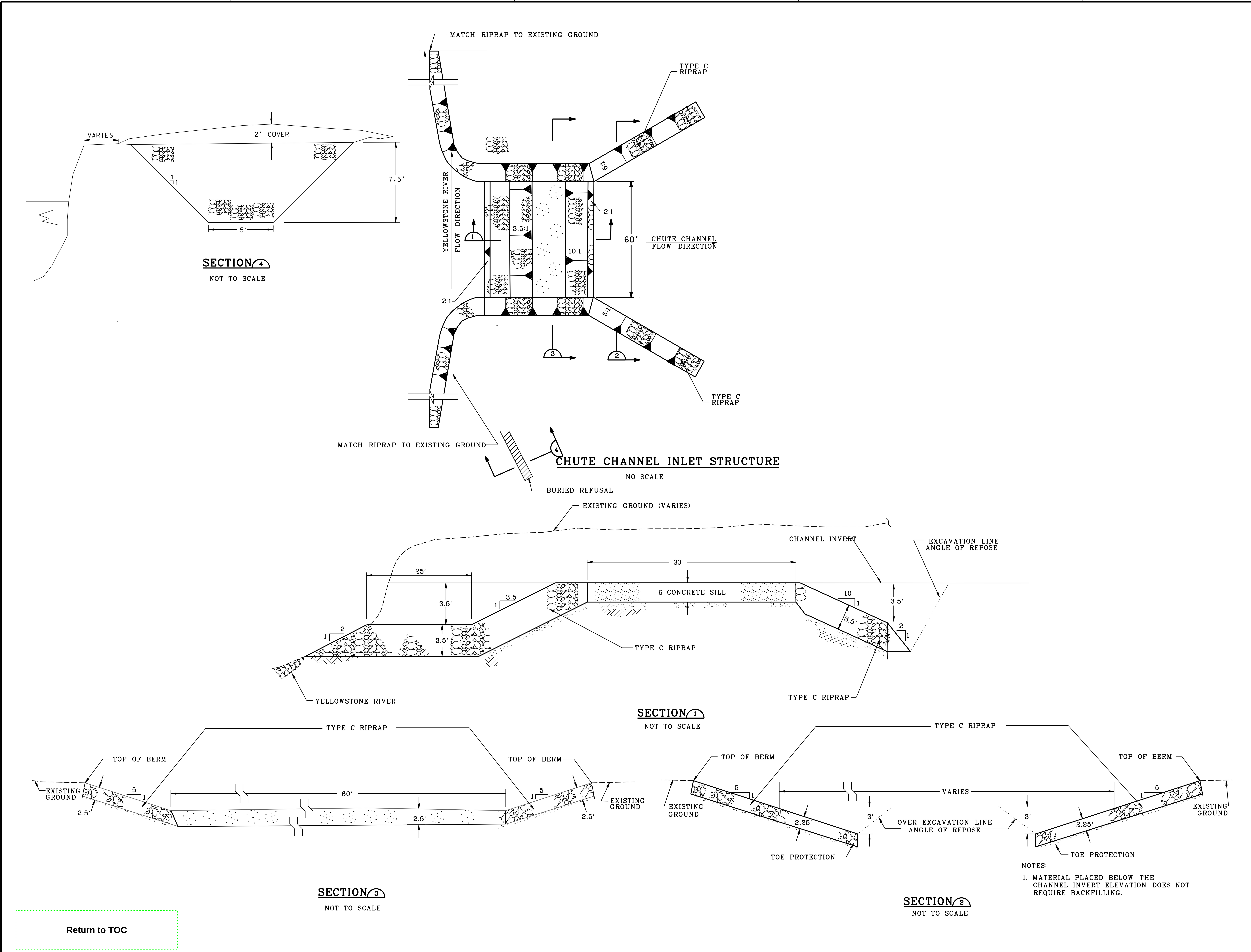


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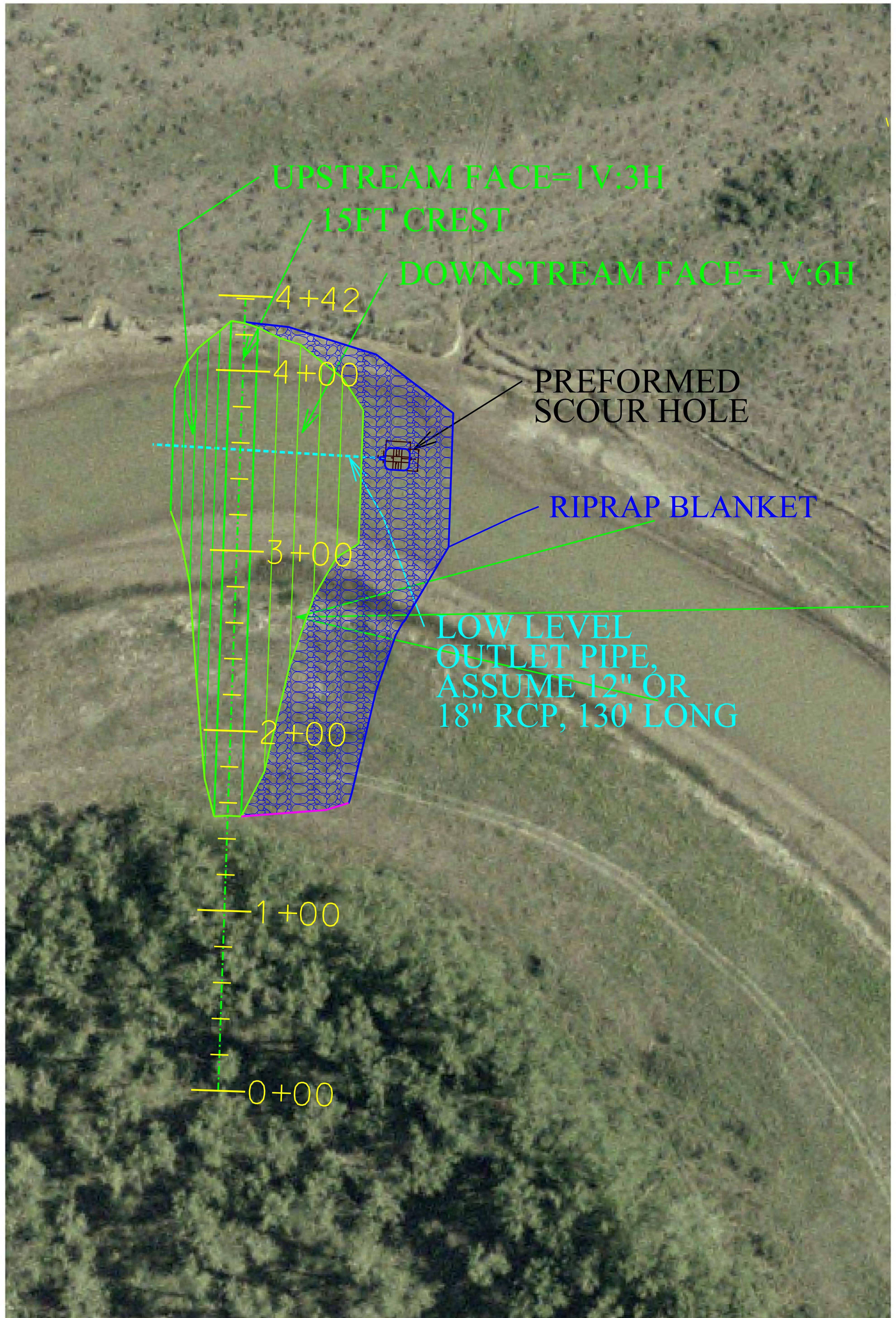
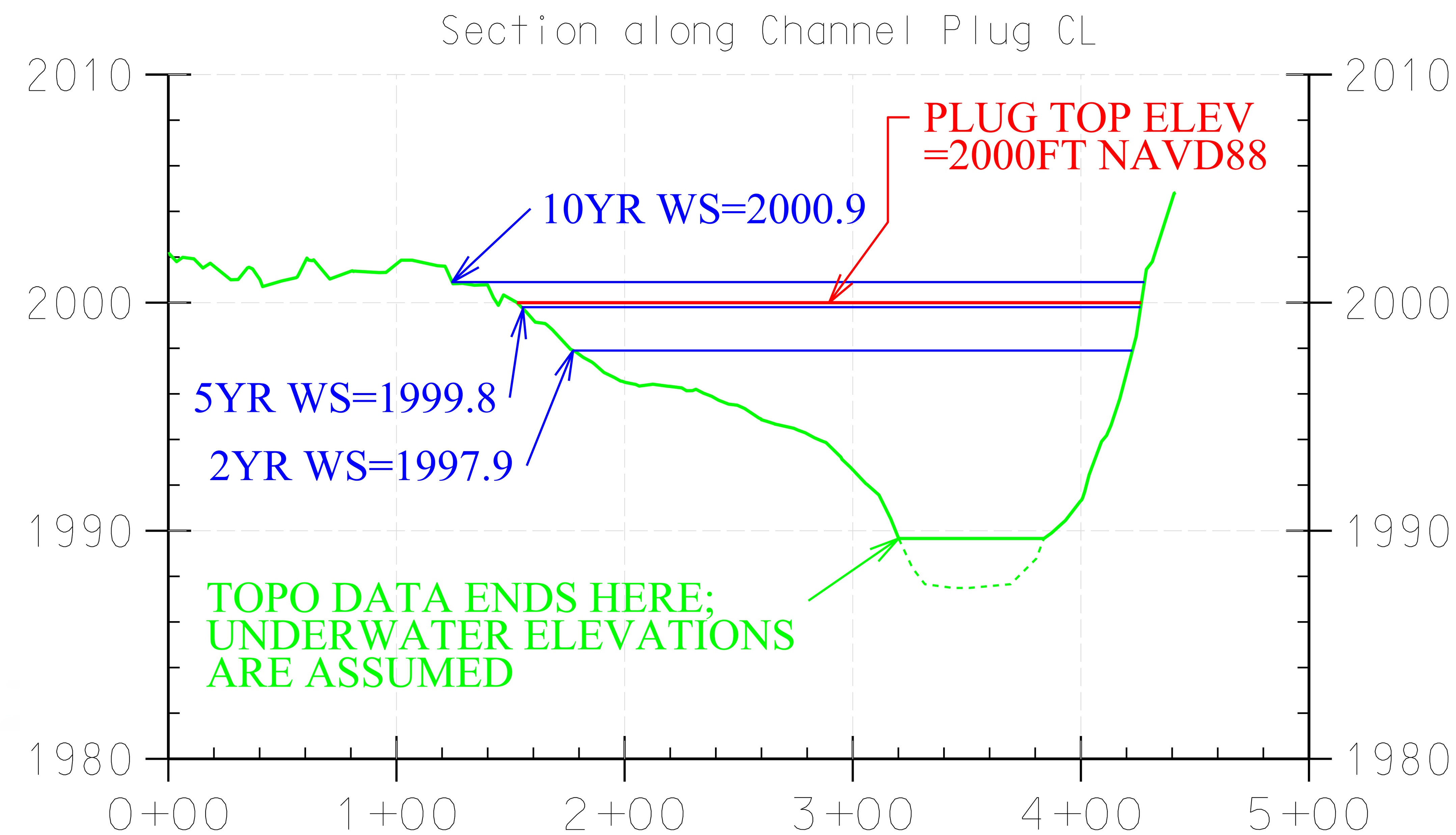
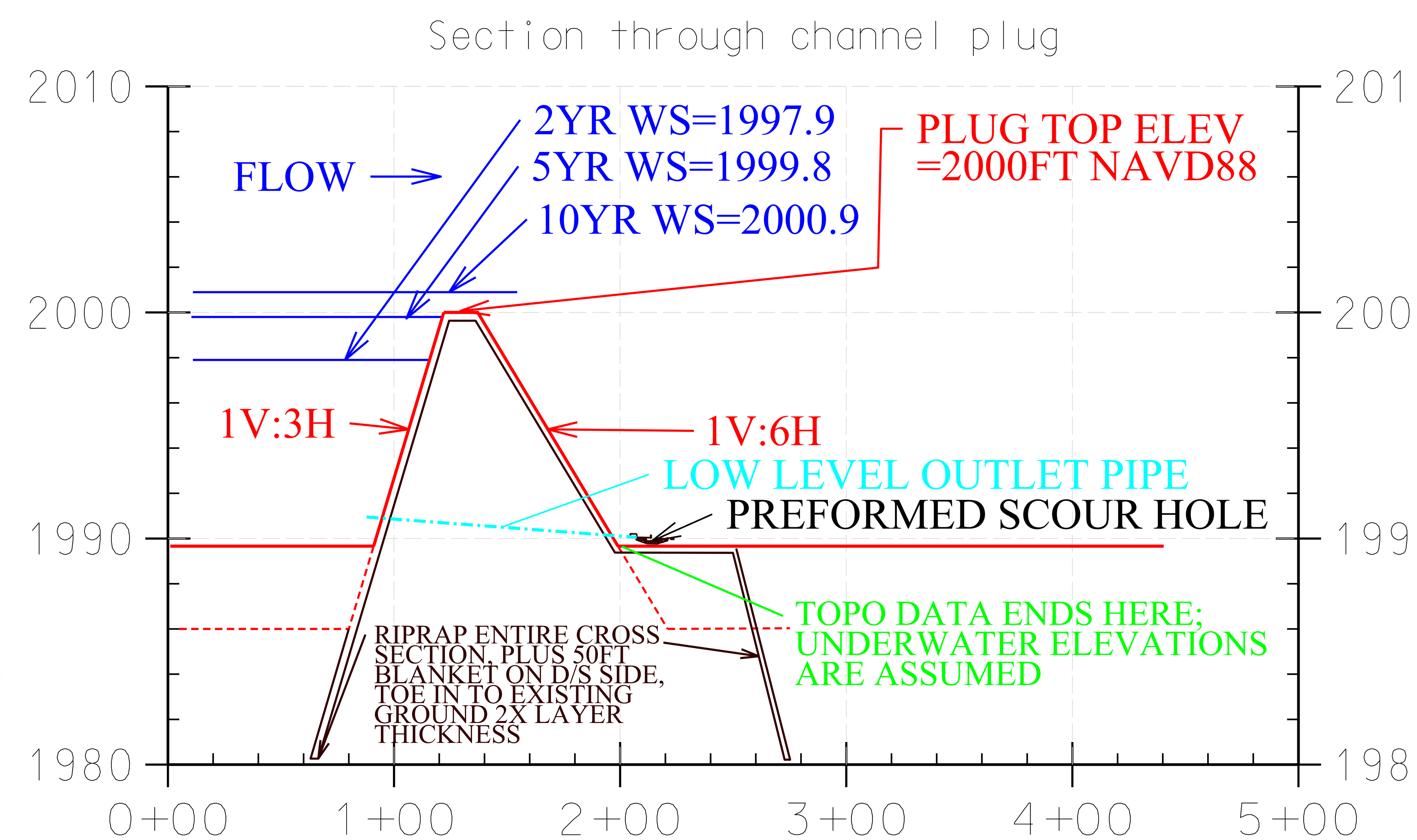
DWN BY: C.J.S. | CKD BY: | DESIGN FILE NO. | SPEC. NO. XXXXX-XX-X-XXXX
REVIEWED BY: | PLOT SCALE RATIO: | CONTRACT NO.
SUBMITTED BY: CHIEF: CHAN. STAB. & SED. SECTION | DRAWING CODE: X | TASK ORDER #XX

INTAKE FISH PASSAGE BYPASS
YELLOWSTONE RIVER MONTANA
UPSTREAM GRADE CONTROL STRUCTURE
SECTIONS

SHEET REFERENCE NUMBER:

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U.S. Army Corps of Engineers Omaha District

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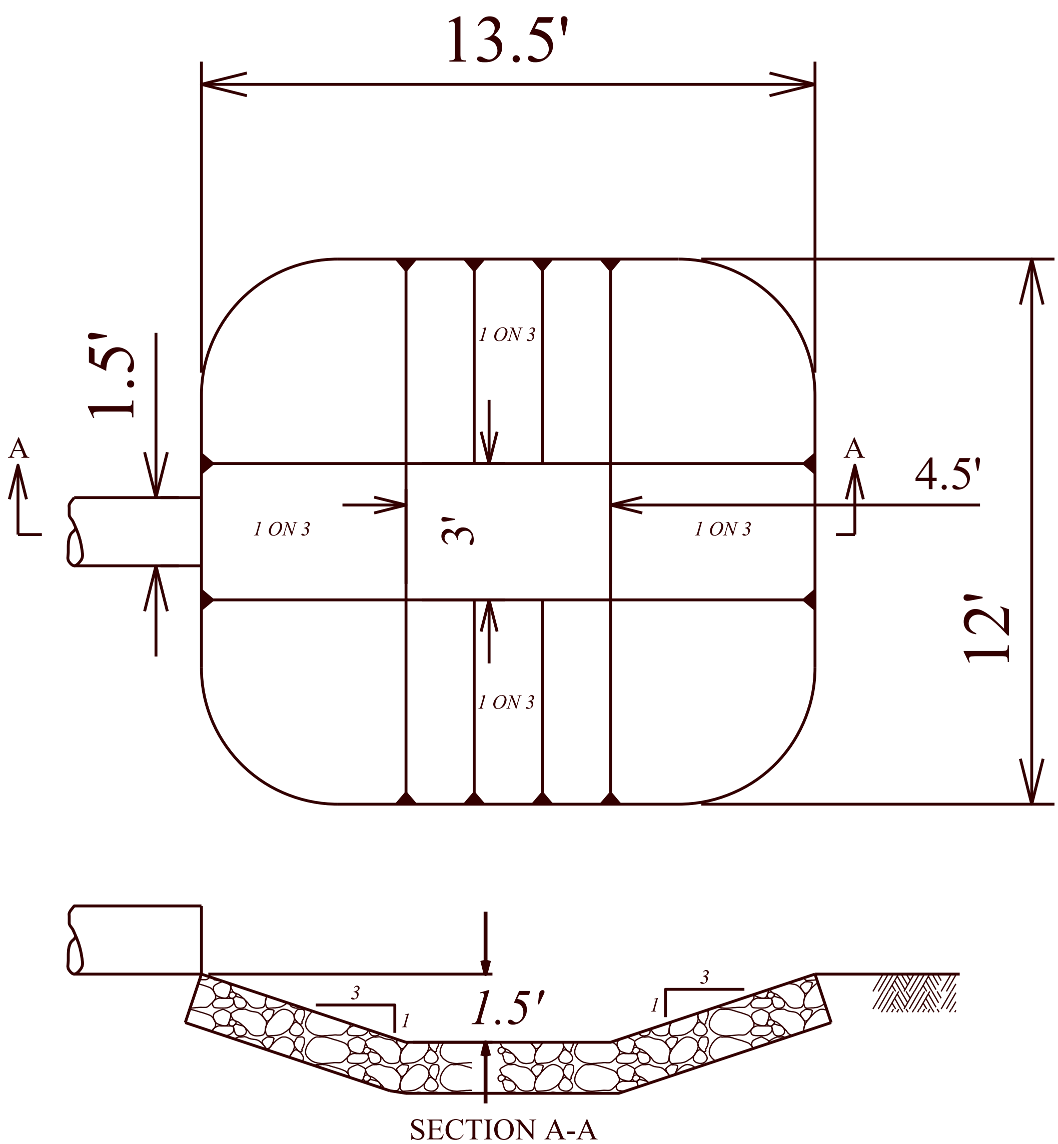


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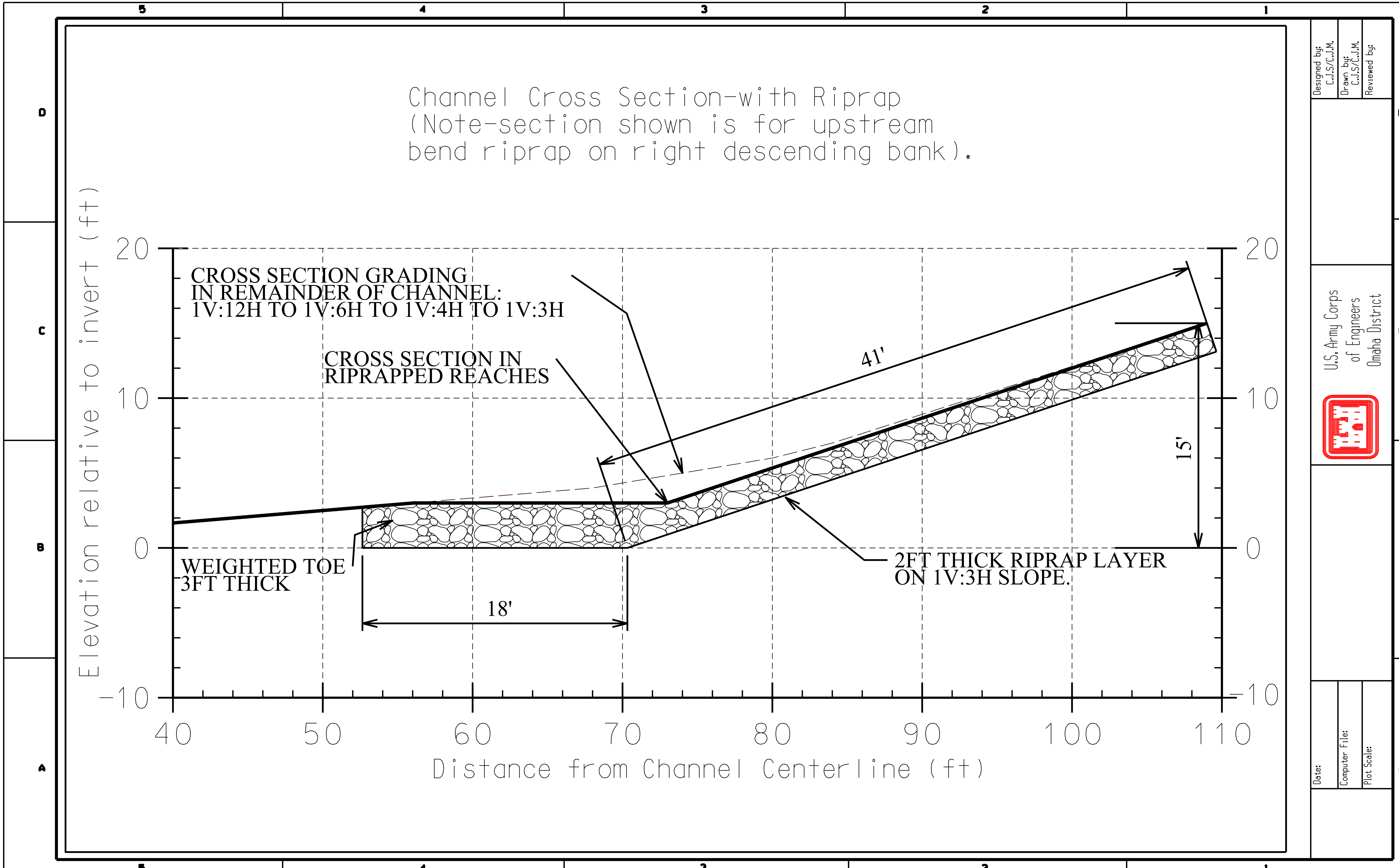


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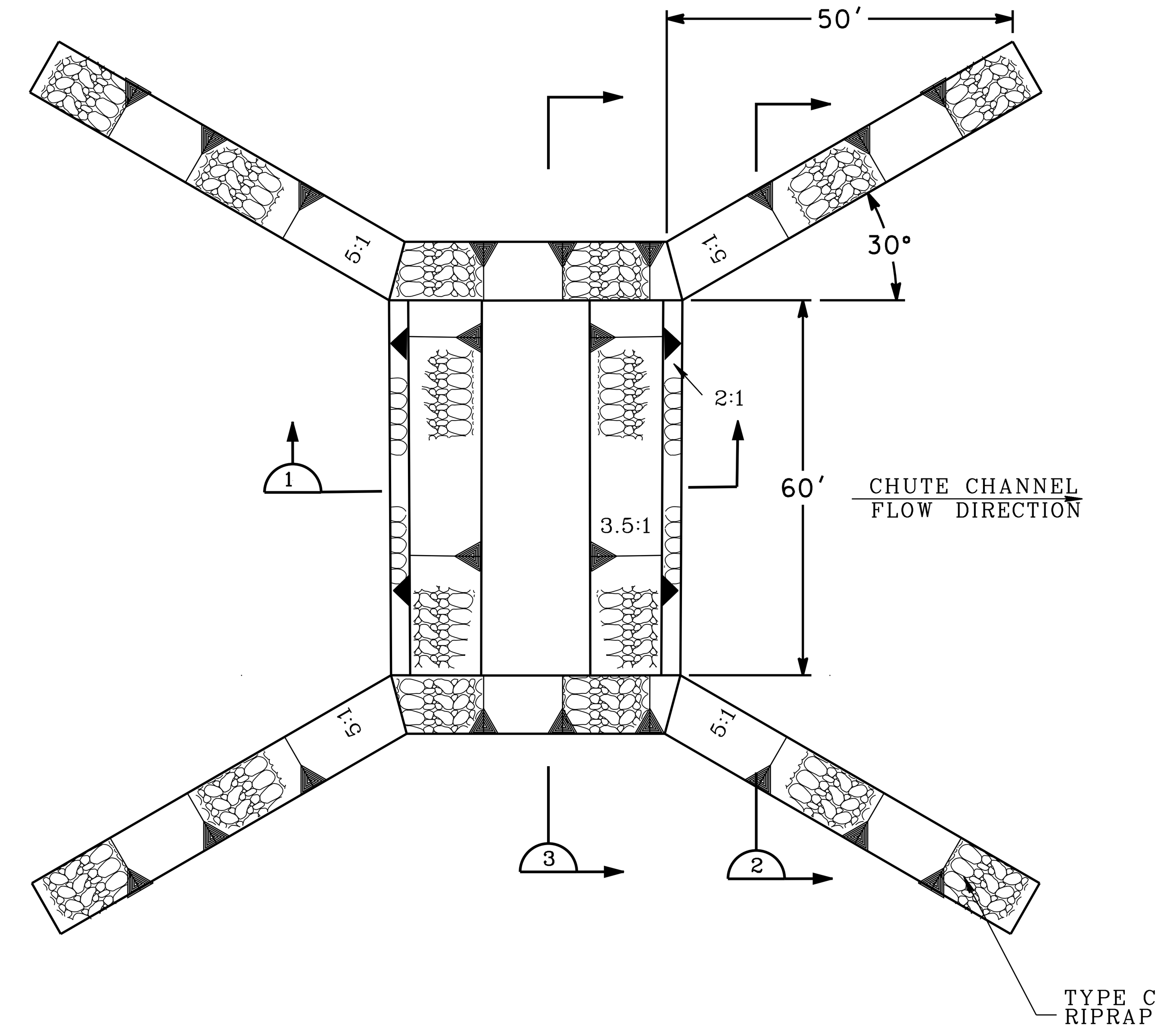


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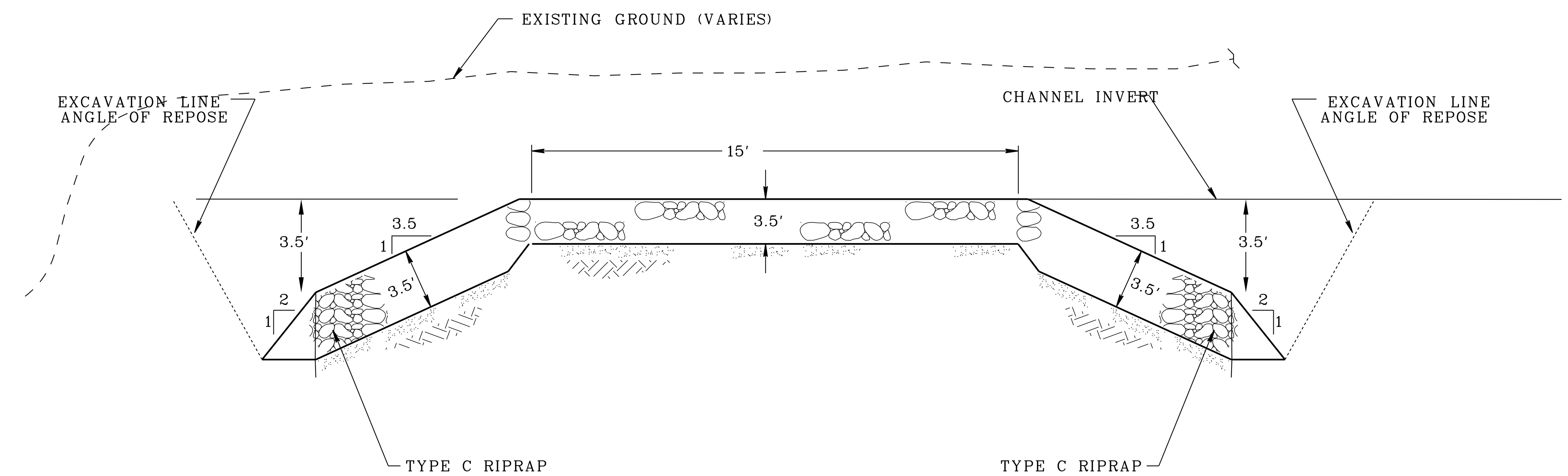


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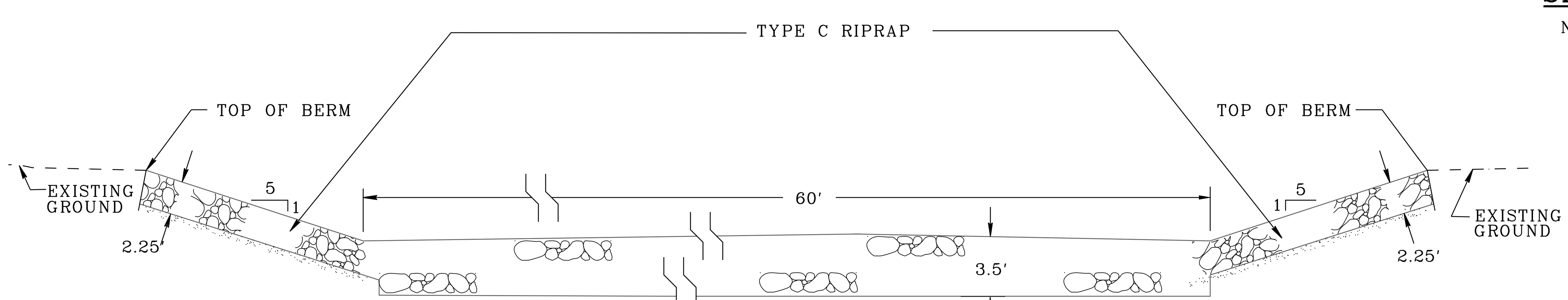


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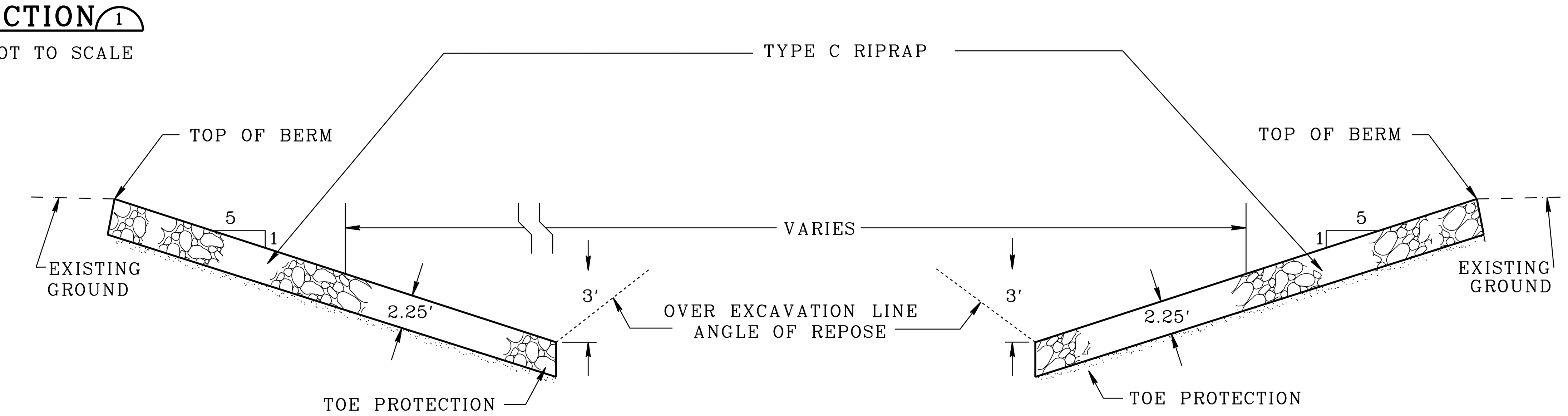


NOTES:

1. MATERIAL PLACED BELOW THE CHANNEL INVERT ELEVATION DOES NOT REQUIRE BACKFILLING.

SECTION 2

NOT TO SCALE

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| SYMBOL | DESCRIPTION | DATE | APPROVED |
| --- | --- | --- | --- |
| | | | |

APPROVED BY:

ENGINEERING DIVISION, CHF.

DATE:

DESIGNED BY: C.J.S. | DATE: DEC 16, 2011 | REV.

DWN BY: C.J.S. | CKD BY: | DESIGN FILE NO. | SPEC. NO.

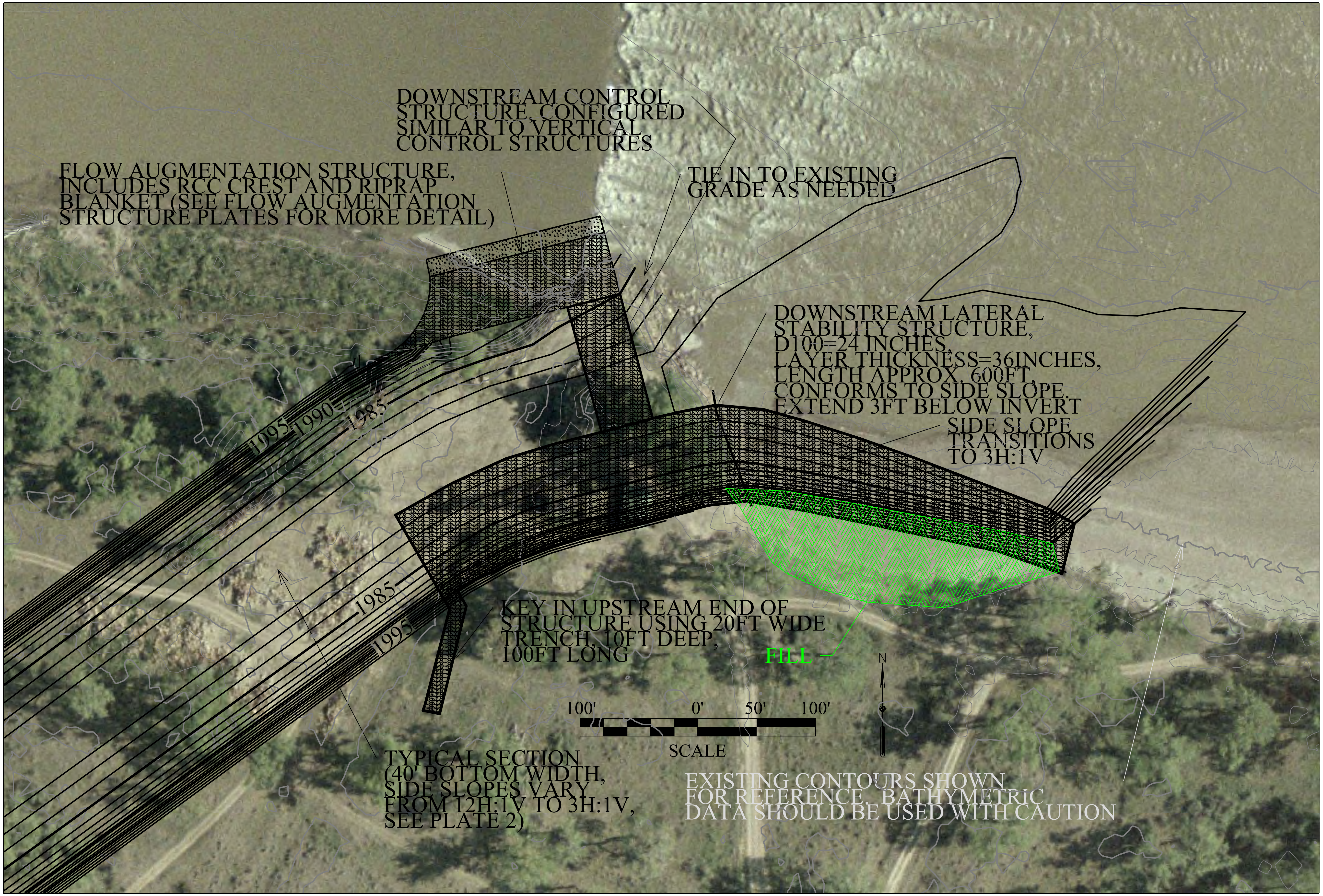
REVIEWED BY: | PLOT SCALE RATIO: | XXXXX-XX-X-XXXX

SUBMITTED BY: CHIEF: CHAN. STAB. & SED. SECTION | DRAWING CODE: X | CONTRACT NO. | TASK ORDER #XX

INTAKE FISH PASSAGE BYPASS
YELLOWSTONE RIVER MONTANA
BYPASS VERTICAL CONTROL SILLS

SECTIONS

SHEET REFERENCE NUMBER:




| Designed by: C.J.S/C.J.M. | Drawn by: C.J.S/C.J.M. | Reviewed by: |
|---|---|---|

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| Date: | Computer File: | Plot Scale: |
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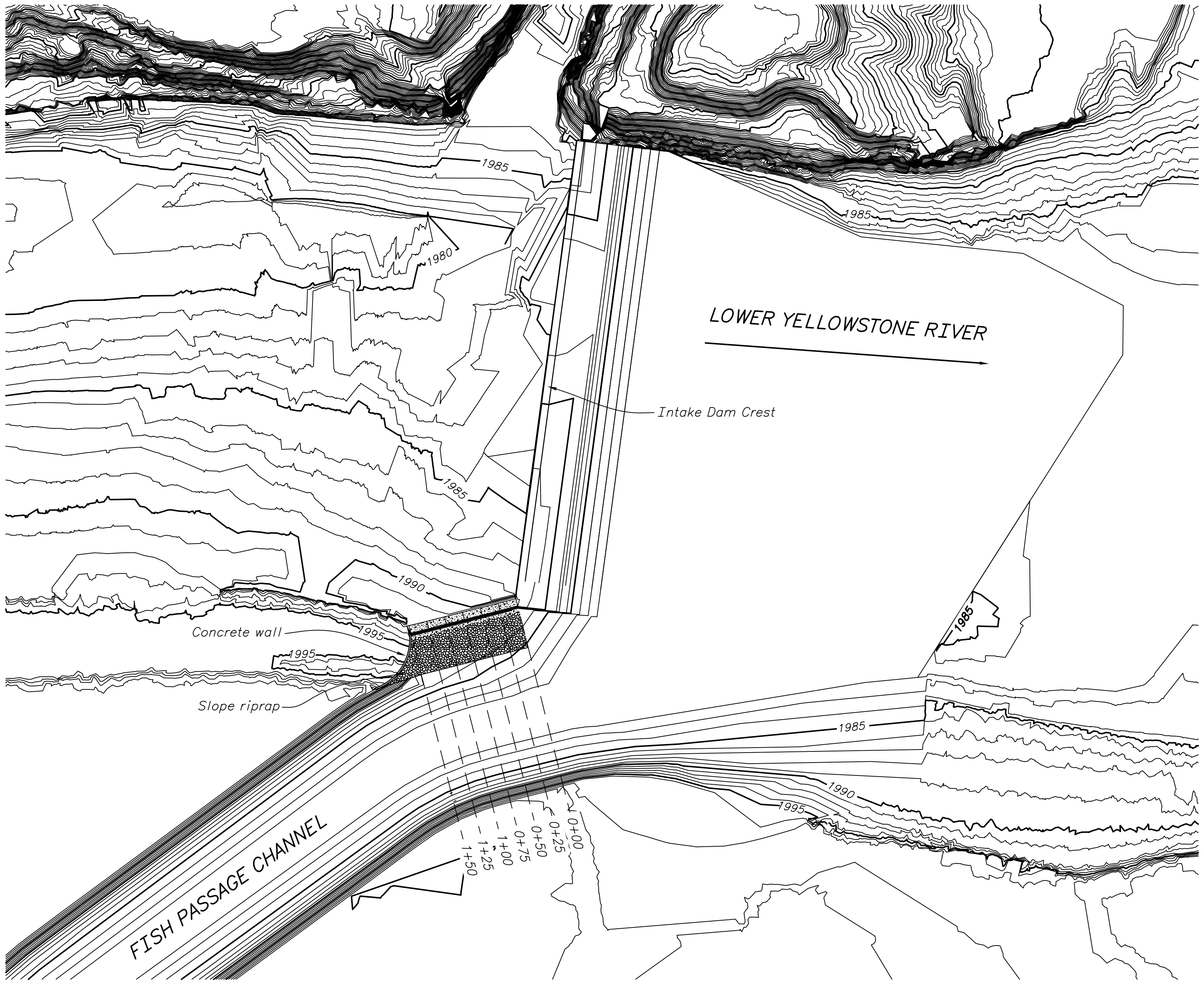


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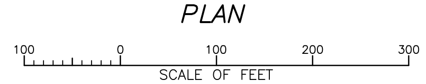


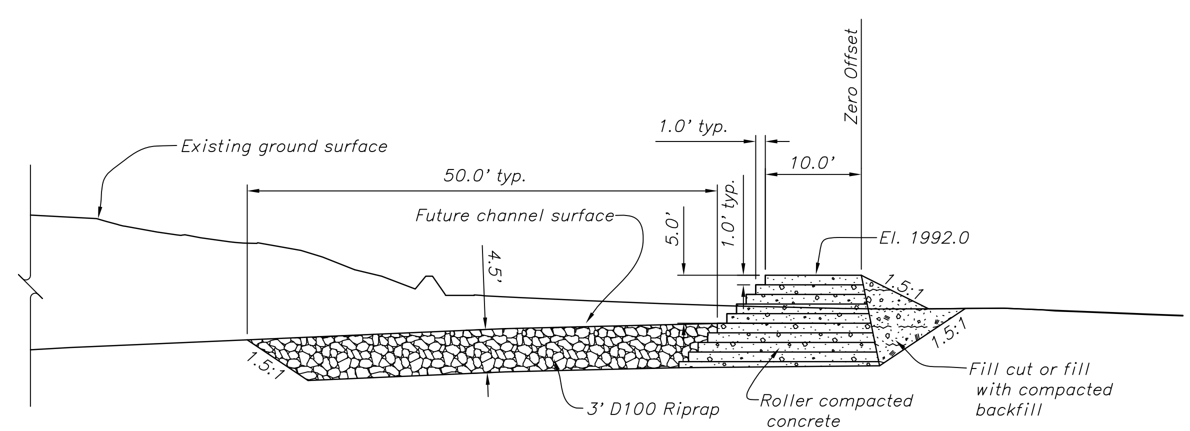


TYPICAL SECTION

( Not to scale )

NOTE

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**LOWER YELLOWSTONE RIVER**
**INTAKE DAM**
FISH PASSAGE – OPTION 1

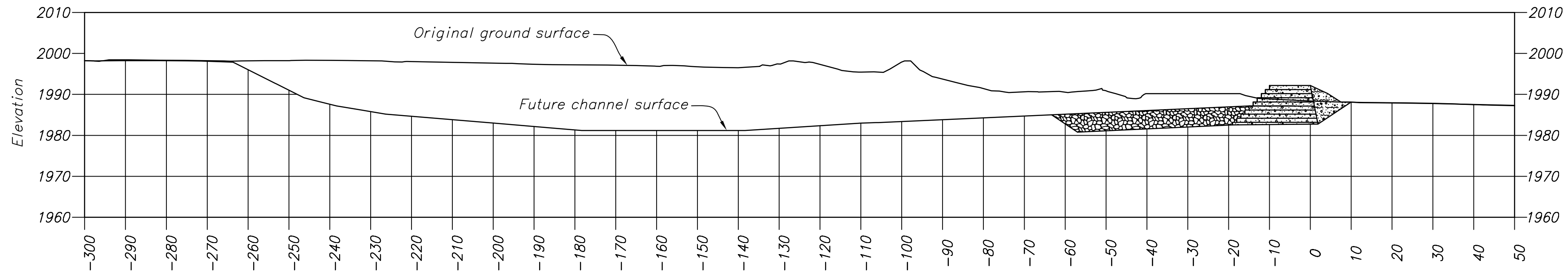


DESIGNED
DRAWN
CHECKED
TECH. APPR. NAME – TITLE
APPROVED PEER REVIEWER – NAME – TITLE
DENVER, COLORADO Dec. 20, 2011

SHEET 1 OF 3

CADD SYSTEM
AutoCAD Rel. 18.1s (LMS Tech)
CADD FILENAME
Lat_Weir_Option1.dwg

DATE AND TIME PLOTTED
December 23, 2011 12:07
PLOTTED BY
MCAMPBELL

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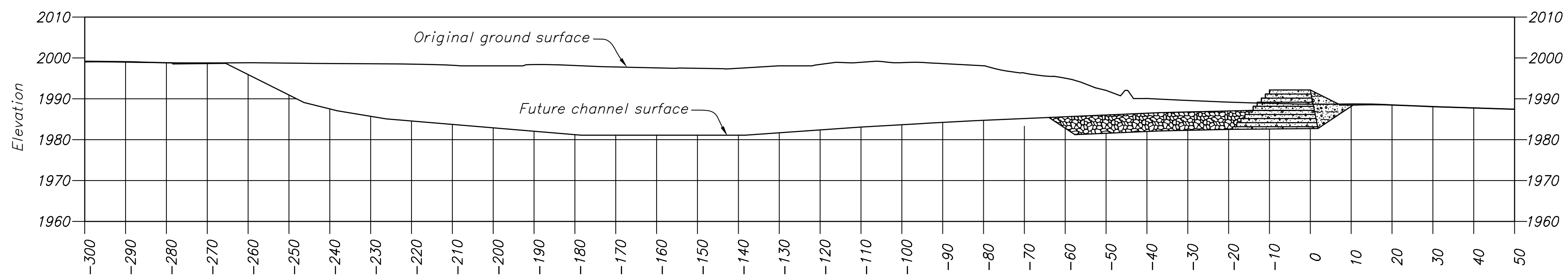


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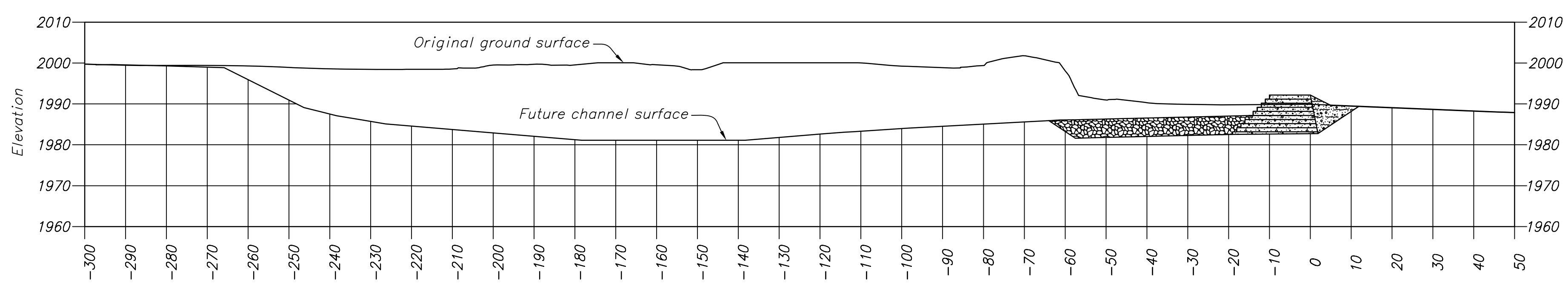


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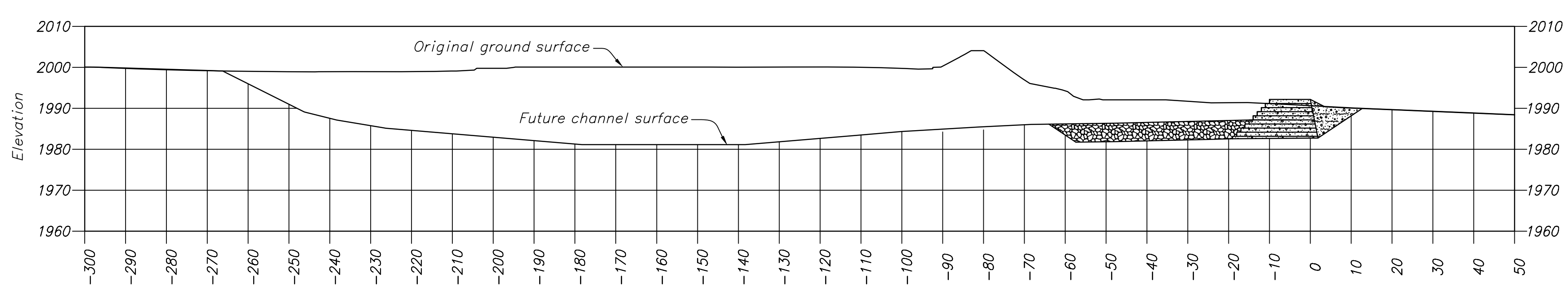


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**LOWER YELLOWSTONE RIVER**
**INTAKE DAM**
FISH PASSAGE - OPTION 1



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APPROVED PEER REVIEWER - NAME - TITLE
DENVER, COLORADO Dec. 20, 2011

SHEET 3 OF 3

DATE AND TIME PLOTTED
December 23, 2011 12:07
PLOTTED BY
MCAMPBELL

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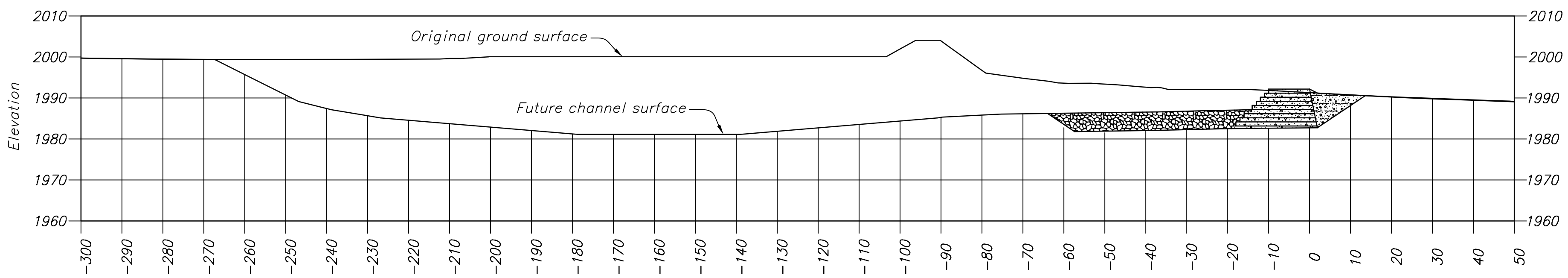


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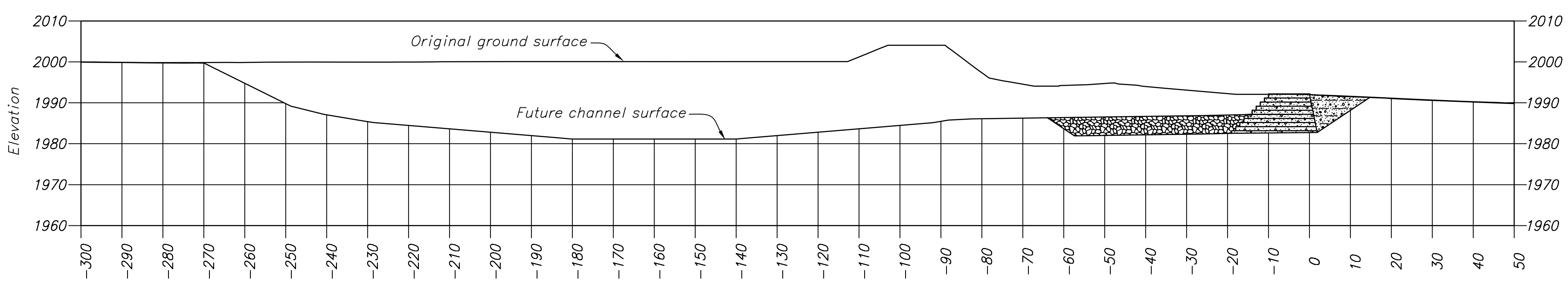


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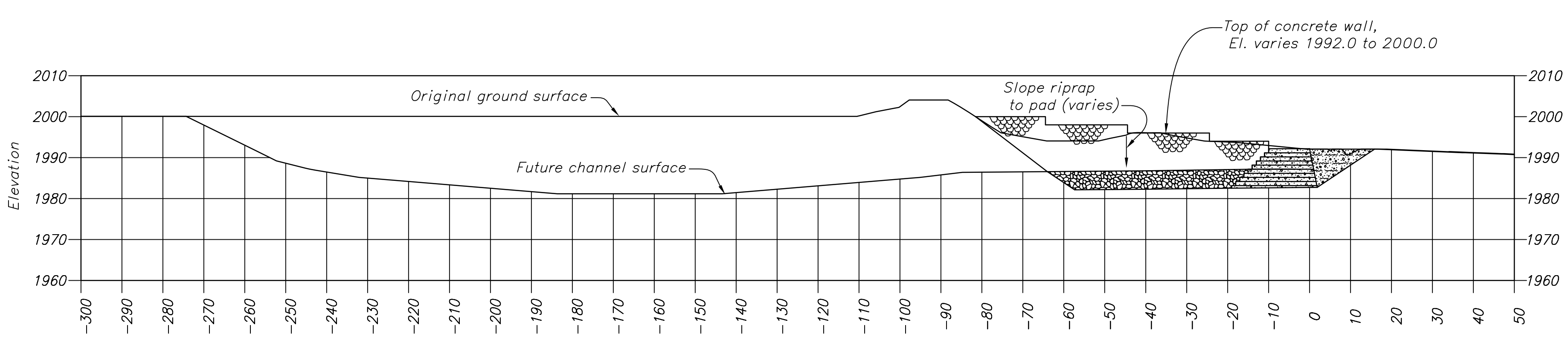


SECTION AT STA. 1+50

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**LOWER YELLOWSTONE RIVER INTAKE DAM**

FISH PASSAGE – OPTION 1



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CHECKED
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APPROVED PEER REVIEWER – NAME – TITLE
DENVER, COLORADO Dec. 20, 2011

Attachment 6  Bypass Channel

# Appendix D

Reference Reach Comparison

19March2012



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Omaha District

| Project: | Lower Yellowstone-Intake | | | | | Sheet No. | 1/1 |
|---|---|---|---|---|---|---|---|
| Subject: | Reference Reach Comparison | | | | | | |
| Computed by: | CJM | Date: | MAR2012 | Checked by: | | Date: | |

**INTRODUCTION**
This document describes an evaluation of eleven side channels on the Yellowstone River, including the existing high flow chute at Lower Yellowstone, Intake. Six of the side channels evaluated are downstream from Intake, four are upstream.

The intent of the evaluation is to compare existing, natural side channels to the proposed bypass channel at intake. It should be stressed that the comparison is simply a GIS exercise and does not guarantee project performance. Additional data and a more in-depth analysis will be required to determine the long term stability of the project.

**COMPARISON**
Available GIS data, aerial photography, and HEC-RAS data were used to compare 11 natural side channels within 60 river miles of Intake Dam. The comparison consisted mainly of measuring side channel length and width and using HEC-RAS or available LiDAR data to estimate energy grades. Dates of aerial photography were used to estimate discharges at the sites based on the USGS gages at Glendive and Sidney.

Plate 1 consists of a table summarizing the evaluation along with assumptions used.

Plate 2 shows a general overview of the area.

Plates 3-13 show each of the individual sites.

**CONCLUSIONS**
Both the short and long bypass channels (15500 ft and 23250ft) fall in the relative range of the reference reaches compared.

The chute to main channel length ratio for the shorter bypass, while falling in the range, is on the high end of those compared with only one reference reach higher. The longer bypass is higher by a third than the highest reference reach.

Both channels fall in the range of estimated energy grade slope.

Chute sinuosity for the shorter bypass falls at the high end of the evaluated range while the longer channel is again nearly a third higher than the reference reach with the highest sinuosity.

The top width of both of the proposed channels falls in the range of the reference reaches.

Return to TOC

| Reach Identifier | River Mile[1] | Bank | Orientation and distance from Intake Dam[2] | Approximate chute length | Approximate main channel length | Chute to Main Channel length ratio | Approximate energy grade slope in main channel[3] | Estimated energy grade slope in reference reach chute | Straight line distance, end to end of chute | Sinuosity (in this context, used ratio of chute length to straight line distance) | Approximate range of chute top width | | Approximate Yellowstone River discharge at which chute flows (rough estimates broken into broad classes) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Low flow[4] | Mid range flow[5] | |
| | | | | (ft) | (ft) | | (ft/ft) | (ft/ft) | (ft) | | (ft) | (ft) | (cfs) |
| 1 | 18.3-19.8 | Right | 54 miles d/s | 9900 | 7900 | 1.3 | 0.0001 | 0.00008 | 6400 | 1.5 | 50-110 | 140-200 | ≤5000 |
| 2 | 34.0-35.7 | Left | 38 miles d/s | 9400 | 8900 | 1.1 | 0.0004 | 0.0004 | 8100 | 1.2 | 15-30 | 30-50 | ≤5000 |
| 3 | 37.7-39.4 | Right | 34 miles d/s | 11400 | 9000 | 1.3 | 0.0003 | 0.0002 | 7500 | 1.5 | 20-50[6] | 50-120 | 20,000<x<40,000 |
| 4 | 41.0-43.3 | Left | 31 miles d/s | 22100 | 12400 | 1.8 | 0.0006 | 0.0004 | 11300 | 2.0 | 20-90[7] | 100-160 | 5000<x<20,000 |
| 5 | 52.7-54.6 | Right | 19 miles d/s | 10600 | 10000 | 1.1 | 0.0006 | 0.0006 | 9200 | 1.2 | 60-200[7] | 250-400 | 5000<x<20,000 |
| 6 | 62.7-64.6 | Right | 9 miles d/s | 8700 | 9800 | 0.9 | 0.0005 | 0.0006 | 5700 | 1.5 | 120-280[8] | N/A | <5000 |
| 7 | 70.8-74.3 | Right | Existing chute at Intake | 24700 | 18400 | 1.3 | 0.0007 | 0.0005 | 16200 | 1.5 | 40-120[6] | N/A | 25,000-30,000 |
| 8 | 90.0-90.8 | Left | 17 miles u/s | 5000 | 4500 | 1.1 | 0.00065 | 0.0006 | 4200 | 1.2 | 40-120[7] | N/A | 5000<x<20,000 |
| 9 | 94.5-96.5 | Left | 23 miles u/s (at Glendive) | 13600 | 10800 | 1.3 | 0.0004 | 0.0003 | 10000 | 1.4 | 60-200 | N/A | <5000 |
| 10 | 99.8-101.8 | Right | 28 miles u/s | 10400 | 10500 | 1.0 | 0.0005 | 0.0005 | 9500 | 1.1 | 40-150[9] | N/A | >5000[10] |
| 11 | 105.8-107.1 | Right | 33 miles u/s | 7500 | 6800 | 1.1 | 0.0007 | 0.0006 | 6400 | 1.2 | 70-100[9] | N/A | >5000[10] |
| PROPOSED BYPASS | 72.4-47.3 | Right | Proposed bypass at Intake | 15500-23250 | 9600 | 1.6-2.4 | 0.0007 | 0.0004-0.0006 | 8300 | 1.9-2.8 | 100 | 190 | ≤5000 |

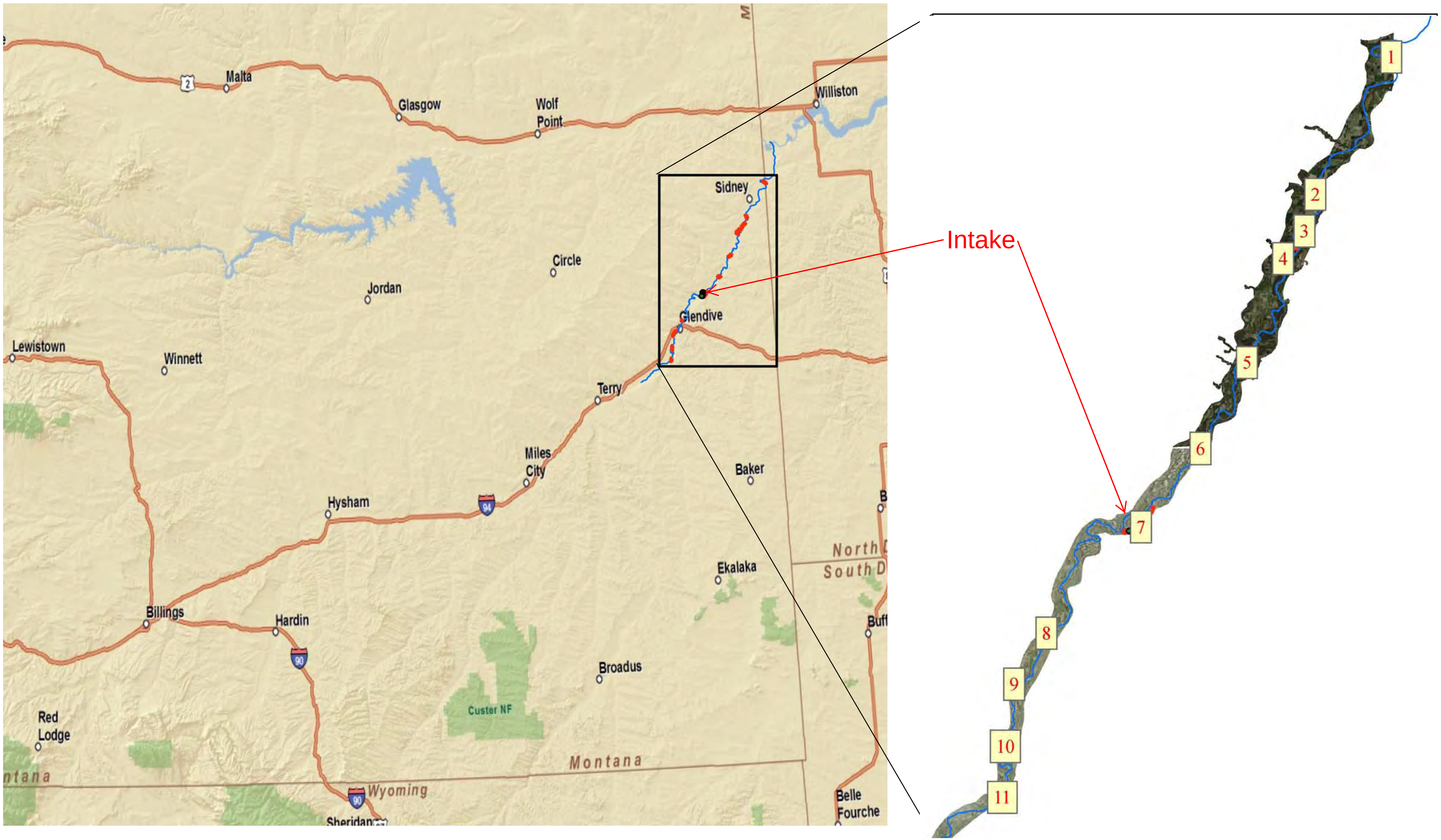
Footnotes:

| | |
|---|---|
| 1 | Approximate downstream and upstream extents of chute based on main channel river station in miles from mouth |
| 2 | Intake Dam is located at approximately RM 73 |
| 3 | For reaches 1-6 (located in Richland County), used 2007 LiDAR survey data assuming data in river reflects approximate water surface elevation. For reaches 7-11 (located in Dawson County), used USACE created HEC-RAS model and averaged energy grade slope from range of profiles. |
| 4 | Based on measurements using aerial photography from 15Oct2007 to 2Nov2007 for reaches 1-6 (Richland County), discharges at Glendive (and Sidney)≈5000-7000cfs; aerials from 1-2May2004 for reaches 7-11 (Dawson County), discharges at Glendive≈4000-6000cfs, at Sidney≈3000cfs. |
| 5 | Based on measurements using Google Earth imagery from 22June2009, discharge at Glendive≈48,000cfs, Sidney≈46,000cfs where available. |
| 6 | Appears that chute is intermittent; i.e. may not be carrying water at low Yellowstone River flow. Using aerial photography from ArcGIS Map Service, ESRI_Imagery_World_2D, still shows intermittent flow in chute but with additional area inundated; date noted for imagery is 14July2005, discharge at Glendive≈17,000cfs, Sidney≈16,000cfs. July 2005 imagery was on receding limb of hydrograph that reached >40,000cfs near the end of June/beginning of July. |
| 7 | Appears that chute is intermittent; i.e. may not be carrying water at low Yellowstone River flow. However, aerial photography from ArcGIS Map Service, ESRI_Imagery_World_2D, shows continuous flow in chute; date noted for imagery is 14July2005, discharge at Glendive≈17,000cfs, Sidney≈16,000cfs |
| 8 | Contains mid channel bars |
| 9 | Appears that chute is intermittent; i.e. may not be carrying water at low Yellowstone River flow. Only other available aerial photography from ArcGIS Map Service, ESRI_Imagery_World_2D, still shows intermittent flow in chute; date noted for imagery is 31July2005, discharge at Glendive≈6300cfs. July 2005 imagery was on receding limb of hydrograph that reached >40,000cfs near the end of June/beginning of July. |
| 10 | May be much larger than 5000cfs; lack of available data prevents determination of range. |





Return to TOC




Att6, AppD

Plate 2

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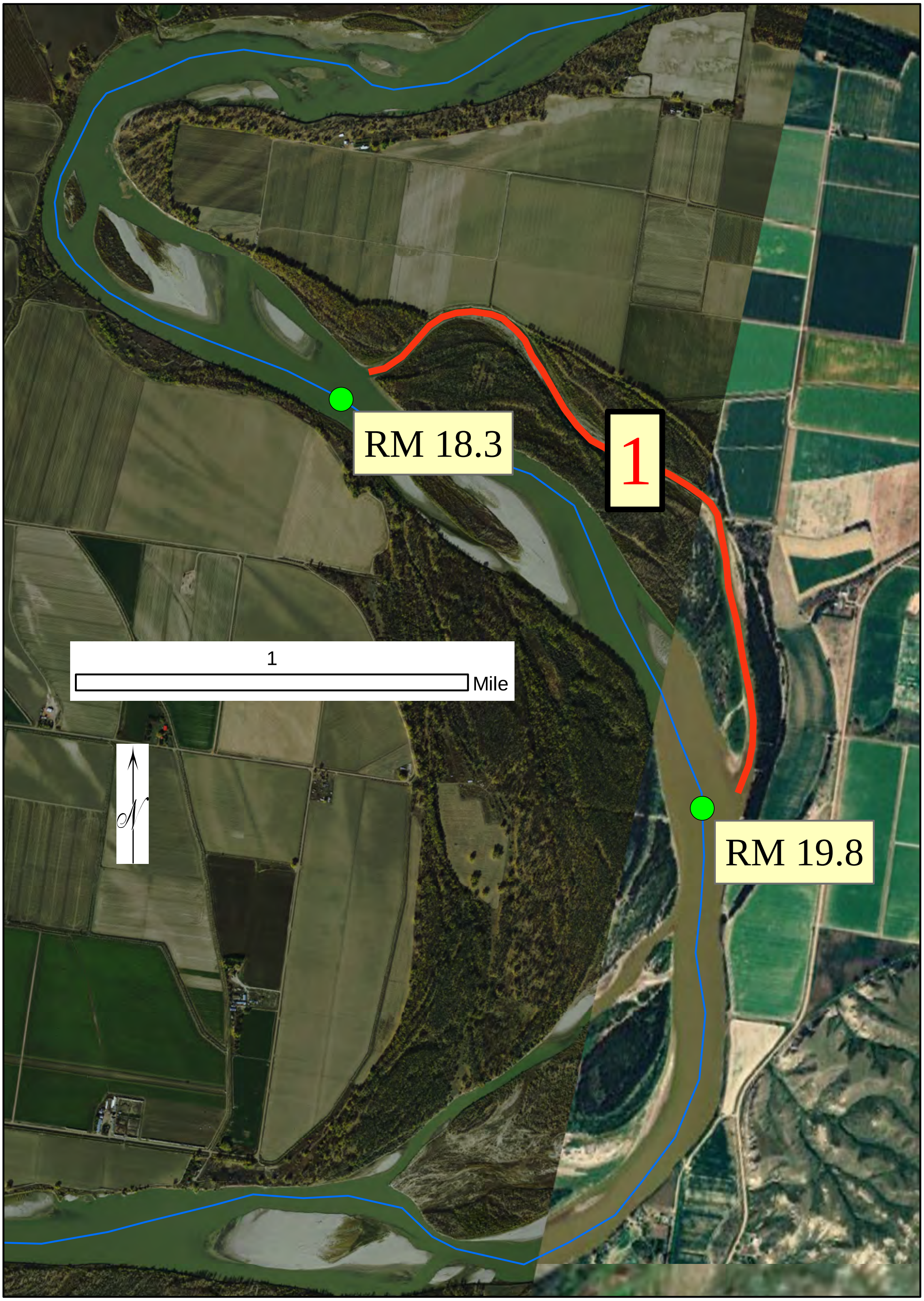


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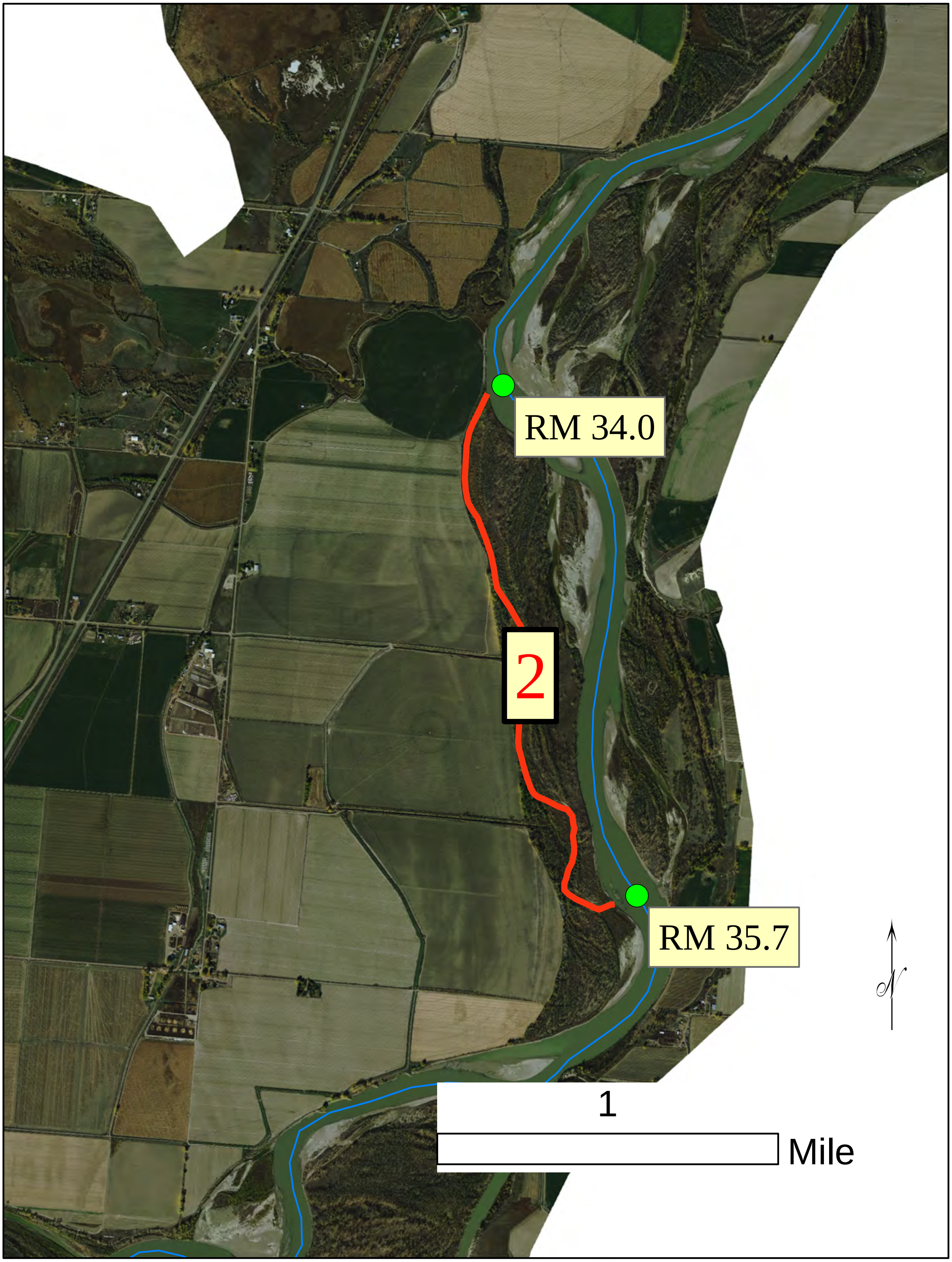


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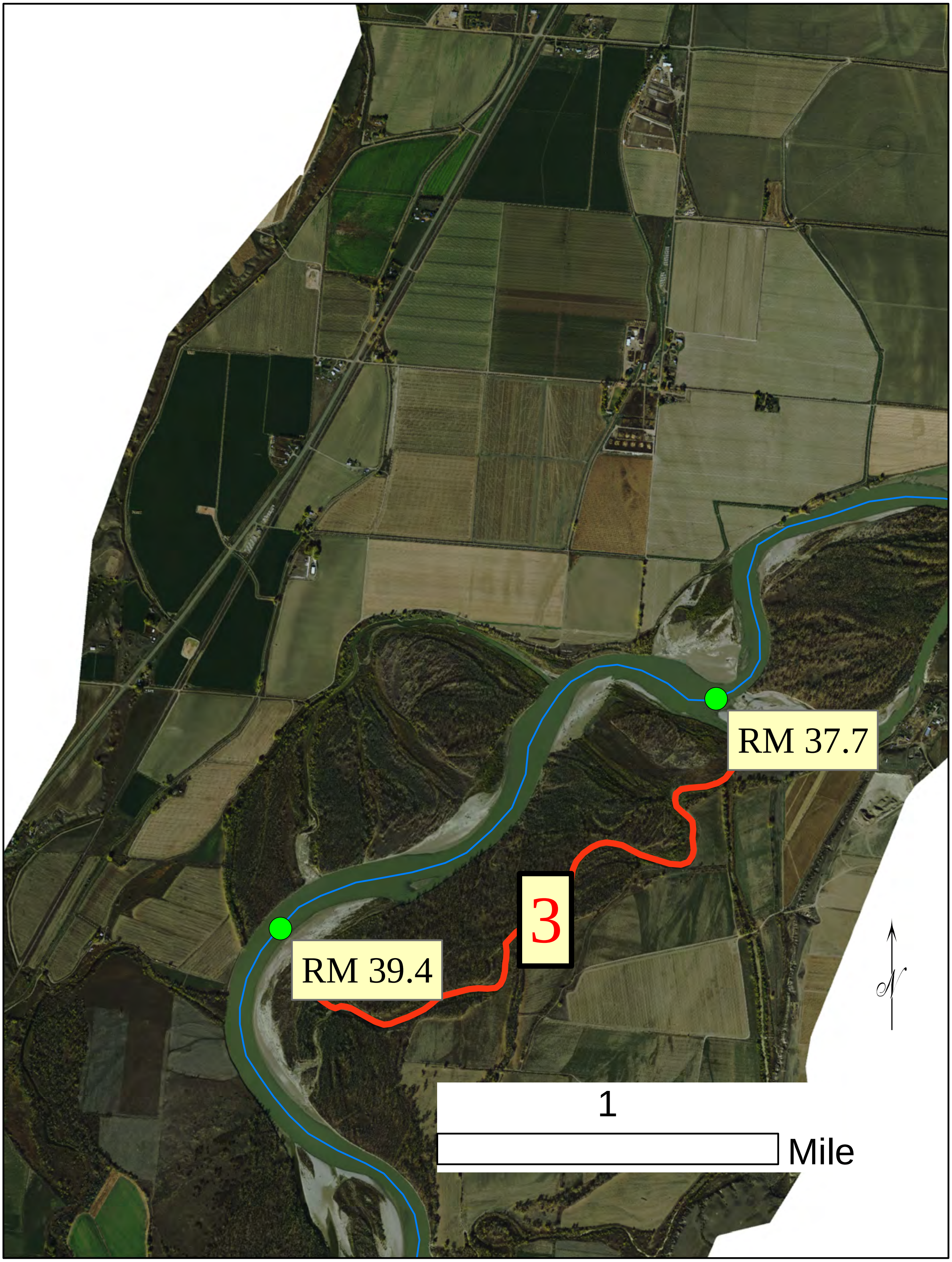


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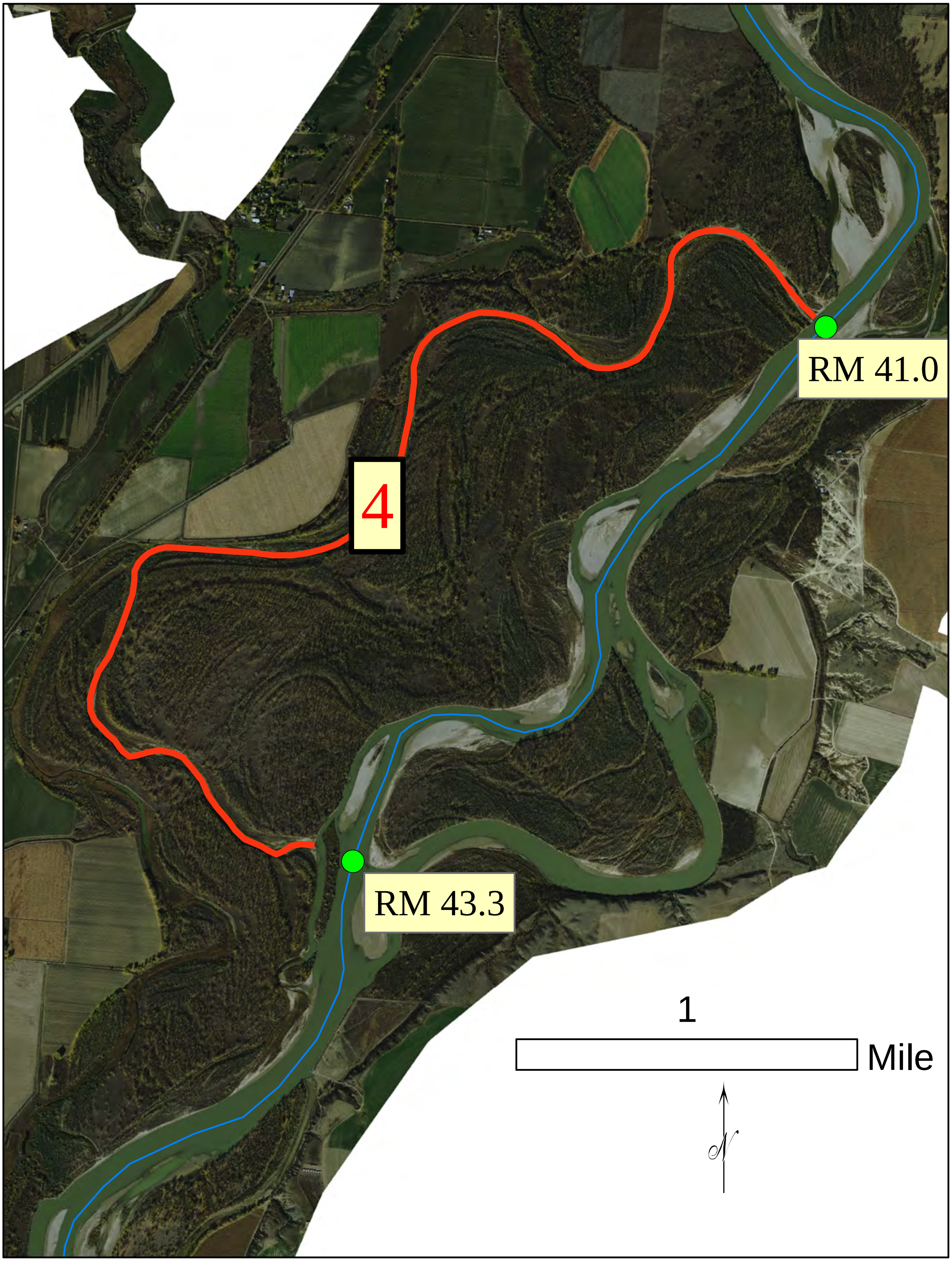


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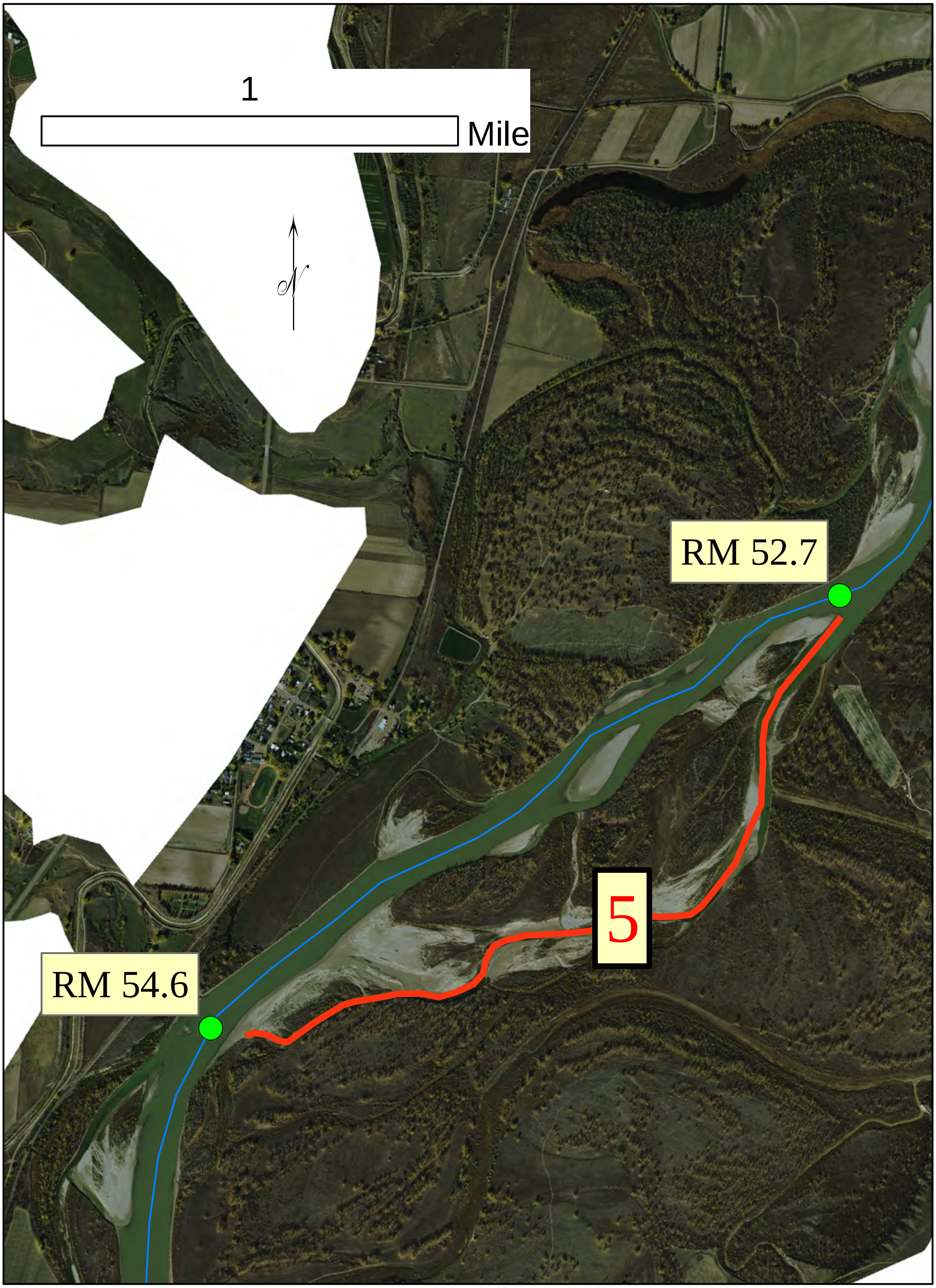


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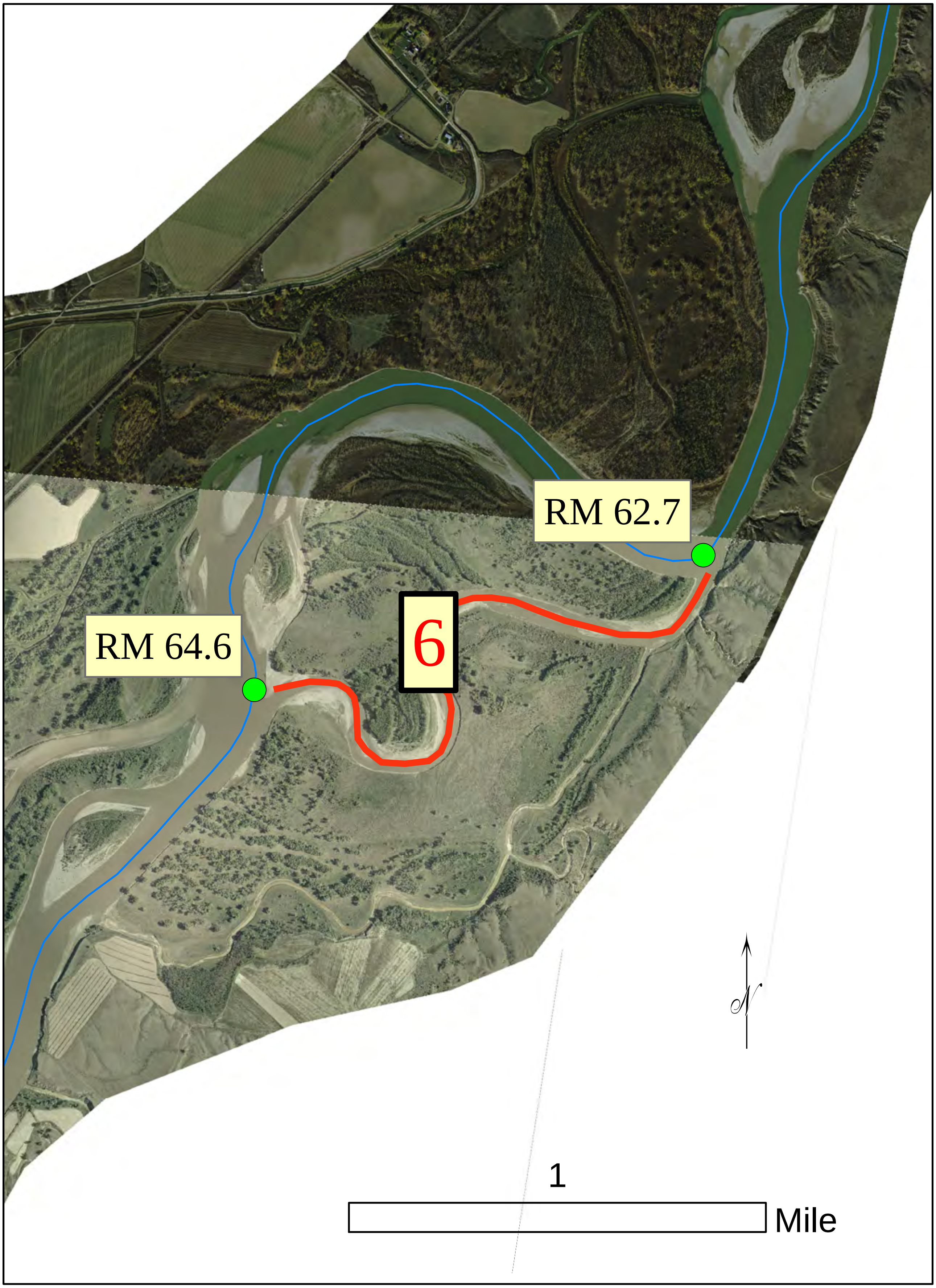


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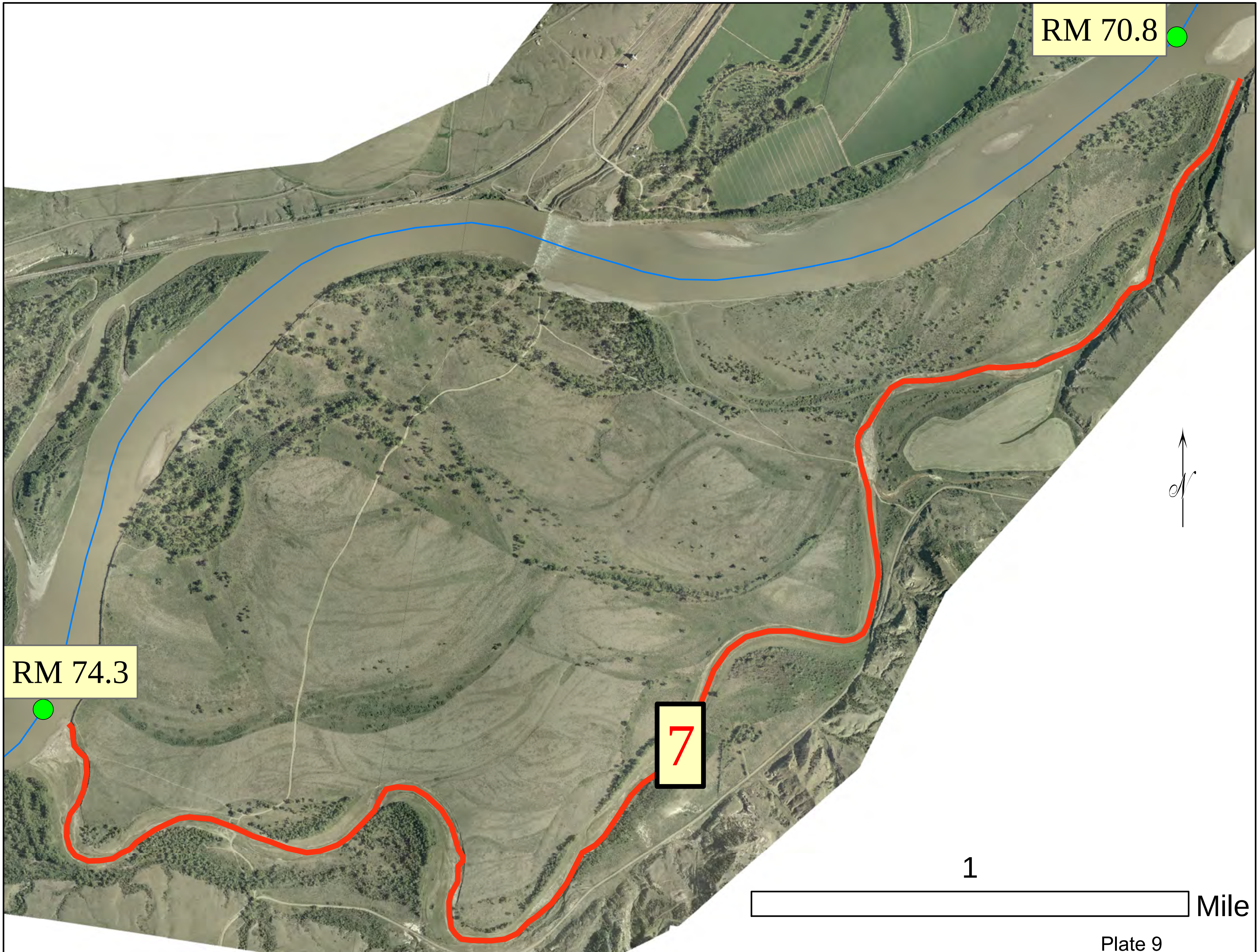
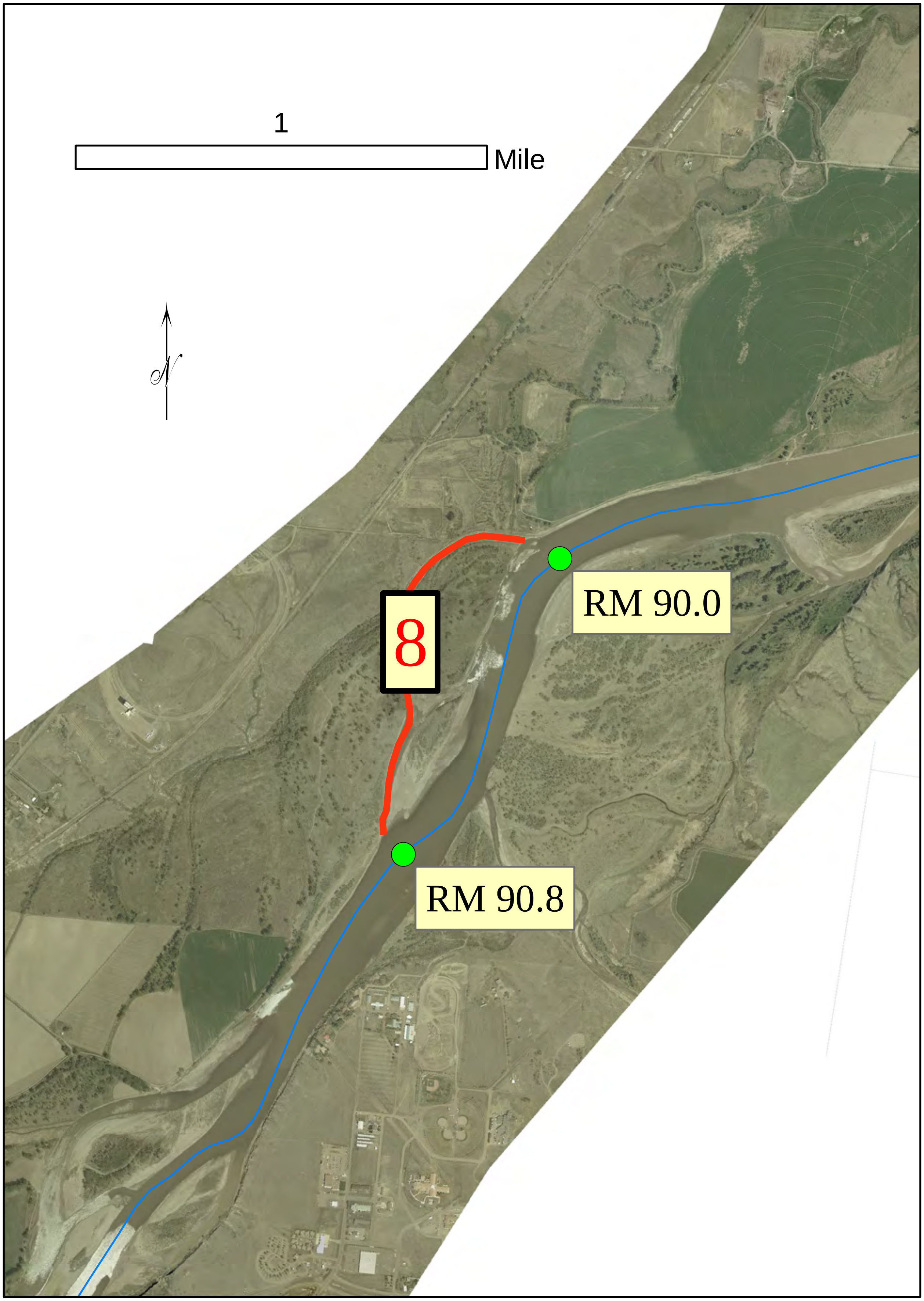



Plate 9

Return to TOC

Return to reference reach comparison table

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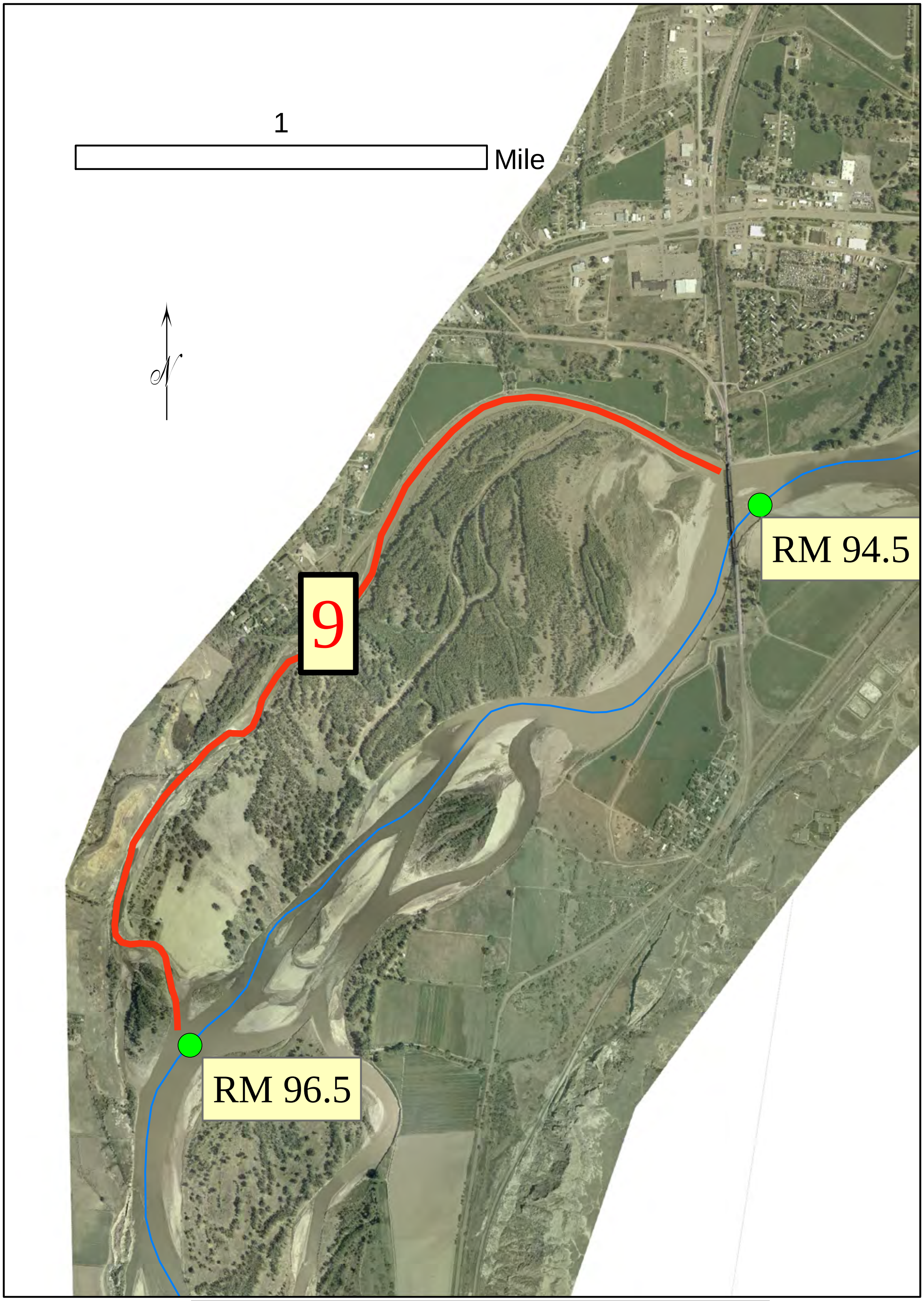


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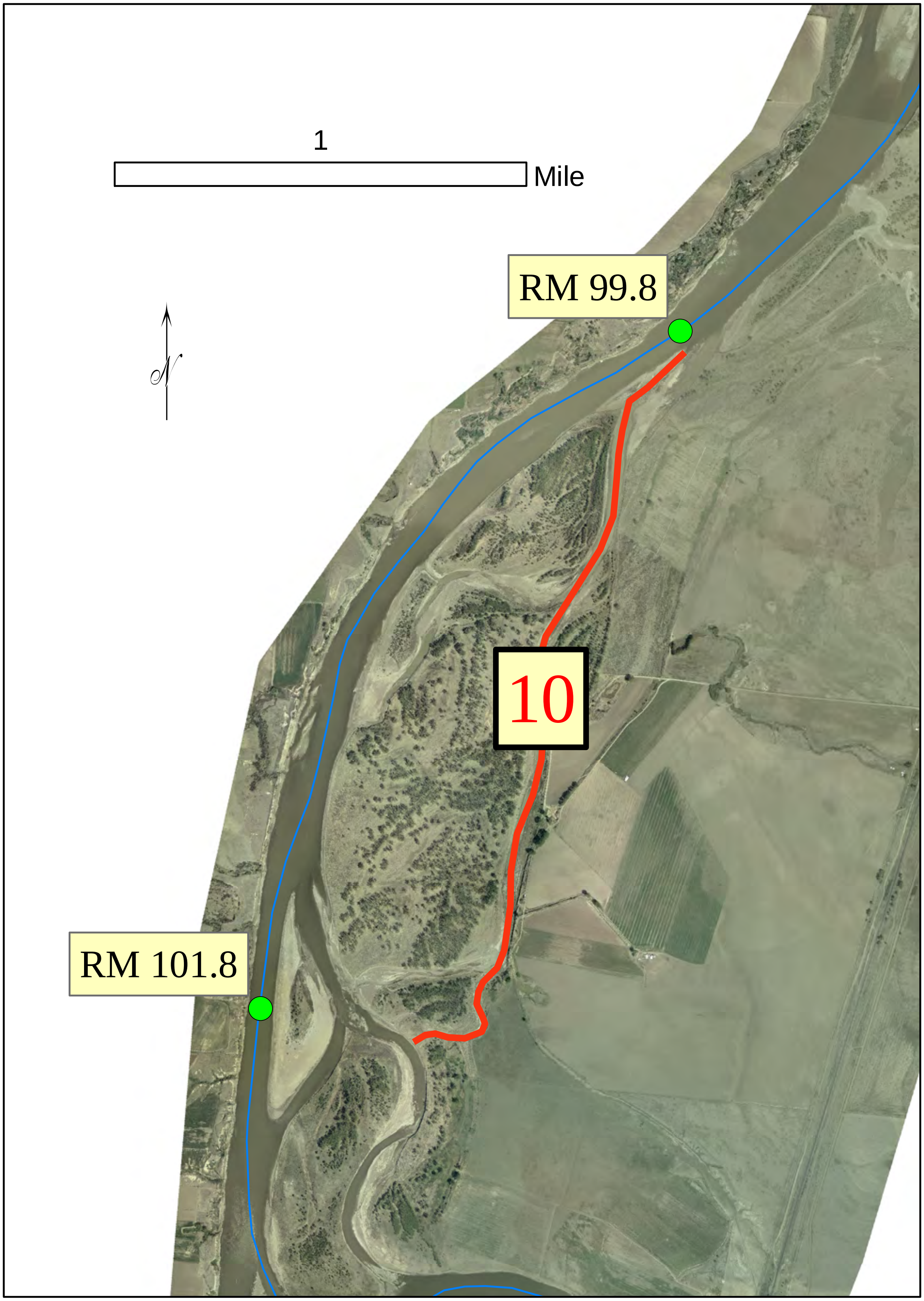


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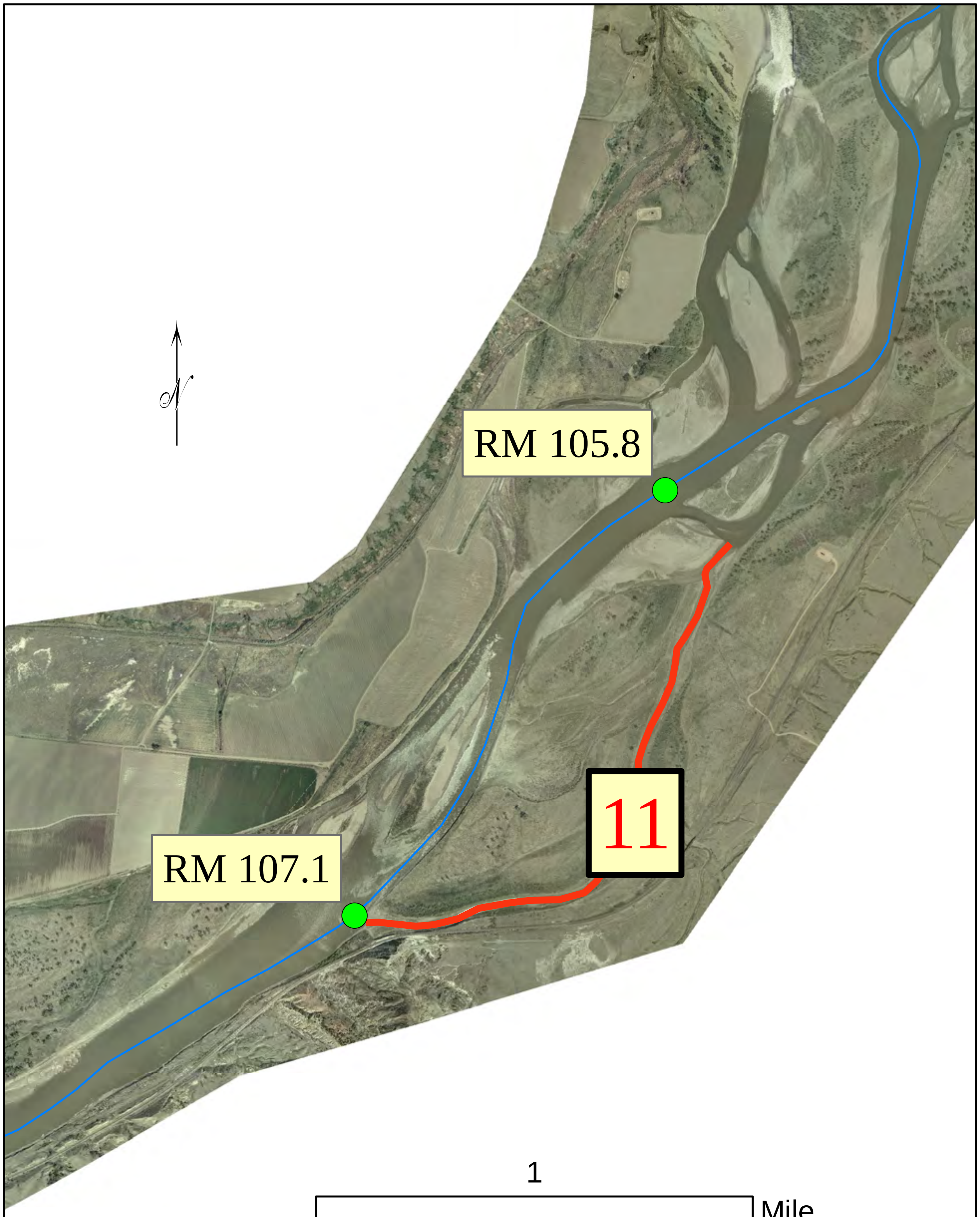


Return to reference reach comparison table

Return to TOC

Attachment 6  Bypass Channel

# Appendix E

Bypass Channel-Stable Channel Materials Analysis

19March2012

Return to TOC

US Army Corps of Engineers®
Omaha District

# Intake Dam Fish Bypass Channel
# Stable Channel Material Analysis
# CENWO-ED-HF
# March 2012



Return to TOC

## TABLE OF CONTENTS



## LIST OF FIGURES



## LIST OF TABLES

# 1. INTRODUCTION

The purpose of this document is to analyze various methods to approximate the characteristics of the armor layer likely to form for the proposed bypass project at Intake. Various methods will be utilized ranging from HEC-RAS Stable Channel Analysis, estimates on stability thresholds, analysis of test pit results at the site, and Shields stability criteria.

# 2. HEC-RAS Stable Channel Analysis Tool

The channel design functions within HEC-RAS are based upon the methods available in the SAM Hydraulic Design Package. For this analysis, the Copeland method was utilized to define the potential for aggradation or degradation within the proposed channel. The tool only allows for analysis of trapezoidal sections, so the proposed channel was approximated using a 60' bottom width and 5:1 sideslopes. For this analysis, 5500 cfs was selected as the channel forming discharge.

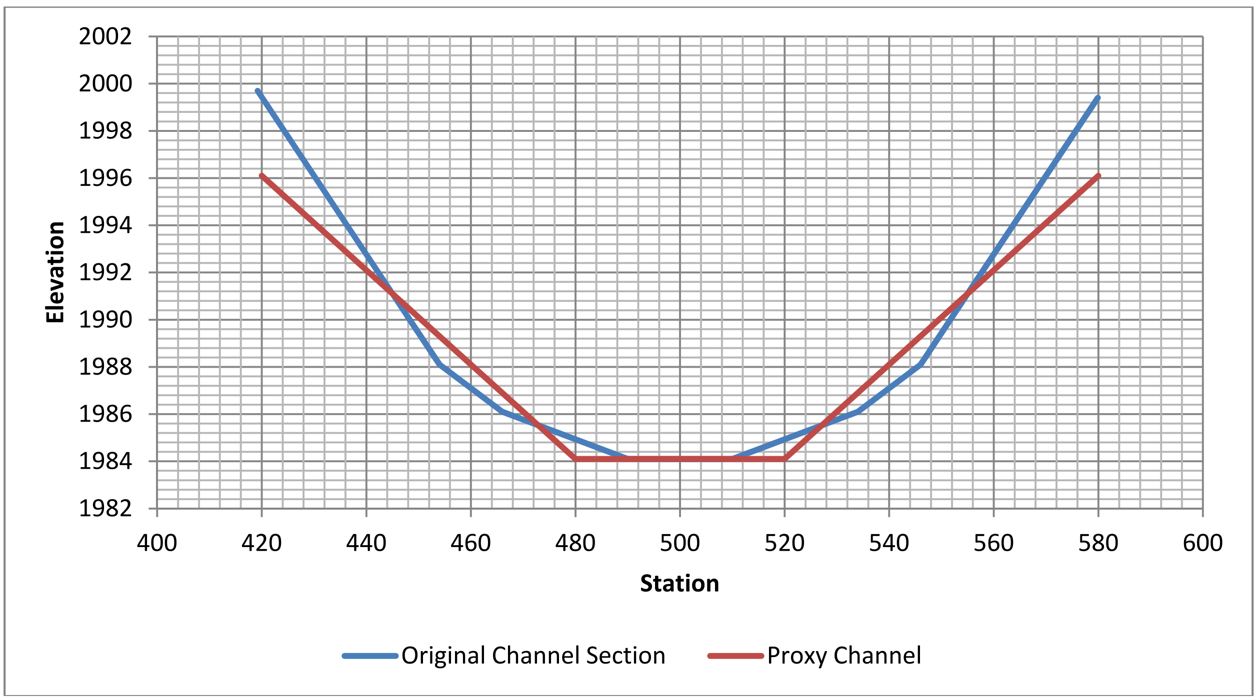


Figure 1 - Channel Approximation

Sediment samples collected on site by the USGS in the summer of 2011 were used to approximate sediment load and the upstream contributing section was assumed to have a 40' base width and a channel slope of .0006 ft/ft. HEC-RAS utilizes the upstream geometry to approximate sediment concentrations, though the concentration can also be input manually.

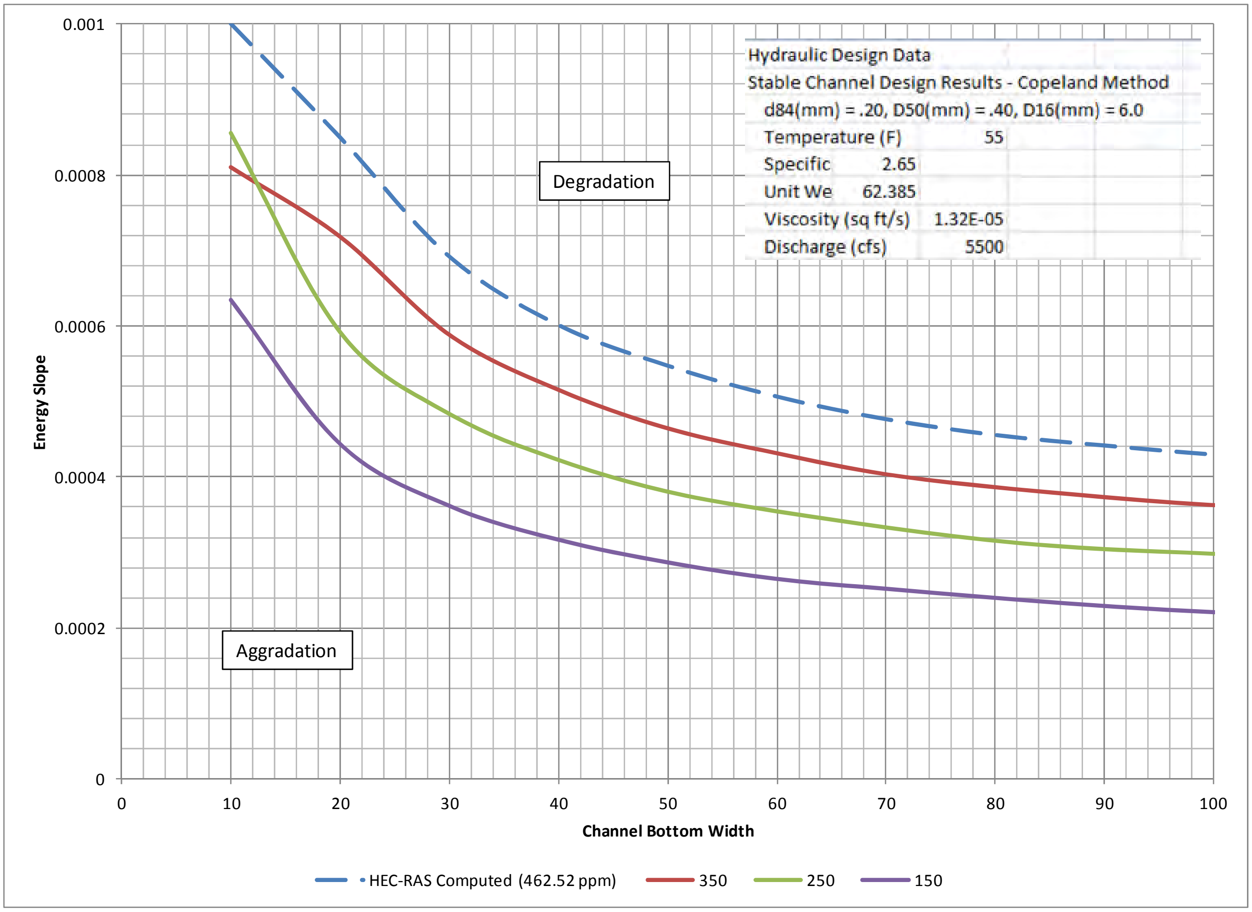

Figure 2 - HEC-RAS Copeland Method Stable Channel Curves for Proposed Bypass

For the proposed geometry, HEC-RAS computed a suspended sediment concentration of 462.52 mg/l. Samples from USGS collection efforts ranged from 397 to 537 mg/l.

## 3. Stability Thresholds for Stream Restoration Materials

Traditional approaches for characterizing erosion potential can be placed in one of two categories; maximum permissible velocity and tractive force (critical shear stress). In May of 2001, ERDC published a document summarizing these methods.

| Boundary Category | Boundary Type | Permissible Shear Stress (lb/sq ft) | Permissible Velocity (ft/sec) | Citation(s) |
|---|---|---|---|---|
| Soils | Fine colloidal sand | 0.02 - 0.03 | 1.5 | A |
| | Sandy loam (noncolloidal) | 0.03 - 0.04 | 1.75 | A |
| | Alluvial silt (noncolloidal) | 0.045 - 0.05 | 2 | A |
| | Silty loam (noncolloidal) | 0.045 - 0.05 | 1.75 – 2.25 | A |
| | Firm loam | 0.075 | 2.5 | A |
| | Fine gravels | 0.075 | 2.5 | A |
| | Stiff clay | 0.26 | 3 – 4.5 | A, F |
| | Alluvial silt (colloidal) | 0.26 | 3.75 | A |
| | Graded loam to cobbles | 0.38 | 3.75 | A |
| | Graded silts to cobbles | 0.43 | 4 | A |
| | Shales and hardpan | 0.67 | 6 | A |
| Gravel/Cobble | 1-in. | 0.33 | 2.5 – 5 | A |
| | 2-in. | 0.67 | 3 – 6 | A |
| | 6-in. | 2.0 | 4 – 7.5 | A |
| | 12-in. | 4.0 | 5.5 – 12 | A |
| Vegetation | Class A turf | 3.7 | 6 – 8 | E, N |
| | Class B turf | 2.1 | 4 - 7 | E, N |
| | Class C turf | 1.0 | 3.5 | E, N |
| | Long native grasses | 1.2 – 1.7 | 4 – 6 | G, H, L, N |
| | Short native and bunch grass | 0.7 - 0.95 | 3 – 4 | G, H, L, N |
| | Reed plantings | 0.1-0.6 | N/A | E, N |
| | Hardwood tree plantings | 0.41-2.5 | N/A | E, N |
| Temporary Degradable RECPs | Jute net | 0.45 | 1 – 2.5 | E, H, M |
| | Straw with net | 1.5 – 1.65 | 1 – 3 | E, H, M |
| | Coconut fiber with net | 2.25 | 3 – 4 | E, M |
| | Fiberglass roving | 2.00 | 2.5 – 7 | E, H, M |
| Non-Degradable RECPs | Unvegetated | 3.00 | 5 – 7 | E, G, M |
| | Partially established | 4.0-6.0 | 7.5 – 15 | E, G, M |
| | Fully vegetated | 8.00 | 8 – 21 | F, L, M |
| Riprap | 6 – in. $d_{50}$ | 2.5 | 5 – 10 | H |
| | 9 – in. $d_{50}$ | 3.8 | 7 – 11 | H |
| | 12 – in. $d_{50}$ | 5.1 | 10 – 13 | H |
| | 18 – in. $d_{50}$ | 7.6 | 12 – 16 | H |
| | 24 – in. $d_{50}$ | 10.1 | 14 – 18 | E |
| Soil Bioengineering | Wattles | 0.2 – 1.0 | 3 | C, I, J, N |
| | Reed fascine | 0.6-1.25 | 5 | E |
| | Coir roll | 3 - 5 | 8 | E, M, N |
| | Vegetated coir mat | 4 - 8 | 9.5 | E, M, N |
| | Live brush mattress (initial) | 0.4 – 4.1 | 4 | B, E, I |
| | Live brush mattress (grown) | 3.90-8.2 | 12 | B, C, E, I, N |
| | Brush layering (initial/grown) | 0.4 – 6.25 | 12 | E, I, N |
| | Live fascine | 1.25-3.10 | 6 – 8 | C, E, I, J |
| | Live willow stakes | 2.10-3.10 | 3 – 10 | E, N, O |
| Hard Surfacing | Gabions | 10 | 14 – 19 | D |
| | Concrete | 12.5 | >18 | H |

Table 1 - Permissible Shear and Velocity for Selected Materials (Source: ERDC TN-EMRRP-SR-29)

Figure 3 summarizes permissible velocities and shear stresses for various types of channel lining materials. Utilizing modeling results from a HEC-RAS simulation of the proposed bypass alternative, an ideal channel lining material can be identified.

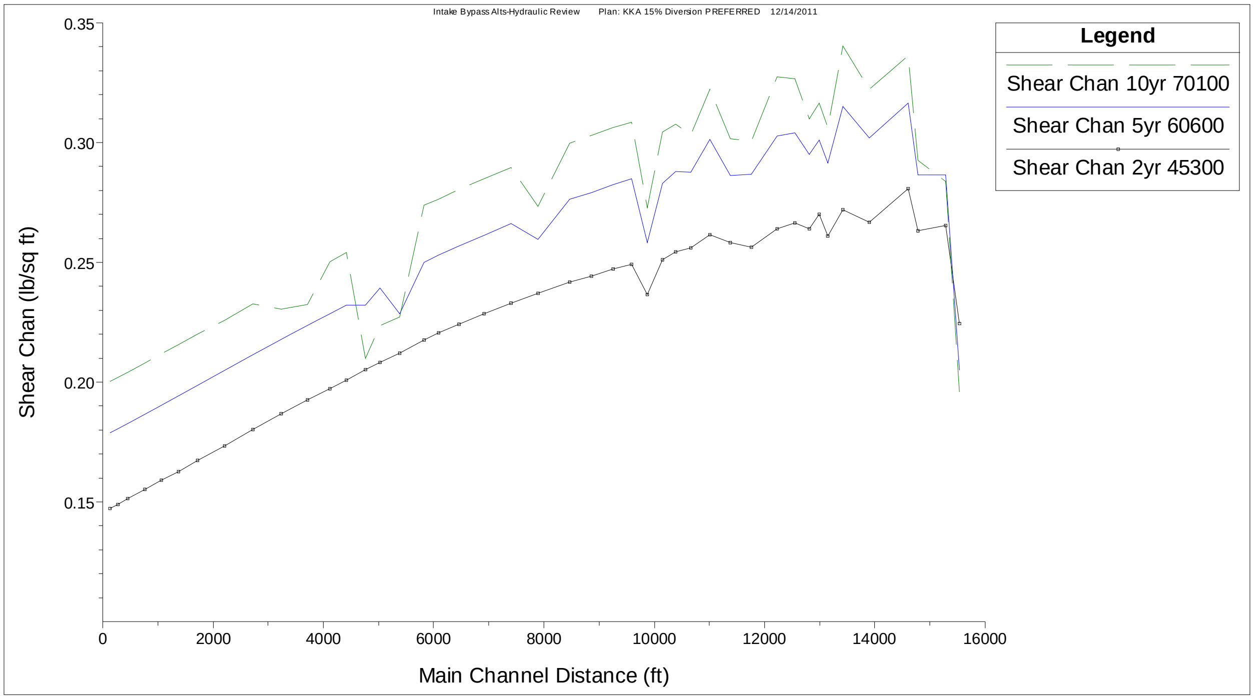

Figure 3 - Bypass Alternative Shear Stress

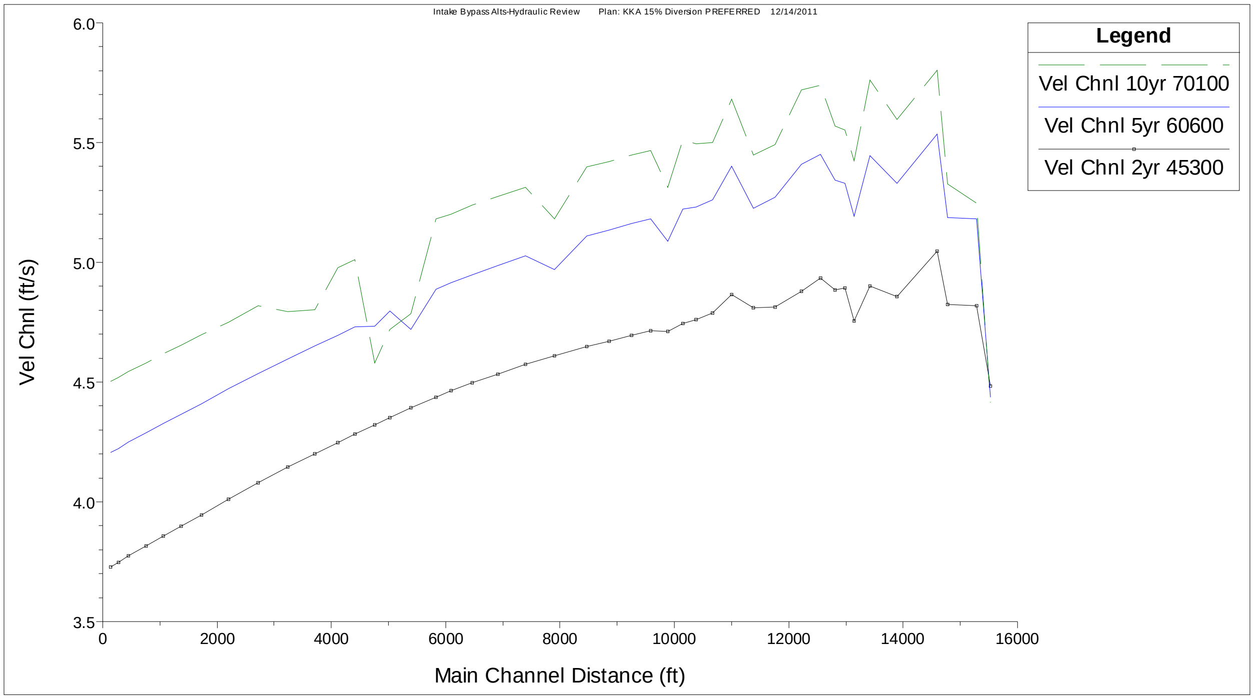

Figure 4 - Bypass Alternative Channel Velocity

Shear stresses in the proposed bypass range from 0.15 lb/sq ft to 0.33 lb/sq ft for the 2 to 10 year events on the Yellowstone River. Average channel velocities for similar events range from 3.7 to 5.7 feet per second. According to guidance summarized in Figure 3, a stable channel material would consist of 1 to 2 inch cobbles based on shear stress and velocity conditions present in the proposed bypass alternative.



Return to TOC

## 4. Field Investigations

### 4.1 Test Pit Results

In October of 2011, test pits were dug throughout the island in an attempt to define the types of materials to be encountered in the proposed excavation. Eleven sites were selected throughout the proposed alignment.

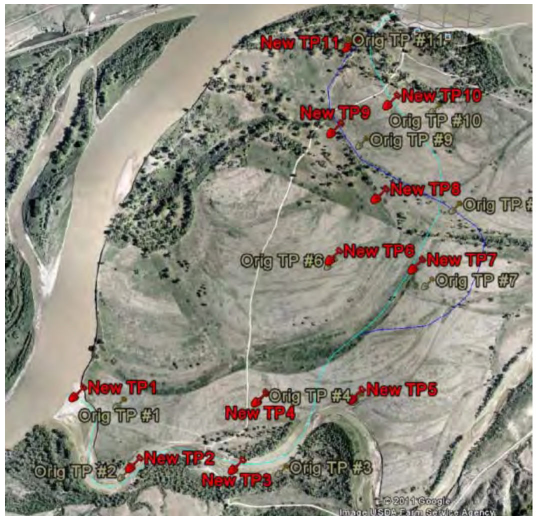


Figure 5 - Bypass Test Pit Locations

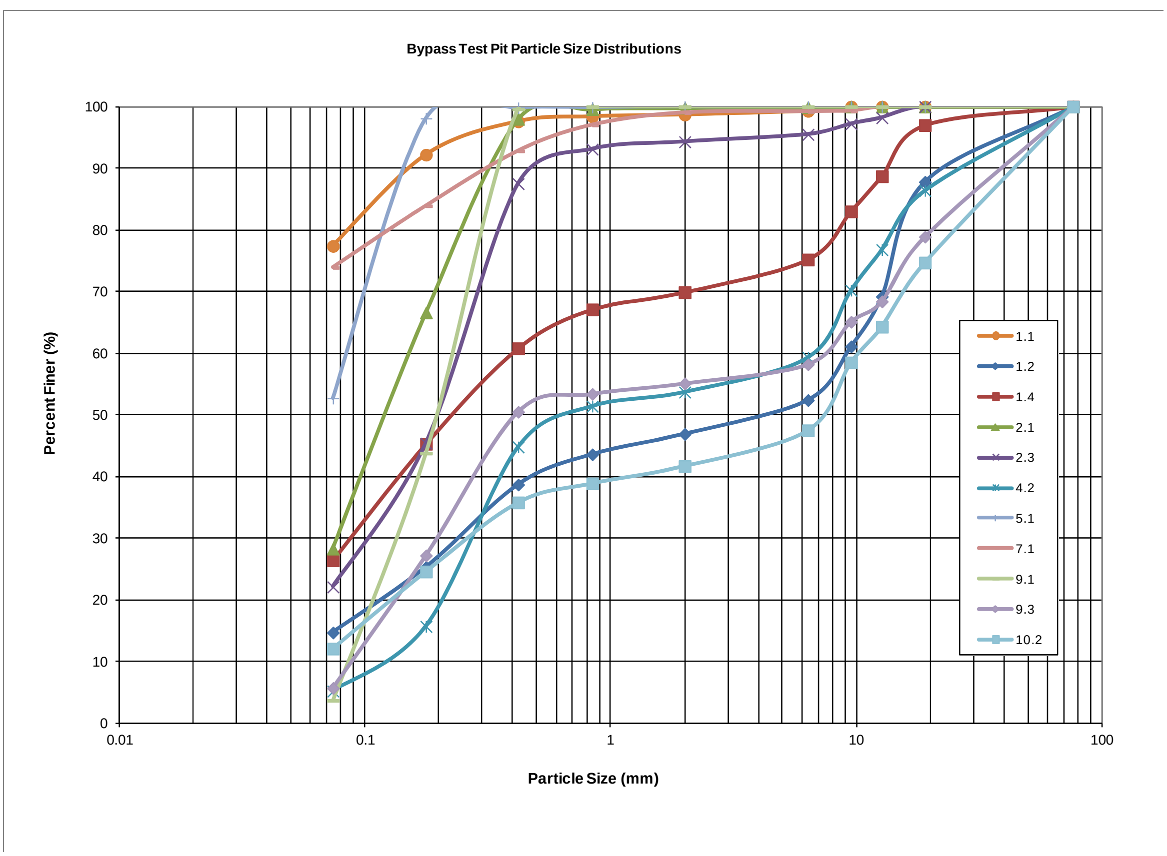


Figure 6 - Bypass Test Pit Results



Return to TOC

| Group | Boring and Sample Nos. | Depth (ft) | USCS | 3" | 3/4" | 1/2" | 3/8" | #4 | #10 | #20 | #40 | #80 | #200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1.1 | 2-3 | CL | 100 | 100 | 100 | 100 | 99.3 | 98.7 | 98.4 | 97.6 | 92.2 | 77.4 |
| B | 1.2 | 3-4 | GC | 100 | 87.8 | 69.2 | 61.1 | 52.4 | 46.9 | 43.6 | 38.7 | 25.3 | 14.7 |
| C | 1.4 | 6-7 | SC | 100 | 97 | 88.7 | 83 | 75.2 | 69.9 | 67.1 | 60.8 | 45.3 | 26.4 |
| D | 2.1 | 1.5-4 | SC-SM | 100 | 100 | 100 | 100 | 99.9 | 99.8 | 99.6 | 98 | 66.6 | 28.3 |
| B | 2.2 | 5-6 | | | | | | | | | | | |
| E | 2.3 | 15-16 | SC-SM | 100 | 100 | 98.2 | 97.2 | 95.5 | 94.3 | 93.1 | 87.5 | 45.4 | 22.1 |
| E | 3.1 | 8-9 | | | | | | | | | | | |
| D | 4.1 | 5-6 | | | | | | | | | | | |
| F | 4.2 | 12-13 | SP-SC | 100 | 86.4 | 76.8 | 70.2 | 59.3 | 53.7 | 51.4 | 44.8 | 15.7 | 5.2 |
| F | 4.3 | 24-25 | | | | | | | | | | | |
| G | 5.1 | 5-6 | ML | 100 | 100 | 100 | 100 | 100 | 100 | 99.9 | 99.8 | 98.1 | 52.7 |
| D | 5.2 | 12-13 | | | | | | | | | | | |
| E | 5.3 | 17-18 | | | | | | | | | | | |
| F | 5.4 | 22-23 | | | | | | | | | | | |
| F | 6.1 | 6-7 | | | | | | | | | | | |
| F | 6.2 | 10-11 | | | | | | | | | | | |
| H | 7.1 | 3-4 | CL-ML | 100 | 100 | 100 | 99.3 | 99.2 | 99 | 97 | 92.8 | 83.9 | 73.9 |
| B | 7.2.1 | 8-9 | | | | | | | | | | | |
| B | 7.2.2 | 8-9 | | | | | | | | | | | |
| D | 8.1 | 5-6 | | | | | | | | | | | |
| F | 8.2 | 7-8 | | | | | | | | | | | |
| I | 9.1 | 4-5 | SP | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99.6 | 43.8 | 3.7 |
| F | 9.2.1 | 6-7 | | | | | | | | | | | |
| F | 9.2.2 | 6-7 | | | | | | | | | | | |
| J | 9.3 | 10-12 | SP-SC | 100 | 78.9 | 68.4 | 65.1 | 58.2 | 55.1 | 53.4 | 50.5 | 27.2 | 5.7 |
| C | 10.1 | 4.5-5 | | | | | | | | | | | |
| K | 10.2 | 11-12 | GC | 100 | 74.7 | 64.3 | 58.5 | 47.5 | 41.7 | 38.9 | 35.8 | 24.6 | 12.1 |
| I | 11.1 | 3-4 | | | | | | | | | | | |
| C | 11.2 | 11-12 | | | | | | | | | | | |
| C | 11.3 | 15-16 | | | | | | | | | | | |

Table 2 - Bypass test pit results

Analysis revealed much of the material of the island to be sandy in nature with spots of clays, silts, and gravels. Of the deeper samples collected (1.2, 1.4, 2.3, 4.2, 9.3, 10.2), D50's ranged from 0.2 – 6.5 mm and D90's ranged from 0.4 – 13 mm.

Most pit excavations were halted once the water table was reached, due to the material no longer being stable along the vertical walls. Photos collected at the site hint at the presence of material coarser than that documented in the analyzed samples at the bottom of many of the pits.



Return to TOC

Figure 7 - Bypass Test Pit Photos



Return to TOC

### 4.2 Boring Logs

In November of 2011, 22 boring logs were collected on Joe's Island where the planned bypass would be excavated. Standard penetration test data and disturbed samples were collected in accordance with ASTM D 1586.

The borings were relatively uniform in their findings. In general, the investigation found much of the island to be covered with 6 – 10 feet of Silts (ML), Clays (CL), and Sands (SM). Below this layer, often encountered was a layer of Silty Sandy Gravel (GW) composed of fine to coarse sands and gravel. Though not analyzed for gradation, soils found in this layer would likely contain material appropriate for the formation of an armor layer in the proposed channel and would likely intersect with the proposed excavation invert.

The boring log findings are consistent with the photos captured during the test pit efforts.

## 5. Shields Stability Analysis

An estimate of the minimum material size for stable bed material can be derived from the equation:

$$d_n \times \frac{S}{(S.G.-1)\sigma} = D_{50}$$

where $d_n$ represents normal depth, $S$ the design slope, $S.G.$ the specific gravity of the material, and $\sigma$ as the shields factor ranging from .03 to .08 for maximum and minimum ranges. For an assumed flow rate of approximately 7200 cfs (approximating the 2 year flow rate in the bypass) the equation produces a range of 2 to 0.6 inches for the recommended $D_{50}$ for bed stability.

## 6. Armor Layer Quantity Estimates

Based upon gradation results from the test pits collected, an effort was made to estimate how much material would need to be processed in order to provide for an artificial armor layer to be placed in the proposed bypass. Placement of this layer would increase the short-term stability of the channel following construction by preempting the suspension of materials too small to resist shear stresses to be encountered once the proposed bypass is completed.

The assumption of the analysis was that any material smaller than 20mm would be screened and removed from the source material. The result presented gradations with a $D_{50}$ ranging from 37 to 45 mm (1.4 to 1.8")



Return to TOC

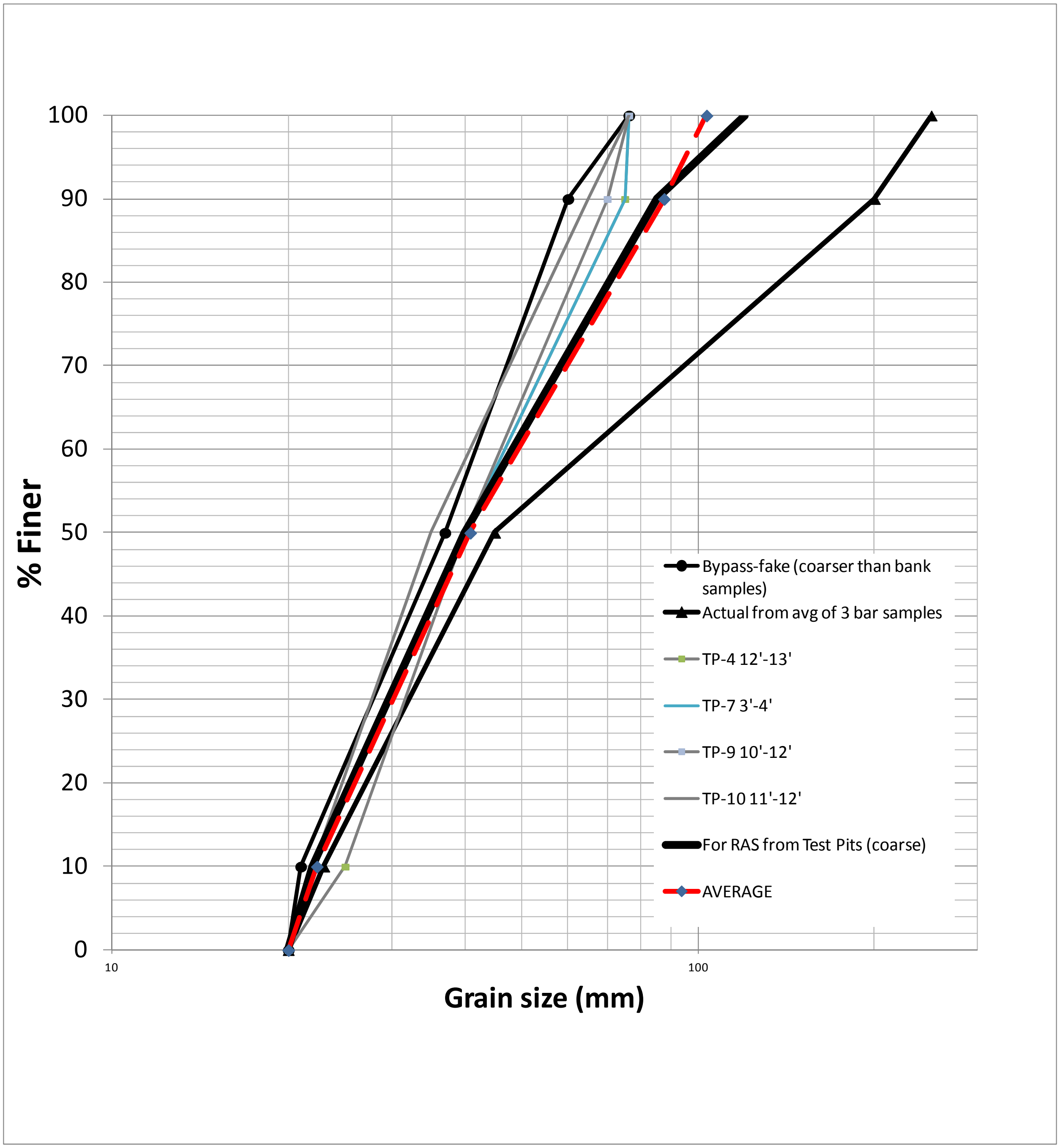


Figure 8 - Bypass bed gradations based upon screening material <20 mm in diameter

From this gradation a variety of placement configurations could be selected based upon level of design. Volume estimates vary greatly based upon the percentage of material assumed to be of the proper size as well. The table below summarizes possible configurations and volumes.



Return to TOC

| Width | Length | Layer Thickness | Volume | Weight | %Material >20mm | %Material >20mm | %Material >20mm | Volume of Processed Material (CY) | Volume of Processed Material (CY) | Volume of Processed Material (CY) |
|---|---|---|---|---|---|---|---|---|---|---|
| ft | ft | ft | CY | TONS | Min | Ave | Max | Min | Ave | Max |
| 60 | 15500 | 0.5 | 17222 | 28417 | 0.03 | 0.18 | 0.38 | 574074 | 95679 | 45322 |
| 60 | 15500 | 0.75 | 25833 | 42625 | 0.03 | 0.18 | 0.38 | 861111 | 143519 | 67982 |
| 60 | 15500 | 1 | 34444 | 56833 | 0.03 | 0.18 | 0.38 | 1148148 | 191358 | 90643 |
| 90 | 15500 | 0.5 | 25833 | 42625 | 0.03 | 0.18 | 0.38 | 861111 | 143519 | 67982 |
| 90 | 15500 | 0.75 | 38750 | 63938 | 0.03 | 0.18 | 0.38 | 1291667 | 215278 | 101974 |
| 90 | 15500 | 1 | 51667 | 85250 | 0.03 | 0.18 | 0.38 | 1722222 | 287037 | 135965 |
| 120 | 15500 | 0.5 | 34444 | 56833 | 0.03 | 0.18 | 0.38 | 1148148 | 191358 | 90643 |
| 120 | 15500 | 0.75 | 51667 | 85250 | 0.03 | 0.18 | 0.38 | 1722222 | 287037 | 135965 |
| 120 | 15500 | 1 | 68889 | 113667 | 0.03 | 0.18 | 0.38 | 2296296 | 382716 | 181287 |

Table 3 - Screened armor layer volume estimates

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Attachment 6  Bypass Channel

# Appendix F

DRAFT USGS Sediment Sampling Report

19March2012

Return to TOC

Prepared in cooperation with the U.S. Army Corps of Engineers, Omaha District

# Sediment Characteristics for the Yellowstone River at a Proposed Bypass Chute near Glendive Montana, 2011

By Brent R. Hanson and Joel M. Galloway

Open-file Report 2012-XXXX

U.S. Department of the Interior
U.S. Geological Survey

Return to TOC

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2012
Revised and reprinted: 2012

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Return to TOC

## Contents



## Figures

## Tables

# Conversion Factors

| Multiply | By | To obtain |
|---|---|---|
| inch (in.) | 25.4 | millimeter (mm) |
| foot (ft) | 0.3048 | meter (m) |
| square mile ($mi^2$) | 259.0 | hectare (ha) |
| pint (pt) | 0.4732 | liter (L) |
| quart (qt) | 0.9464 | liter (L) |
| gallon (gal) | 3.785 | liter (L) |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| ton per day (ton/d) | 0.9072 | metric ton per day |

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Vertical coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Vertical Datum of 1988 (NAVD 88)."

Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Datum of 1983 (NAD 83)."

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).



Return to TOC

# Sediment Characteristics for the Yellowstone River at a Proposed Bypass Channel near Glendive Montana, 2011

By Brent R. Hanson and Joel M. Galloway

## Abstract

In 2011, sediment data was collected by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers on the Yellowstone River at the location of a proposed bypass chute. The sediment data was collected to provide an understanding of the sediment dynamics of the given reach of the Yellowstone River. Samples of suspended sediment (point and integrated) and bedload were collected at three sites during July 19-21, August 9-11, and August 23-24, 2011. Suspended sediment concentrations in the integrated samples collected at the three sites generally decreased with decreasing streamflow. Point samples collected at the three sites showed the variability of suspended sediment concentrations in the cross-section at each site. In general, the highest suspended concentrations were found near the channel bed and towards the center of the channel with lower suspended sediment concentrations near the channel banks and water surface. The particle sizes of suspended sediment from point samples showed similar distributions at each site for the three sampling periods. The majority of sediment in the bedload had a particle size smaller than 16 mm. Suspended sediment was the primary component of the total sediment load for all three sampling locations on the Yellowstone River during the late summer of 2011. Suspended sediment contributed at least 98 percent of the total sediment load at each of the three sites.



Return to TOC

# Introduction

A diversion dam located on the Yellowstone River near Glendive, Montana currently impedes the upstream migration of the endangered *Scaphirhynchus albus,* commonly known as the pallid sturgeon (Bureau of Reclamation, 2011) (fig.1). A proposed bypass chute would result in the excavation of a natural side channel and provide a bypass around the diversion dam. The bypass channel would improve passage for the pallid sturgeon and other fish in the Yellowstone River to proceed with their upstream migrations.

In 2011, sediment data was collected by the U.S. Geological Survey (USGS) in cooperation with the U.S. Army Corps of Engineers (USACOE) on the Yellowstone River in the vicinity of a proposed bypass chute near Glendive, Montana. The sediment data were collected to provide an understanding of the sediment dynamics of the Yellowstone River reach above and below the bypass chute. The USACOE will use the sediment data with hydraulic modeling to evaluate the potential degradation and aggradation effects the bypass chute may have within the Yellowstone River reach (Curtis J. Miller, U.S. Army Corps of Engineers, written commun., 2011). The models will be used to select a favorable channel configuration for the bypass that will minimize the negative impacts on sediment transport that the bypass chute may generate.

Figure 1. Location of study area

# Methods of Data Collection

The following sections describe methods used by the USGS for the collection and analysis of sediment samples and measurement of streamflow. Data were collected by the USGS at three sites on the Yellowstone River in the vicinity of the proposed bypass chute near Glendive, Montana.

Samples of suspended sediment (point and integrated) and bedload were collected at the three sites; one site upstream of the bypass chute entrance (above bypass chute), one site at the entrance of the bypass chute (adjacent to bypass chute) and one site downstream of the bypass chute entrance (below bypass chute) (fig. 1). Streamflow was measured at each site prior to collection sample collection. Samples were collected during July 19-21, August 9-11, and August 23-24, 2011 (fig. 2).

Figure 2. Daily mean streamflow for the Yellowstone River near Glendive, Montana (U.S. Geological Survey station number 06327500) and sample collection dates near a proposed bypass chute, 2011.

Integrated suspended-sediment concentration (SSC) samples were collected three times in 2011 to estimate the amount of suspended material being transported past the three sites during different streamflow conditions. To collect samples that represent the vertical and horizontal variability of suspended sediment in the stream channels, samples were collected using depth-integrated samplers (D-96 and DH-2) (Davis, 2005) and the equal-discharge increment (EDI) method (Edwards and Glysson, 1999). The EDI method involved the collection of vertically integrated, isokinetic (velocity entering the sampler nozzle was the same as the velocity of the stream) samples at 5 intervals representing equal percentages of the total streamflow across the stream cross section (20 percent of the total streamflow in each section).

Suspended-sediment samples were also collected at discrete vertical points (point samples) at each site to estimate the vertical distribution of particle sizes and concentrations at the three sites. Point samples were collected using a US P-61-A1 suspended-sediment sampler that is designed to open and close at varying depths in the water column (Davis, 2005). Samples were collected at six different depths including near the water surface, one foot above the channel bottom, and at four evenly spaced points in the vertical between those points at each of the 5 EDI sample collection locations for each site.



Return to TOC

Bedload samples were collected to estimate the sediment transport along or near the streambed at the three sites. Bedload samples were collected using a cable-suspended Helley-Smith Model 8035 sampler (Davis, 2005). For each sampling site, bedload samples were collected at 20 equal-width sections across the channel according to methods described by Edwards and Glysson (1999). The bedload samples were then composited in a 1-L plastic container.

All samples of suspended sediment (integrated and point) and bedload were analyzed for concentration and particle-size distribution at the USGS Iowa Water Science Center Sediment Laboratory in Iowa City, Iowa, using methods described by Guy (1969). Some suspended-sediment samples were not analyzed for the complete particle-size distribution because of insufficient sediment mass present in the sample. Results from the analysis were stored in the USGS National Water Information System (NWIS) database (*http://nwis.waterdata.usgs.gov/nd/nwis/qw*).

Streamflow data were collected for use with the sediment concentration data to calculate sediment loads. Streamflow was measured using an acoustic Doppler current profiler (ADCP) with the methods and procedures described in Mueller and Wagner (2009). Streamflow was measured for each sampling site prior to the collection of sediment samples.

Suspended-sediment loads were estimated for the three sites using the measured streamflow data and SSC data collected during the three sampling events. Loads were estimated using equation 1 (Porterfield, 1972):

$$Q_s = Q_w \text{ x } C_s \text{ x } K \quad (1)$$

where

$Q_s$ is the suspended-sediment load (sediment discharge), in tons (English short tons) per day (tons/day);

$Q_w$ is the instantaneous streamflow (water discharge), in cubic feet per second ($ft^3/s$);



Return to TOC

$C_s$ is the SSC, in milligrams per liter (mg/L); and

K is a coefficient (0.0027) to convert the units of measurement of water discharge and SSC into tons/day and assumes a specific gravity of 2.65 for sediment.

The bedload was calculated from the measured data using equation 2 (Edwards and Glysson, 1999):

$$Q_b=K\times(W_T/t_T)\times M_T \qquad (2)$$

where

$Q_b$ is the bedload discharge, in tons/day;

K is a conversion factor (0.381 for a 3-inch nozzle).

$W_T$ is the total width of the stream from which samples were collected, in feet, and is equal to the increment width times the total number of vertical samples;

$t_T$ is the total time the sampler was on the streambed, in seconds, computed by multiplying the individual sample time by the total number of vertical samples; and

$M_T$ is the total mass of sample collected from all verticals sampled in the cross section, in grams

## Sediment Characteristics

The three locations on the Yellowstone River were sampled for suspended sediment and bedload during three different hydrologic flow conditions (fig. 2; table 1) Streamflow ranged from 49,900 (above bypass chute) to 46,200 cubic feet per second (cfs) (adjacent to bypass chute) for the July 19-21 samples, and from 22,800 (above bypass chute) to 20,100(cfs) (adjacent to bypass chute) for the Aug 9-11 samples. During the Aug 23-24 sampling, all three sites had the same streamflow of 13,400 cfs. Due to safety and timing constraints, the suspended samples were collected during the falling limb of the above average high flows during the summer of 2011.

## Suspended Sediment Concentration

SSC in the integrated samples collected at three sites on the Yellowstone River in 2011 decreased with decreasing streamflow (table 1). The SSC was 428 milligrams per liter (mg/l) above the bypass chute during the highest streamflow (July 19, 2011), and 72 mg/l at the lowest streamflow (August 24, 2011). The SSC for samples collected at the locations adjacent to bypass chute and below bypass chute had similar results ranging from 438 to 83 mg/l and 452 to 75 mg/l, respectively.

**Table 1.** Measured streamflow, suspended-sediment concentrations, and fall diameters for three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

Point samples collected at the three sites showed the variability of SSC in the cross-section at each site (figs. 3-5 and table 2). In general, the highest SSC were found near the channel bed and towards the center of the channel with lower SSCs near the channel banks and water surface (figs. 3-5 and table 2). The maximum SSC for the point samples was found above the bypass chute, one foot above the channel bed near the center of channel at 694 mg/l on July 19, 2011(table 2) at a measured streamflow of 49,900 cfs (table 1). The minimum SSC was 32 mg/l below the bypass near the right edge of water on Aug 23, 2011 with a measured streamflow of 13,400 cfs.

Due to equipment malfunction, the full point sample set was not collected for the above bypass chute on July 19, 2011. Due to the incomplete sample set, a concentration contour graph was not prepared for the July 19, 2011 point sample data.

**Table 2.** Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.



Return to TOC

Figure 3. Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

Figure 4. Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

Figure 5. Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

## Particle Size Distribution of Suspended Sediment and Bedload

The particle size distribution of suspended sediment from point samples collected at three sites on the Yellowstone River in 2011 showed similar distributions at each site for the three sampling periods (figs, 6-8 and table 2). Most of the suspended sediment was smaller than 0.062 mm in size. At the highest measured flows of 49,900 to 46,200 cfs (July 19-21, 2011; table 1), 50 to 95 percent of the suspended sediment in the Yellowstone River was finer than 0.062 mm across the channel with an average of 71 percent finer than 0.062 mm. At the lowest measured flows of 13,400 cfs (August 23-24,2011), the amount of suspended sediment finer than 0.062 mm increased to an average of 82 percent ranging of 58 to 99 percent finer than 0.062 mm across the channel. In general, the coarsest material for each sample was found to be near the center of the channel and near the channel bed (figs. 6-8). For all three sampling visits, the suspended-sediment size generally tended to decrease near the channel banks and the surface of the water column.

Due to equipment malfunction, the full point sample set was not collected for the above bypass chute on July 19, 2011. Due to the incomplete sample set, a particle size distribution contour graph was not prepared for the July 19, 2011 point sample data.



Return to TOC

Figure 6. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

Figure 7. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

Figure 8. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

Overall, the bedload sediment had a particle size less than 16 mm (table 3). Most of the bedload particles sizes measured were between 0.25 to 0.50 mm. For the site above bypass chute, 41 to 85 percent of the bedload material was between 0.25 to 0.50 mm in the three samples. For the site adjacent to the bypass chute, 54 to 60 percent of the bedload material was between 0.25 to 0.50 mm in the three samples. The bedload at the site below the bypass chute had 37 to 58 percent of the material between 0.25 to 0.50 mm in the three samples.

Table 3. Sieve diameters and mass of bedload samples for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

## Sediment loads

Suspended sediment was the primary component of the total sediment load for all three sampling locations on the Yellowstone River during July and August, 2011 (table 4). Suspended sediment contributed at least 98 percent of the total sediment load at each of the three sites.

Table 4. Sediment loads for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.



Return to TOC

The sampling location above the bypass chute had the greatest suspended sediment load among the three sites at the highest streamflow and least suspended-sediment load among the three sites at the lowest measured streamflow. At the highest measured streamflow of 49,900 cfs (July 19, 2011; table 1), the site above the bypass chute had a suspended sediment load of 57,700 tons/day and at the lowest measured streamflow of 13,400 cfs (August 24, 2011) the same sampling location had a suspended load of 2,600 tons/day (table 4).

The amount of bedload measured at the three sites on the Yellowstone River in 2011 generally decreased as streamflow decreased. At the highest measured streamflow (July 19-21, 2011; table 1), the measured bedload amount ranged from 254 tons/day above bypass chute to 301 ton/day below bypass chute (table 4). At the lowest measured streamflow (August 23-24, 2011), the measured bedload ranged from 5 tons/day above bypass chute to 55 ton/day adjacent to bypass chute.

The total sediment load within the channel is comprised of the suspended sediment load and the bedload. The highest total sediment load was found during the highest measured streamflow of 49,900 cfs above the bypass on July 19, 2011 with a total load of 57,954 tons/day (table 4). The lowest total sediment load was also found above the bypass with 2,605 tons/day at a streamflow of 13,400 cfs on August 24, 2011.

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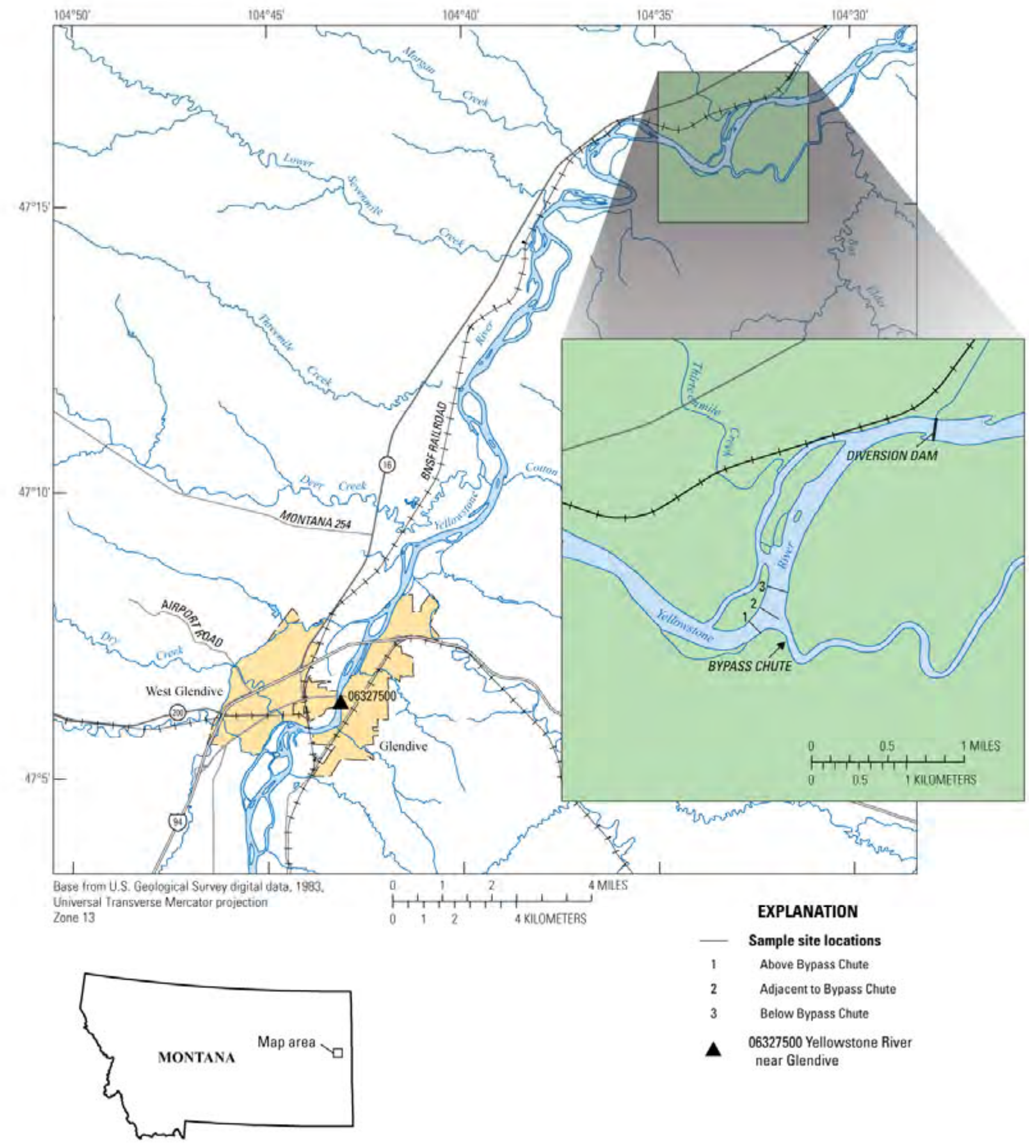



Figure 1. Location of study area

Return to TOC

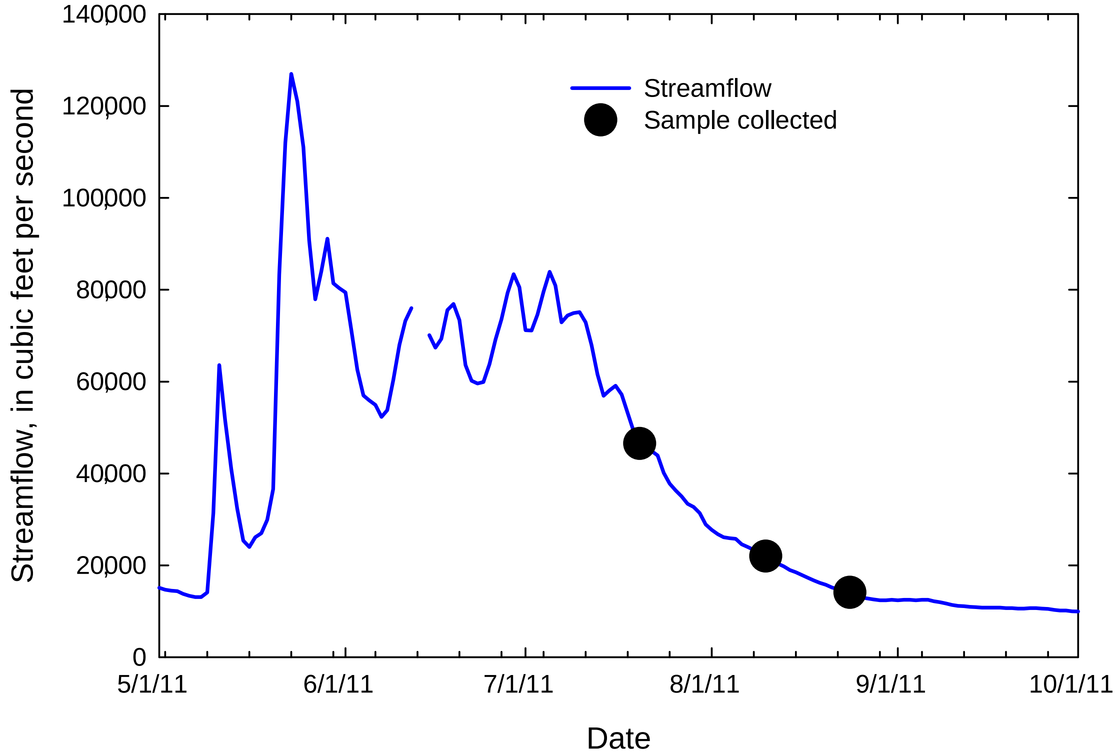



**Figure 2.** Daily mean streamflow for the Yellowstone River near Glendive, Montana (U.S. Geological Survey station number 06327500) and sample collection dates near a proposed bypass chute, 2011.

Return to TOC

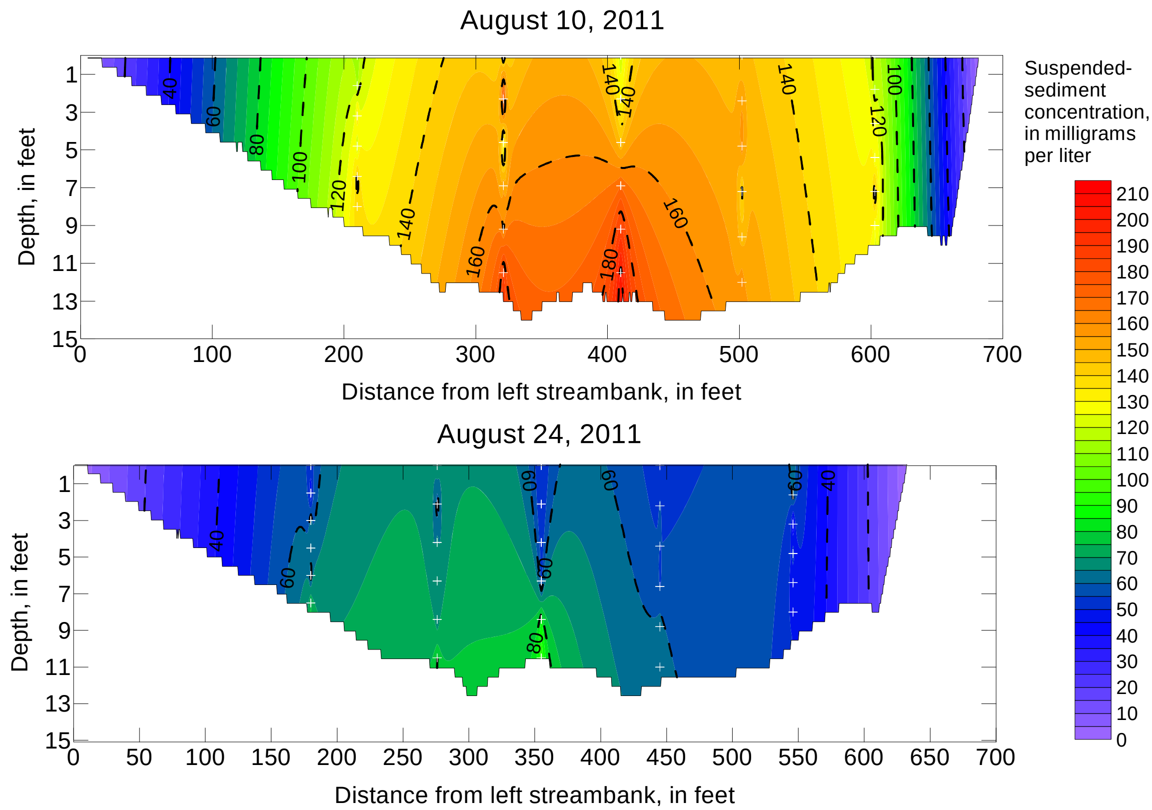



**Figure 3.** Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

Return to TOC

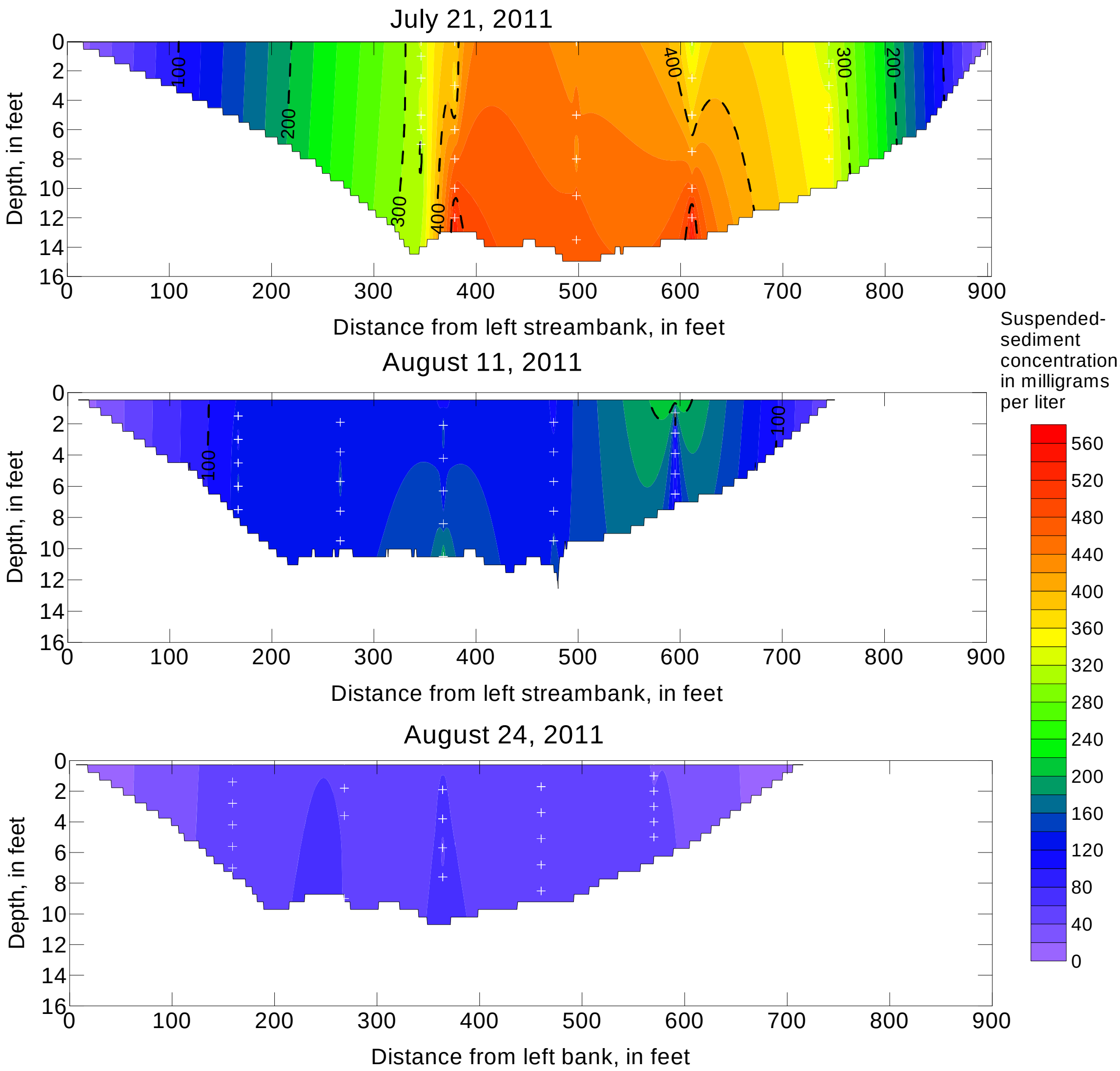



**Figure 4.** Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

Return to TOC

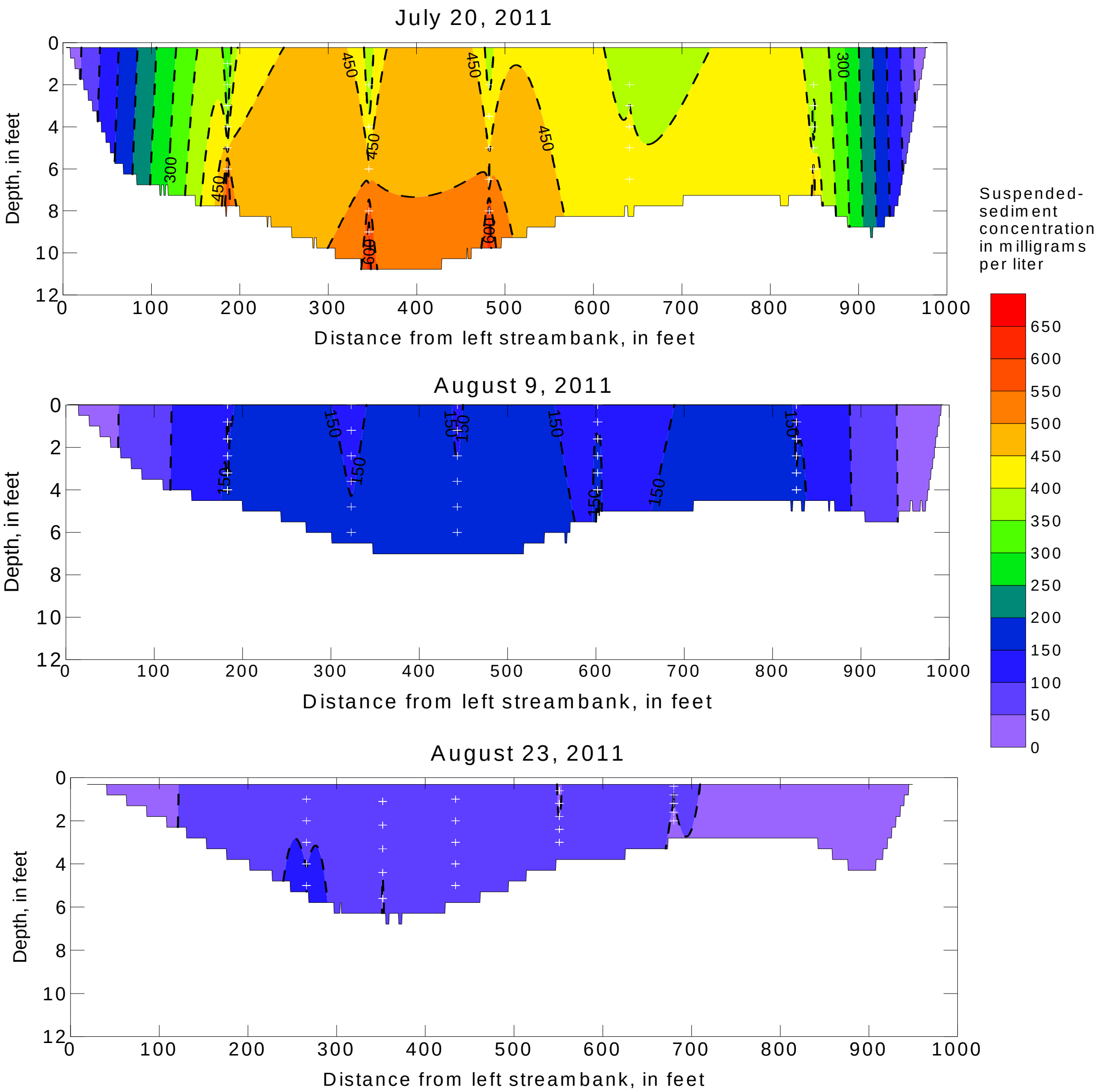



Figure 5. Distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

Return to TOC

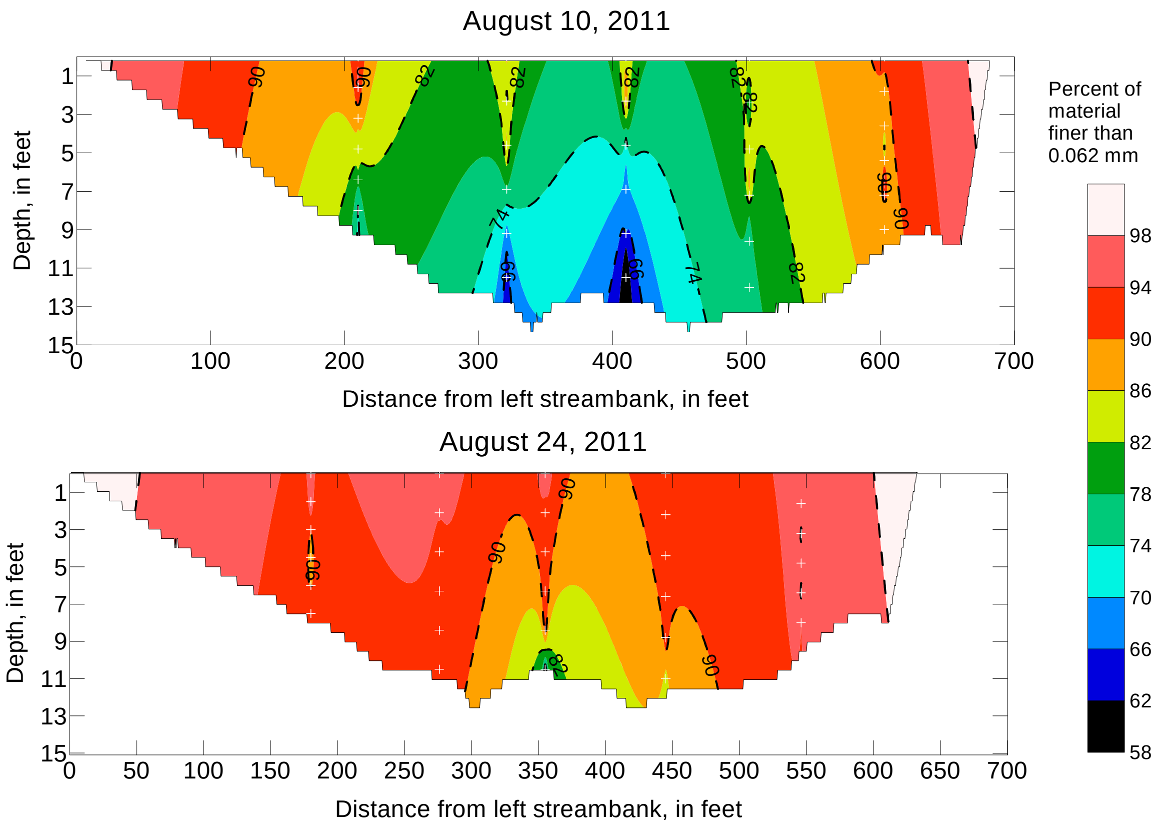



Figure 6. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

Return to TOC

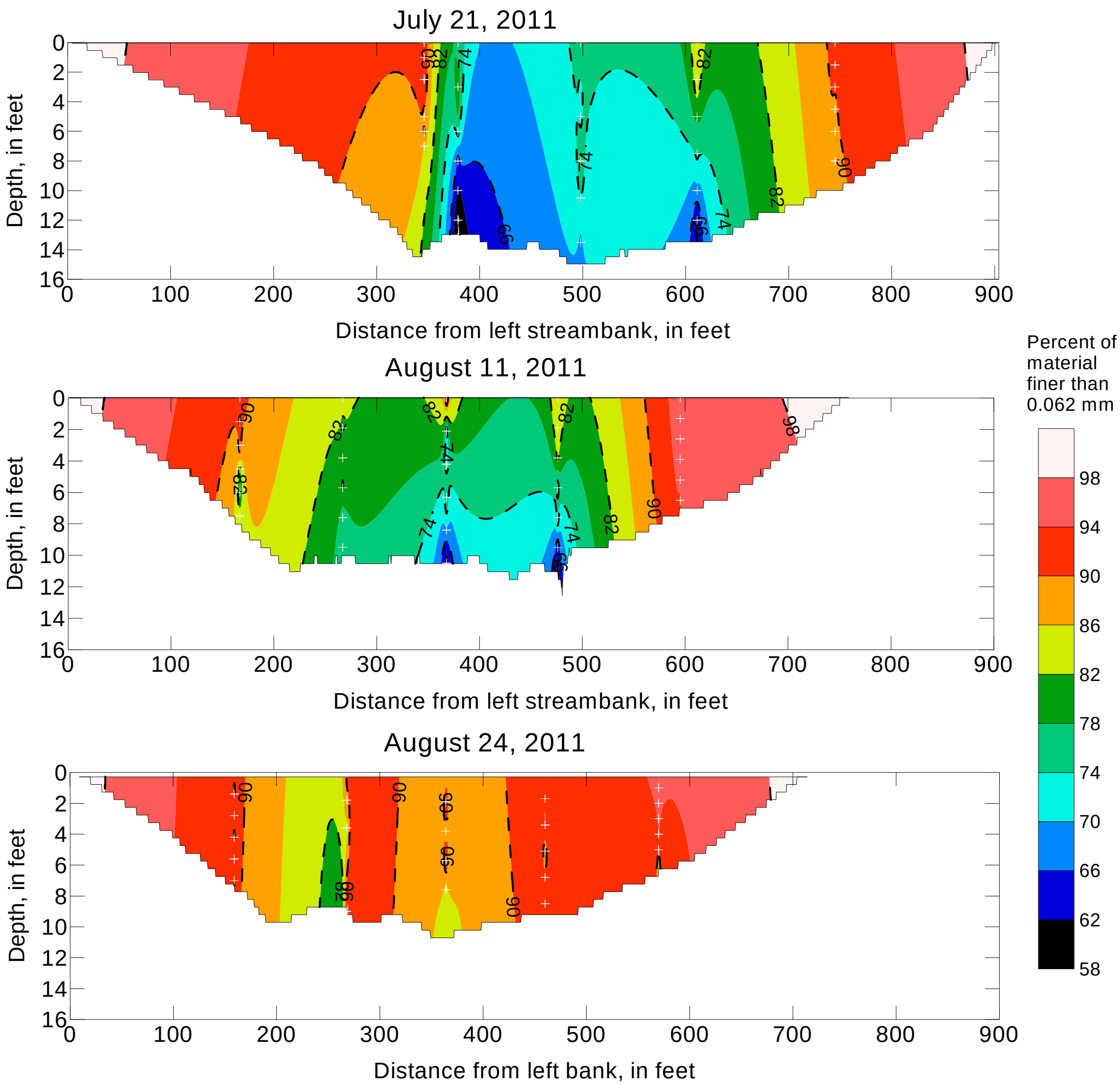



Figure 7. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

Return to TOC

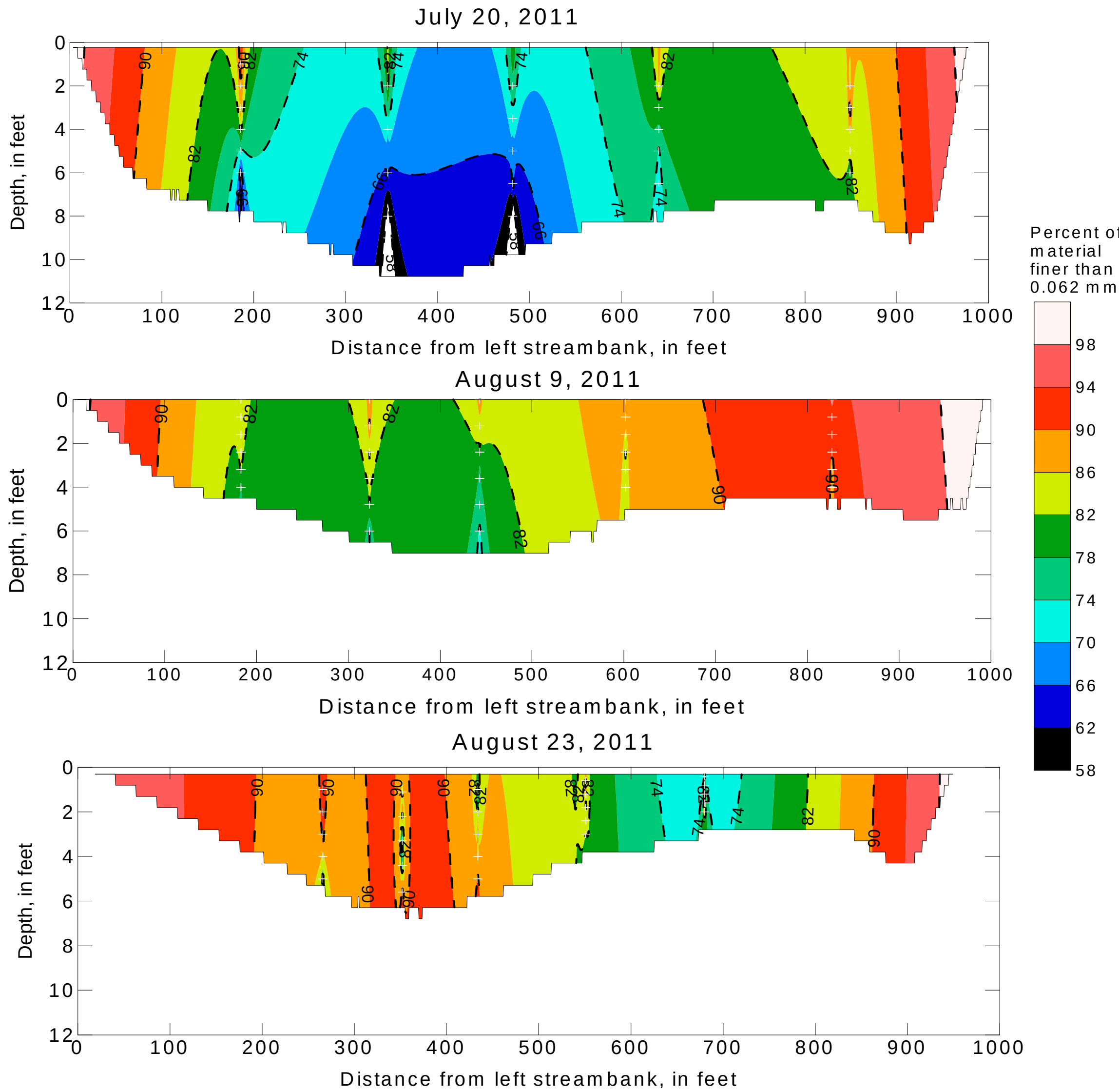



Figure 8. Distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

Return to TOC

**Table 1.** Measured streamflow, suspended-sediment concentrations, and fall diameters for three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

[ft, feet; $ft^3/s$, cubic feet per second; µS/cm, microsiemens per centimeter; deg. C, degrees Celsius; mg/L, milligram per liter; mm, millimeter]

| Dates | Water Surface elevation (ft above NAVD88) | Measured streamflow ($ft^3/s$) | Specific conductance (µS/cm at 25 deg. C) | Water Temperature (deg. C) | Suspended-sediment concentration (mg/L) | Suspended-sediment fall diameter (values in percent finer than size) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.062 mm | 0.125 mm | 0.250 mm | 0.500 mm |
| Above bypass chute | | | | | | | | | |
| 7/19/2011 | 1,995.12 | 49,900 | 337 | 23.9 | 428 | 73 | 81 | 95 | 100 |
| 8/10/2011 | 1,992.24 | 22,800 | 452 | 21.6 | 134 | 77 | 88 | 98 | 99 |
| 8/24/2011 | 1,990.20 | 13,400 | 505 | 22.0 | 72 | 82 | 93 | 100 | 100 |
| Adjacent to bypass chute | | | | | | | | | |
| 7/21/2011 | 1,994.70 | 46,200 | 345 | 22.0 | 438 | 71 | 79 | 95 | 100 |
| 8/11/2011 | 1,992.06 | 20,100 | 453 | 22.0 | 117 | 79 | 92 | 100 | 100 |
| 8/24/2011 | 1,990.92 | 13,400 | 505 | 22.5 | 83 | 84 | 98 | 100 | 100 |
| Below bypass chute | | | | | | | | | |
| 7/20/2011 | 1,994.84 | 46,900 | 354 | 23.4 | 452 | 69 | 80 | 96 | 100 |
| 8/9/2011 | 1,992.34 | 22,700 | 456 | 21.6 | 151 | 78 | 91 | 99 | 100 |
| 8/23/2011 | 1,990.99 | 13,400 | 500 | 23.8 | 75 | 81 | 93 | 100 | 100 |

Return to TOC

**Table 2.** Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

[DD, decimal degrees; ft, feet; mm, millimeter; mg/L, milligram per liter]

| Dates | Latitude (DD) | Longitude (DD) | Location in cross section, distance from left bank looking downstream (ft) | Sampling depth (ft) | Suspended-sediment concen-tration (mg/L) | Suspended-sediment fall diameter (values in percent finer than size) | | | | Percent finer than suspended sediment sieve diameter of 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.062 mm | 0.125 mm | 0.250 mm | 0.500 mm | |
| Above bypass chute | | | | | | | | | | |
| 7/19/2011 | 47.2611800 | 104.554758 | 344 | 0.0 | 352 | 87 | 94 | 100 | 100 | -- |
| | 47.2611800 | 104.554758 | 344 | 3.0 | 454 | 72 | 79 | 100 | 100 | -- |
| | 47.2611800 | 104.554758 | 344 | 6.0 | 467 | 68 | 75 | 97 | 100 | -- |
| | 47.2611800 | 104.554758 | 344 | 9.0 | 511 | 59 | 72 | 97 | 100 | -- |
| | 47.2611800 | 104.554758 | 344 | 12.0 | 577 | 58 | 73 | 96 | 100 | -- |
| | 47.2611800 | 104.554758 | 344 | 15.0 | 694 | 50 | 61 | 95 | 100 | -- |
| | 47.2610143 | 104.554569 | 426 | 0.0 | 450 | 79 | 89 | 100 | 100 | -- |
| | 47.2610143 | 104.554569 | 426 | 3.0 | 555 | 62 | 76 | 97 | 100 | -- |
| 8/10/2011 | 47.2613008 | 104.555254 | 210 | 0.0 | 112 | 93 | 94 | 100 | 100 | -- |
| | 47.2613008 | 104.555254 | 210 | 1.6 | 113 | 96 | 99 | 100 | 100 | -- |
| | 47.2613008 | 104.555254 | 210 | 3.2 | 136 | 87 | 94 | 100 | 100 | -- |
| | 47.2613008 | 104.555254 | 210 | 4.8 | 118 | 85 | 94 | 100 | 100 | -- |
| | 47.2613008 | 104.555254 | 210 | 6.4 | 145 | 82 | 95 | 100 | 100 | -- |
| | 47.2613008 | 104.555254 | 210 | 8.0 | 136 | 74 | 91 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 0.0 | 131 | 87 | 95 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 2.3 | 184 | 81 | 91 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 4.6 | 123 | 87 | 93 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 6.9 | 155 | 80 | 94 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 9.2 | 159 | 71 | 84 | 100 | 100 | -- |
| | 47.261108 | 104.55491 | 321 | 11.5 | 187 | 65 | 81 | 99 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 0.0 | 122 | 84 | 93 | 100 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 2.3 | 129 | 91 | 96 | 100 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 4.6 | 146 | 74 | 85 | 100 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 6.9 | 170 | 68 | 83 | 100 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 9.2 | 187 | 70 | 82 | 94 | 100 | -- |
| | 47.2608996 | 104.554644 | 410 | 11.5 | 202 | 59 | 69 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 0.0 | 145 | 84 | 93 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 2.4 | 154 | 80 | 86 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 4.8 | 159 | 83 | 90 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 7.2 | 138 | 88 | 93 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 9.6 | 148 | 75 | 86 | 100 | 100 | -- |
| | 47.260728 | 104.55441 | 502 | 12.0 | 158 | 76 | 84 | 95 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 0.0 | 119 | 87 | 91 | 100 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 1.8 | 114 | 90 | 92 | 100 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 3.6 | 132 | 81 | 92 | 100 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 5.4 | 123 | 97 | 99 | 100 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 7.2 | 148 | 87 | 97 | 100 | 100 | -- |
| | 47.260523 | 104.554162 | 603 | 9.0 | 125 | 93 | 97 | 100 | 100 | -- |
| 8/24/2011 | 47.2613346 | 104.555041 | 180 | 0.0 | 56 | 94 | 98 | 100 | 100 | -- |
| | 47.2613346 | 104.555041 | 180 | 1.5 | 43 | IM | IM | IM | IM | 98 |
| | 47.2613346 | 104.555041 | 180 | 3.0 | 65 | 90 | 97 | 100 | 100 | -- |
| | 47.2613346 | 104.555041 | 180 | 4.5 | 63 | 87 | 98 | 100 | 100 | -- |
| | 47.2613346 | 104.555041 | 180 | 6.0 | 57 | 90 | 99 | 100 | 100 | -- |
| | 47.2613346 | 104.555041 | 180 | 7.5 | 76 | 92 | 97 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 0.0 | 70 | 98 | 98 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 2.1 | 56 | 95 | 95 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 4.2 | 67 | 90 | 92 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 6.3 | 65 | 93 | 95 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 8.4 | 66 | 90 | 93 | 100 | 100 | -- |
| | 47.2611368 | 104.554795 | 276 | 10.5 | 80 | 92 | 95 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 0.0 | 52 | 97 | 98 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 2.1 | 50 | 92 | 95 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 4.2 | 55 | 91 | 95 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 6.3 | 51 | 93 | 94 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 8.4 | 86 | 93 | 95 | 100 | 100 | -- |
| | 47.260968 | 104.554606 | 355 | 10.5 | 93 | 71 | 77 | 100 | 100 | -- |
| | 47.2607695 | 104.554365 | 445 | 0.0 | 49 | IM | IM | IM | IM | 94 |
| | 47.2607695 | 104.554365 | 445 | 2.2 | 56 | 93 | 94 | 100 | 100 | -- |
| | 47.2607695 | 104.554365 | 445 | 4.4 | 55 | 92 | 99 | 100 | 100 | -- |
| | 47.2607695 | 104.554365 | 445 | 6.6 | 54 | 91 | 92 | 100 | 100 | -- |
| | 47.2607695 | 104.554365 | 445 | 8.8 | 63 | 93 | 96 | 100 | 100 | -- |
| | 47.2607695 | 104.554365 | 445 | 11.0 | 64 | 84 | 91 | 100 | 100 | -- |
| | 47.2605396 | 104.554175 | 546 | 1.6 | 64 | IM | IM | IM | IM | 94 |
| | 47.2605396 | 104.554175 | 546 | 3.2 | 39 | IM | IM | IM | IM | 99 |
| | 47.2605396 | 104.554175 | 546 | 4.8 | 54 | 96 | 96 | 100 | 100 | -- |

Return to TOC

**Table 2.** Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

[DD, decimal degrees; ft, feet, mm, millimeter; mg/L, milligram per liter]

| Dates | Latitude (DD) | Longitude (DD) | Location in cross section, distance from left bank looking downstream (ft) | Sampling depth (ft) | Suspended-sediment concen-tration (mg/L) | Suspended-sediment fall diameter (values in percent finer than size) | | | | Percent finer than suspended sediment sieve diameter of 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.062 mm | 0.125 mm | 0.250 mm | 0.500 mm | |
| | 47.2605396 | 104.554175 | 546 | 6.4 | 44 | IM | IM | IM | IM | 99 |
| | 47.2605396 | 104.554175 | 546 | 8.0 | 50 | 94 | 94 | 100 | 100 | -- |
| Adjacent to bypass chute | | | | | | | | | | |
| 7/21/2011 | 47.2627976 | 104.553531 | 346 | 0.0 | 336 | 91 | 99 | 99 | 100 | -- |
| | 47.2627976 | 104.553531 | 346 | 1.0 | 305 | 92 | 96 | 100 | 100 | -- |
| | 47.2627976 | 104.553531 | 346 | 2.5 | 311 | 95 | 97 | 100 | 100 | -- |
| | 47.2627976 | 104.553531 | 346 | 5.0 | 348 | 88 | 94 | 97 | 100 | -- |
| | 47.2627976 | 104.553531 | 346 | 6.0 | 325 | 91 | 94 | 98 | 100 | -- |
| | 47.2627976 | 104.553531 | 346 | 7.0 | 292 | 85 | 91 | 97 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 0.0 | 397 | 75 | 83 | 96 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 3.0 | 362 | 82 | 89 | 96 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 6.0 | 414 | 76 | 81 | 94 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 8.0 | 459 | 64 | 72 | 94 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 10.0 | 479 | 62 | 71 | 91 | 100 | -- |
| | 47.2626110 | 104.553086 | 379 | 12.0 | 537 | 57 | 64 | 83 | 100 | -- |
| | 47.2624346 | 104.552677 | 498 | 0.0 | 417 | 75 | 83 | 95 | 100 | -- |
| | 47.2624346 | 104.552677 | 498 | 5.0 | 455 | 73 | 79 | 97 | 100 | -- |
| | 47.2624346 | 104.552677 | 498 | 8.0 | 422 | 77 | 85 | 96 | 100 | -- |
| | 47.2624346 | 104.552677 | 498 | 10.5 | 472 | 74 | 78 | 97 | 100 | -- |
| | 47.2624346 | 104.552677 | 498 | 13.5 | 478 | 69 | 75 | 96 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 0.0 | 320 | 85 | 93 | 100 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 2.5 | 370 | 86 | 92 | 97 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 5.0 | 373 | 78 | 84 | 97 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 7.5 | 422 | 75 | 81 | 97 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 10.0 | 451 | 69 | 81 | 98 | 100 | -- |
| | 47.2622623 | 104.552286 | 611 | 12.0 | 543 | 61 | 72 | 97 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 0.0 | 321 | 91 | 96 | 100 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 1.5 | 307 | 93 | 99 | 100 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 3.0 | 331 | 91 | 95 | 97 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 4.5 | 357 | 88 | 93 | 100 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 6.0 | 369 | 90 | 97 | 100 | 100 | -- |
| | 47.2620336 | 104.55186 | 745 | 8.0 | 345 | 89 | 96 | 98 | 100 | -- |
| 8/11/2011 | 47.2627555 | 104.553385 | 167 | 0.0 | 115 | 94 | 98 | 100 | 100 | -- |
| | 47.2627555 | 104.553385 | 167 | 1.5 | 136 | 89 | 96 | 100 | 100 | -- |
| | 47.2627555 | 104.553385 | 167 | 3.0 | 108 | 95 | 98 | 100 | 100 | -- |
| | 47.2627555 | 104.553385 | 167 | 4.5 | 134 | 81 | 93 | 100 | 100 | -- |
| | 47.2627555 | 104.553385 | 167 | 6.0 | 147 | 75 | 90 | 97 | 100 | -- |
| | 47.2627555 | 104.553385 | 167 | 7.5 | 123 | 86 | 96 | 98 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 0.0 | 123 | 85 | 95 | 100 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 1.9 | 128 | 80 | 92 | 97 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 3.8 | 139 | 79 | 93 | 99 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 5.7 | 143 | 83 | 94 | 100 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 7.6 | 137 | 75 | 86 | 100 | 100 | -- |
| | 47.2627316 | 104.553041 | 267 | 9.5 | 137 | 76 | 92 | 100 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 0.0 | 92 | 96 | 98 | 100 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 2.1 | 154 | 71 | 82 | 95 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 4.2 | 134 | 72 | 87 | 100 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 6.3 | 128 | 79 | 90 | 100 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 8.4 | 147 | 69 | 83 | 100 | 100 | -- |
| | 47.2624758 | 104.552682 | 368 | 10.5 | 198 | 59 | 70 | 93 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 0.0 | 115 | 86 | 89 | 100 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 1.9 | 114 | 86 | 92 | 100 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 3.8 | 129 | 83 | 89 | 100 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 5.7 | 134 | 71 | 85 | 97 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 7.6 | 132 | 79 | 88 | 100 | 100 | -- |
| | 47.2623151 | 104.552333 | 476 | 9.5 | 143 | 61 | 77 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 0.0 | 323 | 96 | 98 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 1.3 | 85 | 95 | 98 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 2.6 | 105 | 96 | 100 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 3.9 | 117 | 96 | 98 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 5.2 | 116 | 94 | 100 | 100 | 100 | -- |
| | 47.2621248 | 104.551915 | 595 | 6.5 | 113 | 94 | 97 | 100 | 100 | -- |
| 8/24/2011 | 47.2626747 | 104.553373 | 159 | 0.0 | 46 | IM | IM | IM | IM | 91 |
| | 47.2626747 | 104.553373 | 159 | 1.4 | 62 | 89 | 97 | 100 | 100 | -- |
| | 47.2626747 | 104.553373 | 159 | 2.8 | 45 | IM | IM | IM | IM | 94 |
| | 47.2626747 | 104.553373 | 159 | 4.2 | 56 | IM | IM | IM | IM | 88 |

Return to TOC

**Table 2.** Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

[DD, decimal degrees; ft, feet; mm, millimeter; mg/L, milligram per liter]

| Dates | Latitude (DD) | Longitude (DD) | Location in cross section, distance from left bank looking downstream (ft) | Sampling depth (ft) | Suspended-sediment concen-tration (mg/L) | Suspended-sediment fall diameter (values in percent finer than size) | | | | Percent finer than suspended sediment sieve diameter of 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.062 mm | 0.125 mm | 0.250 mm | 0.500 mm | |
| | 47.2626747 | 104.553373 | 159 | 5.6 | 55 | 96 | 99 | 100 | 100 | -- |
| | 47.2626747 | 104.553373 | 159 | 7.0 | 55 | 90 | 96 | 100 | 100 | -- |
| | 47.2625065 | 104.553001 | 268 | 0.0 | 43 | IM | IM | IM | IM | 91 |
| | 47.2625065 | 104.553001 | 268 | 1.8 | 53 | IM | IM | IM | IM | 89 |
| | 47.2625065 | 104.553001 | 268 | 3.6 | 55 | IM | IM | IM | IM | 85 |
| | 47.2625065 | 104.553001 | 268 | 9.0 | 51 | IM | IM | IM | IM | 95 |
| | 47.2623663 | 104.552669 | 364 | 0.0 | 51 | IM | IM | IM | IM | 86 |
| | 47.2623663 | 104.552669 | 364 | 1.9 | 69 | 94 | 95 | 100 | 100 | -- |
| | 47.2623663 | 104.552669 | 364 | 3.8 | 73 | 87 | 91 | 100 | 100 | -- |
| | 47.2623663 | 104.552669 | 364 | 5.7 | 52 | IM | IM | IM | IM | 95 |
| | 47.2623663 | 104.552669 | 364 | 7.6 | 65 | 83 | 89 | 100 | 100 | -- |
| | 47.2623663 | 104.552669 | 364 | 9.5 | 71 | 79 | 84 | 100 | 100 | -- |
| | 47.2622328 | 104.552327 | 460 | 0.0 | 51 | IM | IM | IM | IM | 94 |
| | 47.2622328 | 104.552327 | 460 | 1.7 | 49 | IM | IM | IM | IM | 93 |
| | 47.2622328 | 104.552327 | 460 | 3.4 | 40 | IM | IM | IM | IM | 95 |
| | 47.2622328 | 104.552327 | 460 | 5.1 | 52 | 86 | 89 | 100 | 100 | -- |
| | 47.2622328 | 104.552327 | 460 | 6.8 | 53 | 92 | 94 | 100 | 100 | -- |
| | 47.2622328 | 104.552327 | 460 | 8.5 | 54 | 92 | 92 | 100 | 100 | -- |
| | 47.2620273 | 104.551995 | 570 | 0.0 | 35 | IM | IM | IM | IM | 97 |
| | 47.2620273 | 104.551995 | 570 | 1.0 | 35 | IM | IM | IM | IM | 92 |
| | 47.2620273 | 104.551995 | 570 | 2.0 | 43 | IM | IM | IM | IM | 97 |
| | 47.2620273 | 104.551995 | 570 | 3.0 | 48 | IM | IM | IM | IM | 93 |
| | 47.2620273 | 104.551995 | 570 | 4.0 | 43 | IM | IM | IM | IM | 96 |
| | 47.2620273 | 104.551995 | 570 | 5.0 | 55 | IM | IM | IM | IM | 89 |
| Below bypass chute | | | | | | | | | | |
| 7/20/2011 | 47.2651015 | 104.552643 | 186 | 0.0 | 304 | 92 | 95 | 97 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 1.0 | 315 | 92 | 96 | 100 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 2.0 | 323 | 89 | 95 | 98 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 3.0 | 335 | 90 | 92 | 97 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 4.0 | 350 | 82 | 89 | 98 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 5.0 | 409 | 76 | 85 | 93 | 100 | -- |
| | 47.2651015 | 104.552643 | 186 | 6.0 | 597 | 60 | 70 | 92 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 0.0 | 369 | 82 | 87 | 96 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 2.0 | 355 | 83 | 89 | 99 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 4.0 | 419 | 70 | 78 | 97 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 6.0 | 452 | 68 | 76 | 97 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 8.0 | 587 | 54 | 64 | 91 | 100 | -- |
| | 47.2649765 | 104.552019 | 346 | 9.0 | 611 | 52 | 62 | 95 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 0.0 | 357 | 81 | 88 | 96 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 2.0 | 396 | 77 | 86 | 100 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 3.5 | 417 | 72 | 82 | 95 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 5.0 | 454 | 68 | 79 | 93 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 6.5 | 443 | 70 | 77 | 97 | 100 | -- |
| | 47.2649045 | 104.551457 | 482 | 8.0 | 625 | 51 | 61 | 94 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 0.0 | 355 | 87 | 93 | 100 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 2.0 | 355 | 87 | 94 | 98 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 3.0 | 408 | 79 | 86 | 96 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 4.0 | 409 | 78 | 87 | 100 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 5.0 | 441 | 73 | 85 | 99 | 100 | -- |
| | 47.2647773 | 104.550853 | 641 | 6.5 | 429 | 71 | 81 | 99 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 0.0 | 370 | 87 | 92 | 94 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 2.0 | 386 | 84 | 93 | 100 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 3.0 | 333 | 95 | 98 | 100 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 4.0 | 304 | 85 | 94 | 97 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 5.0 | 377 | 84 | 93 | 100 | 100 | -- |
| | 47.2647086 | 104.550448 | 849 | 6.0 | 470 | 79 | 91 | 98 | 100 | -- |
| 8/9/2011 | 47.2650712 | 104.55267 | 183 | 0.0 | 143 | 85 | 97 | 100 | 100 | -- |
| | 47.2650712 | 104.55267 | 183 | 0.8 | 153 | 86 | 97 | 100 | 100 | -- |
| | 47.2650712 | 104.55267 | 183 | 1.6 | 154 | 85 | 93 | 100 | 100 | -- |
| | 47.2650712 | 104.55267 | 183 | 2.4 | 140 | 84 | 94 | 97 | 100 | -- |
| | 47.2650712 | 104.55267 | 183 | 3.2 | 144 | 84 | 92 | 100 | 100 | -- |
| | 47.2650712 | 104.55267 | 183 | 4.0 | 163 | 76 | 90 | 96 | 100 | -- |
| | 47.265012 | 104.55211 | 323 | 0.0 | 138 | 87 | 95 | 100 | 100 | -- |
| | 47.265012 | 104.55211 | 323 | 1.2 | 132 | 91 | 96 | 100 | 100 | -- |
| | 47.265012 | 104.55211 | 323 | 2.4 | 136 | 81 | 91 | 100 | 100 | -- |
| | 47.265012 | 104.55211 | 323 | 3.6 | 140 | 85 | 94 | 100 | 100 | -- |

Return to TOC

**Table 2.** Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

[DD, decimal degrees; ft, feet mm, millimeter; mg/L, milligram per liter]

| Dates | Latitude (DD) | Longitude (DD) | Location in cross section, distance from left bank looking downstream (ft) | Sampling depth (ft) | Suspended-sediment concen-tration (mg/L) | Suspended-sediment fall diameter (values in percent finer than size) | | | | Percent finer than suspended sediment sieve diameter of 0.062 mm |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0.062 mm | 0.125 mm | 0.250 mm | 0.500 mm | |
| | 47.265012 | 104.55211 | 323 | 4.8 | 157 | 82 | 94 | 98 | 100 | -- |
| | 47.265012 | 104.55211 | 323 | 6.0 | 170 | 74 | 84 | 100 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 0.0 | 142 | 90 | 93 | 100 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 1.2 | 115 | 83 | 90 | 100 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 2.4 | 151 | 82 | 87 | 96 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 3.6 | 180 | 74 | 85 | 100 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 4.8 | 159 | 80 | 88 | 100 | 100 | -- |
| | 47.2649188 | 104.551618 | 443 | 6.0 | 183 | 72 | 81 | 96 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 0.0 | 143 | 90 | 93 | 100 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 0.8 | 152 | 87 | 93 | 100 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 1.6 | 138 | 87 | 92 | 100 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 2.4 | 173 | 81 | 85 | 100 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 3.2 | 161 | 83 | 91 | 100 | 100 | -- |
| | 47.2648178 | 104.550986 | 602 | 4.0 | 148 | 86 | 92 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 0.0 | 142 | 96 | 99 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 0.8 | 146 | 91 | 97 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 1.6 | 157 | 91 | 96 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 2.4 | 135 | 93 | 97 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 3.2 | 156 | 85 | 93 | 100 | 100 | -- |
| | 47.2646167 | 104.550129 | 827 | 4.0 | 173 | 90 | 93 | 100 | 100 | -- |
| 8/23/2011 | 47.2649966 | 104.552262 | 266 | 0.0 | 68 | 91 | 93 | 100 | 100 | -- |
| | 47.2649966 | 104.552262 | 266 | 1.0 | 60 | 95 | 95 | 100 | 100 | -- |
| | 47.2649966 | 104.552262 | 266 | 2.0 | 64 | 92 | 95 | 100 | 100 | -- |
| | 47.2649966 | 104.552262 | 266 | 3.0 | 64 | 95 | 97 | 99 | 100 | -- |
| | 47.2649966 | 104.552262 | 266 | 4.0 | 89 | 83 | 92 | 100 | 100 | -- |
| | 47.2649966 | 104.552262 | 266 | 5.0 | 151 | 81 | 87 | 100 | 100 | -- |
| | 47.2649493 | 104.551916 | 352 | 0.0 | 85 | 94 | 97 | 100 | 100 | -- |
| | 47.2649493 | 104.551916 | 352 | 1.1 | 92 | IM | IM | IM | IM | 79 |
| | 47.2649493 | 104.551916 | 352 | 2.2 | 68 | 94 | 95 | 100 | 100 | -- |
| | 47.2649493 | 104.551916 | 352 | 3.3 | 63 | IM | IM | IM | IM | 68 |
| | 47.2649493 | 104.551916 | 352 | 4.4 | 50 | IM | IM | IM | IM | 77 |
| | 47.2649493 | 104.551916 | 352 | 5.6 | 48 | IM | IM | IM | IM | 94 |
| | 47.2648925 | 104.551593 | 434 | 0.0 | 49 | IM | IM | IM | IM | 85 |
| | 47.2648925 | 104.551593 | 434 | 1.0 | 53 | IM | IM | IM | IM | 70 |
| | 47.2648925 | 104.551593 | 434 | 2.0 | 51 | IM | IM | IM | IM | 85 |
| | 47.2648925 | 104.551593 | 434 | 3.0 | 52 | IM | IM | IM | IM | 88 |
| | 47.2648925 | 104.551593 | 434 | 4.0 | 54 | IM | IM | IM | IM | 83 |
| | 47.2648925 | 104.551593 | 434 | 5.0 | 71 | 92 | 99 | 100 | 100 | -- |
| | 47.264804 | 104.551138 | 551 | 0.0 | 50 | IM | IM | IM | IM | 81 |
| | 47.264804 | 104.551138 | 551 | 0.6 | 41 | IM | IM | IM | IM | 94 |
| | 47.264804 | 104.551138 | 551 | 1.2 | 39 | IM | IM | IM | IM | 91 |
| | 47.264804 | 104.551138 | 551 | 1.8 | 55 | IM | IM | IM | IM | 74 |
| | 47.264804 | 104.551138 | 551 | 2.4 | 49 | IM | IM | IM | IM | 91 |
| | 47.264804 | 104.551138 | 551 | 3.0 | 61 | 80 | 87 | 100 | 100 | -- |
| | 47.2646951 | 104.550634 | 680 | 0.0 | 79 | IM | IM | IM | IM | 58 |
| | 47.2646951 | 104.550634 | 680 | 0.4 | 72 | IM | IM | IM | IM | 63 |
| | 47.2646951 | 104.550634 | 680 | 0.8 | 46 | IM | IM | IM | IM | 96 |
| | 47.2646951 | 104.550634 | 680 | 1.2 | 53 | IM | IM | IM | IM | 93 |
| | 47.2646951 | 104.550634 | 680 | 1.6 | 46 | IM | IM | IM | IM | 88 |
| | 47.2646951 | 104.550634 | 680 | 2.0 | 32 | 81 | 93 | 100 | 100 | 88 |

Return to TOC

**Table 3.** Sieve diameters and mass of bedload samples for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

[mm, millimeters]

| Date | Bedload-sediment fall diameter (values in percent finer than size) | | | | | | | | | | Mass (grams) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.062 mm | 0.125 mm | 0.25 mm | 0.5 mm | 1 mm | 2 mm | 4 mm | 8 mm | 16 mm | 32 mm | |
| Above bypass chute | | | | | | | | | | | |
| 7/19/2011 | 0 | 1 | 32 | 73 | 77 | 79 | 81 | 83 | 87 | 100 | 375.4 |
| 8/10/2011 | 0 | 0 | 2 | 87 | 95 | 96 | 97 | 98 | 100 | 100 | 167.8 |
| 8/24/2011 | 1 | 1 | 6 | 63 | 69 | 73 | 79 | 93 | 100 | 100 | 35.5 |
| Adjacent to bypass chute | | | | | | | | | | | |
| 7/21/2011 | 0 | 0 | 2 | 62 | 73 | 76 | 80 | 88 | 94 | 100 | 295.3 |
| 8/11/2011 | 0 | 0 | 1 | 55 | 70 | 76 | 81 | 87 | 100 | 100 | 221.3 |
| 8/24/2011 | 0 | 1 | 8 | 67 | 74 | 76 | 78 | 80 | 100 | 100 | 138.0 |
| Below bypass chute | | | | | | | | | | | |
| 7/20/2011 | 0 | 0 | 20 | 72 | 78 | 81 | 85 | 91 | 96 | 100 | 322.1 |
| 8/9/2011 | 0 | 0 | 1 | 59 | 72 | 78 | 82 | 87 | 96 | 100 | 308.8 |
| 8/23/2011 | 0 | 0 | 1 | 38 | 52 | 63 | 70 | 75 | 87 | 100 | 275.5 |

Return to TOC

**Table 4.** Sediment loads for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011

| Date | Load, in tons per day | | |
|---|---|---|---|
| | Suspended sediment | Measured bedload | Measured total sediment |
| Above bypass chute | | | |
| 7/19/2011 | 57,700 | 254 | 57,954 |
| 8/10/2011 | 8,250 | 36 | 8,286 |
| 8/24/2011 | 2,600 | 5 | 2,605 |
| Adjacent to bypass chute | | | |
| 7/21/2011 | 54,600 | 255 | 54,855 |
| 8/11/2011 | 6,350 | 53 | 6,403 |
| 8/24/2011 | 3,000 | 20 | 3,020 |
| Below bypass chute | | | |
| 7/20/2011 | 57,200 | 301 | 57,501 |
| 8/9/2011 | 9,260 | 96 | 9,356 |
| 8/23/2011 | 2,710 | 55 | 2,765 |

Return to TOC

Attachment 6  Bypass Channel

# Appendix G

Fish Bypass Channel Entrance and Exit-Reclamation

10April2012

Return to TOC

# RECLAMATION

*Managing Water in the West*

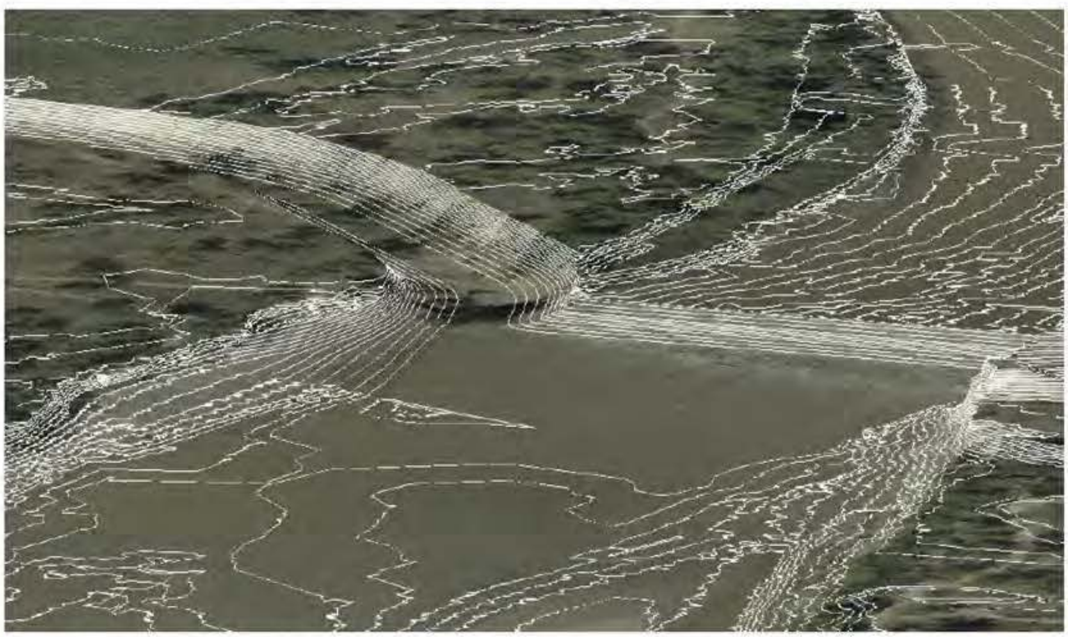
PAP-1053

# Lower Yellowstone Intake Diversion Dam

## Fish Bypass Channel Entrance and Exit Pre-appraisal Study

## Progress Report March 2012

**By Bryan Heiner, Dale Lentz, and Josh Mortensen**



**U.S. Department of the Interior**
**Bureau of Reclamation**
**Technical Service Center**
**Hydraulic Investigations and Laboratory Services Group**
**Denver, Colorado**

# Lower Yellowstone Intake Diversion

## Fish Bypass Channel Entrance and Exit Pre-appraisal Study

***Progress Report***


Prepared By:

Bryan Heiner
Hydraulic Engineer, Hydraulic Investigations and Laboratory Services Group, 86-68460

Dale Lentz
Hydraulic Engineer, Hydraulic Investigations and Laboratory Services Group, 86-68460

Josh Mortensen
Hydraulic Engineer, Hydraulic Investigations and Laboratory Services Group, 86-68460

Technical Approval: Robert F. Einhellig, P.E.
Manager, Hydraulic Investigations and Laboratory Services Group, 86-68460

7/27/2012
Peer Review: Brent Mefford, P.E. Date
Technical Specialist, Hydraulic Investigations and Laboratory Services Group, 86-68460



This study was funded by the U.S. Corps of Engineers, Omaha District. The Corps is the lead agency for the design and construction of fish passage at Intake Diversion Dam on the Yellowstone River near Glendive Montana.

## Project Background

Intake dam is a Bureau of Reclamation irrigation diversion dam on the Yellowstone River approximately 70 miles upstream from its confluence with the Missouri River. It presents a barrier to fish migration on the Yellowstone. The project consists of two phases, first the construction of a fish screen structure to prevent fish entrainment (including the federally protected pallid sturgeon). Construction of a fish screen structure was initiated in 2010. The second phase includes design and construction of fish passage over or around the diversion dam. Two alternatives for fish passage were identified from project scoping studies for further design development. These are a rock ramp downstream of the diversion dam that would provide passage over the structure and a split-channel bypass that would provide passage around the diversion dam. Feasibility level design of the rock ramp alternative based on numerical and physical modeling has been completed. This report covers pre-appraisal level development of the split-channel bypass alternative focusing on design of the channel entrance and exit which are key to achieving fish passage and long term channel stability.

The Biological Review Team (BRT) provided guidance for the split-channel bypass fishway design in March, 2011. Their recommendations addressing bypass entrance and exit issues were as follows:

> (1) The BRT has concern that existing tracking data for pallid sturgeon indicates limited use of side channels during upstream migratory movement. The BRT recommends removing the 10% Diversion option and focusing on options capable of conveying 15%, 20%, 25%, and 30 % of the river flow.
>
> (2) We recognize the limitations of the 1-dimensional HEC-RAS model, but additional data related to the shear flow, mixing zone, and attraction flow at the fish entrance to the bypass channel are essential. Future analysis will be improved with additional data depicting the fish-way entrance and its orientation relative to the base of the dam and the main river thalweg.
>
> (3) A possible low weir to divert additional attraction water was discussed, and it would be good to review and evaluate some possible alignments as soon as possible.
>
> (4) Future analysis will be improved with the addition of model cross-sectional data at the water entrance and exit. Specifically, the BRT requests details on anticipated depths at the modeled discharges for these locations.
>
> (5) The bypass channel should be constructed such that 2 meters of water depth is possible at discharges exceeding 10,000 $ft^3/s$ to better mimic those habitat parameters that coincide with adult pallid sturgeon locations (Bramblett 1996; Bramblett and White 2001; MFWP unpublished data).



Return to TOC

The proposed bypass channel would extend from immediately downstream of the diversion weir to approximately 2 miles upstream of the diversion, Figure 1. Bypass channel entrance and exit used herein are referenced to upstream fish movement. The bypass entrance and exit refer to the downstream and upstream end of the channel respectively, opposite that of flow direction.

## Split-Channel Bypass Alternative - Design Data Assumptions

Preliminary design data for the bypass were established based on applicable design data from the rock ramp fishway studies and recommendations of the BRT. Table 1 presents design data used for the basis of the designs presented in this report.

Table 1 - Considerations for the fish bypass design

| | |
|---|---|
| Split-channel Bypass Flow | The bypass conveys a minimum of 15 percent of river flow at the dam for river flows larger than10,000 $ft^3/s$. Bypass flows of greater than the minimum are considered highly desirable for increased fish attraction and passage. |
| Average Fishway Velocity | Average flow velocity of about 1 m/s (~3 ft/s) at 10,000 $ft^3/s$ river flow increasing to about 2 m/s (~6 ft/s) at 70,000 $ft^3/s$ river flow. This range is similar to the mean river velocity measured about 1000 ft downstream of the dam and BRT recommendations. |
| Channel slope | Average bypass channel slope should be similar to that of the river below the dam which is about 0.00055. |
| Bypass Entrance Shape | Information from sturgeon tracking and habitat use studies were compiled with river cross section data below the dam. These data support a channel shape with a wide, nearly flat invert at the center of the channel transitioning to shallow sloping banks. The invert slope should gradually increase toward the bank lines. |
| Bypass Channel Entrance Depth | A thalweg depth of about 2 m (~6 ft) at 10,000 $ft^3/s$ increasing to about 5 m (~16 ft) at 70,000 $ft^3/s$. Depth at the bypass entrance should be similar to the thalweg depth downstream of the dam. |
| Bypass Channel Exit Depth | A minimum thalweg depth of about 2 m (~6 ft) for river flows above 10,000 $ft^3/s$. |

| | |
|---|---|
| Bypass Entrance Orientation to the River | Flows from the bypass should merge with river flow in a downstream direction avoiding large eddies and strong shear zones. |
| Irrigation Diversion Criteria | Diverting water into the bypass must not impact the ability of the irrigation diversion to meet established diversion criteria. A minimum water surface of 1991.1 is required at Intake diversion headworks. |
| Channel Bed Roughness | The bypass channel entrance should be designed to support large areas of silt/sand and small gravel bed materials. Riprap required on the channel bed should be set below design grade and choked with fines. |

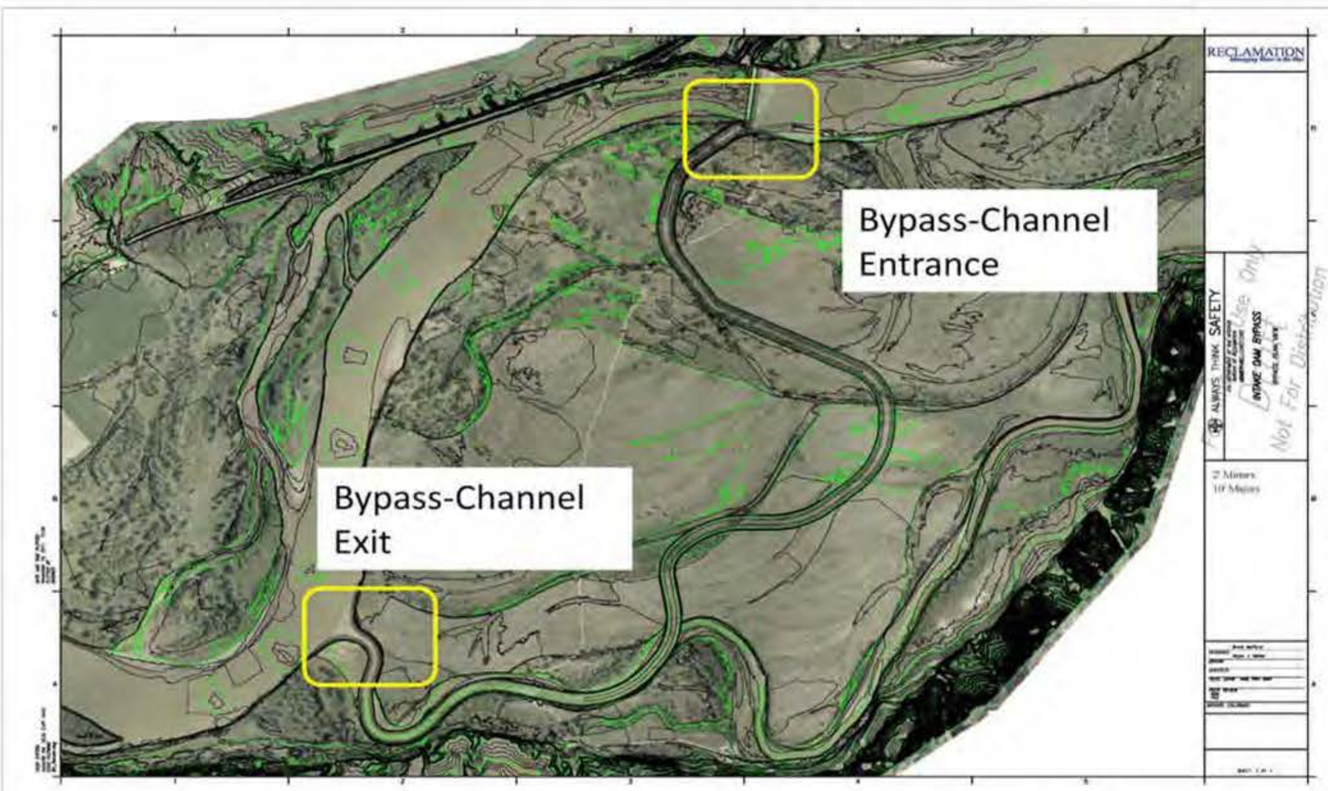



Figure 1 - Preliminary split-channel bypass design showing passage entrance and exit locations.

## Bypass Channel Shape

A characteristic shape for the bypass channel was developed assuming the channel should approximately emulate the main stem river downstream from the influence of the diversion dam. The bypass channel shape chosen has a flat invert with shallow side slopes that become steeper closer to the banks, Figure 2. The bypass channel side slopes are similar to the natural bank slopes found in river transitions between bends downstream of the diversion dam. The importance of providing shallow sloping banks off the channel invert were presented by the BRT and are supported by studies of channel habitat utilization by sturgeon in the Yellowstone River, (Bramblett, R. 1996, DNRC, 1977).

The bypass channel shape given in Figure 2 was used in this study to evaluate the channel entrance and exit transition shapes, alignments and hydraulic performance. As the bypass channel design advances, the shape of the bypass channel between the entrance and exit will likely include attributes of bends, transitions and straighter runs. The length of the outer bank slope (1V:2H) shown is approximate. For all drawings and flow simulations conducted for this study the outer bank slope was carried to daylight at the elevation of the natural topography.

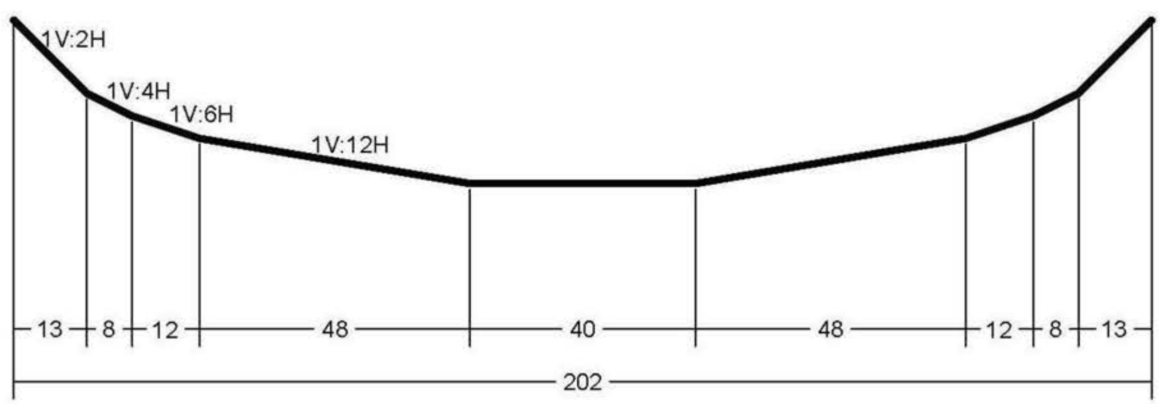



Figure 2 - Typical bypass channel section showing slopes and slope widths. Note: the plot's vertical scale is exaggerated by a factor of two.

## Bypass Channel Entrance

The entrance to the bypass channel should be located approximately adjacent to the right abutment of the diversion dam. For this study, a new dam at the existing dam location with a crest geometry matching that developed for the design of the fish screens/headworks was assumed. Future selection of an upstream dam location should not significantly alter the findings of this study if the bypass entrance and dam are relocated together.

### HEC-RAS Modeling

A HEC-RAS 1 dimensional numerical model of the Lower Yellowstone River around the Intake diversion dam was given to Reclamation from USACE. The model boundaries extended approximately 5 miles upstream and downstream of Intake dam. It also included approximately 4 miles of the irrigation canal and the proposed headworks structure. This existing model was modified to model various bypass alternatives, primarily focusing on the hydraulic characteristics of the bypass relating to fish passage and the percentage of flow in the bypass without affecting the ability to divert irrigations flows. Alternatives were not evaluated with respect to sediment transport capabilities, ice stability, or cut and fill. For all bypass alternatives the following parameters were assumed; channel roughness represented by a manning's n of .028, an invert elevation at the channel entrance of 1981.0 and a bypass channel length of 15500 ft. The sensitivity of the flow split between the river and bypass channel to higher roughness values was not analyzed. A Manning's n of .028 was considered a conservative low value for the purpose of guaranteeing diversion water.

Six bypass alternatives were modeled with varying slopes and channel widths. Major hydraulic parameters for each alternative are presented in Table 2. Alternatives 1 and 2 simulated 202 ft wide channels (assuming a reference depth of 14.5 ft) with slopes of 0.0005 and 0.0006, respectively. The steeper slope results in a higher invert elevation of the bypass channel at the upstream junction. In bypass alternatives 3 through 6, the horizontal invert of the bypass channel was increased by 50 ft, giving a reference channel width of 252 ft. These four alternatives then vary in channel slope from 0.0005 to 0.0007. Based on the HEC-RAS simulation results given in Table 2, Bypass 2 was carried forward for the development of bypass channel entrance and exit designs to a pre-appraisal level (no cost estimates). Bypass 2 was chosen as it represents the minimum excavation of the alternatives studied that meets the design data objectives. Bypass 2 meets all objectives with the exception of depth at the exit for a river flow of 10,000 $ft^3/s$. This was considered acceptable as the exit depth is similar to downstream river thalweg depths and exceeds the target depth prior to river flows reaching 20,000 $ft^3/s$.

A plot of average channel velocity in the bypass channel and downstream river is presented in Figure 3 for Bypass 2. Flow velocity for normal depth conditions in the upper reach of the bypass channel is similar to that of the downstream river. Tailwater inundation of the bypass entrance and lower channel reach results in a gradual reduction in bypass channel velocity from upstream toward the entrance. The entrance of the channel is designed to provide optimum flow depth, velocity and bed substrate for sturgeon habitat and movement as described by Bramblett, 1996. Plan and sections for the proposed bypass entrance are given as drawings 1 – 4 at the end of the report.

Table 2 - Bypass Alternatives with varying slopes and widths

| **Plan Name** | **Bypass 1** | **Bypass 2** | **Bypass 3** | **Bypass 4** | **Bypass 5** | **Bypass 6** |
|---|---|---|---|---|---|---|
| | | | | | | |
| Channel Length | 15500 | 15500 | 15500 | 15500 | 15500 | 15500 |
| Slope | 0.0005 | 0.0006 | 0.0005 | 0.0006 | 0.00065 | 0.0007 |
| Downstream Invert El. | 1981 | 1981 | 1981 | 1981 | 1981 | 1981 |
| Upstream Invert El. | 1988.75 | 1990.3 | 1988.75 | 1990.3 | 1991.08 | 1991.85 |
| Bypass width | 202 | 202 | 252 | 252 | 252 | 252 |
| | | | | | | |
| **Bypass Flow** | | | | | | |
| 5 KCFS | 1044 | 559 | 1544 | 894 | 613 | 366 |
| 10 KCFS | 2024 | 1311 | 2867 | 1956 | 1524 | 1134 |
| 20 KCFS | 3897 | 2905 | 5318 | 4099 | 3503 | 2902 |
| 30 KCFS | 5618 | 4481 | 7535 | 6123 | 5555 | 4721 |
| 40 KCFS | 7417 | 6151 | 9749 | 8245 | 7469 | 6684 |
| 70 KCFS | 12814 | 11304 | 16304 | 14545 | 13658 | 12720 |
| | | | | | | |
| **Main Channel Flow (Downstream of Bypass and Upstream of Irrigation Diversion)** | | | | | | |
| 5 KCFS | 3957 | 4442 | 3457 | 4107 | 4388 | 4635 |
| 10 KCFS | 7977 | 8690 | 7134 | 8045 | 8477 | 8867 |
| 20 KCFS | 16104 | 17096 | 14683 | 15902 | 16498 | 17099 |
| 30 KCFS | 24383 | 25520 | 22466 | 23878 | 24446 | 25280 |
| 40 KCFS | 32584 | 33850 | 30252 | 31756 | 32532 | 33317 |
| 70 KCFS | 57187 | 58697 | 53697 | 55456 | 56343 | 57281 |
| | | | | | | |
| **Main Channel Flow (Downstream of Irrigation Diversion)** | | | | | | |
| 5 KCFS | 2562 | 3041 | 2120 * | 2708 | 2987 | 3234 |
| 10 KCFS | 6579 | 7290 | 5733 | 6645 | 7077 | 7467 |
| 20 KCFS | 14707 | 15694 | 13284 | 14502 | 15098 | 15698 |
| 30 KCFS | 22983 | 24121 | 21067 | 22479 | 23047 | 23880 |
| 40 KCFS | 31181 | 32451 | 28853 | 30357 | 31132 | 31915 |
| 70 KCFS | 55787 | 57297 | 52298 | 54059 | 54944 | 55878 |
| | | | | | | |
| **Bypass Flow/ Total Flow (Upstream of Bypass)** | | | | | | |
| 5 KCFS | 20.9% | 11.2% | 30.9% | 17.9% | 12.3% | 7.3% |
| 10 KCFS | 20.2% | 13.1% | 28.7% | 19.6% | 15.2% | 11.3% |
| 20 KCFS | 19.5% | 14.5% | 26.6% | 20.5% | 17.5% | 14.5% |
| 30 KCFS | 18.7% | 14.9% | 25.1% | 20.4% | 18.5% | 15.7% |
| 40 KCFS | 18.5% | 15.4% | 24.4% | 20.6% | 18.7% | 16.7% |
| 70 KCFS | 18.3% | 16.1% | 23.3% | 20.8% | 19.5% | 18.2% |
| | | | | | | |
| | | | | | | |

| Plan Name | Bypass 1 | Bypass 2 | Bypass 3 | Bypass 4 | Bypass 5 | Bypass 6 |
|---|---|---|---|---|---|---|
| **Bypass Flow/ Flow Downstream of Dam** | | | | | | |
| 5 KCFS | 40.7% | 18.4% | 72.8% | 33.0% | 20.5% | 11.3% |
| 10 KCFS | 30.8% | 18.0% | 50.0% | 29.4% | 21.5% | 15.2% |
| 20 KCFS | 26.5% | 18.5% | 40.0% | 28.3% | 23.2% | 18.5% |
| 30 KCFS | 24.4% | 18.6% | 35.8% | 27.2% | 24.1% | 19.8% |
| 40 KCFS | 23.8% | 19.0% | 33.8% | 27.2% | 24.0% | 20.9% |
| 70 KCFS | 23.0% | 19.7% | 31.2% | 26.9% | 24.9% | 22.8% |
| **Bypass Data** | | | | | | |
| **10 KCFS** | | | | | | |
| Avg Velocity, upstream channel | 3.0 | 2.8 | 3.2 | 3.0 | 2.8 | 2.6 |
| Max Depth, upstream channel | 6.1 | 4.8 | 5.8 | 4.6 | 4.0 | 3.3 |
| % cross-section with 1.5-3 m depth | 34% | 0% | 30% | 0% | 0% | 0% |
| Avg Velocity, downstream channel | 3.0 | 1.9 | 2.9 | 2.0 | 1.5 | 1.1 |
| Max Depth, downstream channel | 6.2 | 6.2 | 6.2 | 6.2 | 6.2 | 6.2 |
| **20 KCFS** | | | | | | |
| Avg Velocity, upstream channel | 3.8 | 3.7 | 3.9 | 3.8 | 3.7 | 3.6 |
| Max Depth, upstream channel | 8.3 | 6.9 | 7.9 | 6.6 | 6.0 | 5.4 |
| % cross-section with 1.5-3 m depth | 59% | 43% | 55% | 40% | 33% | 25% |
| Avg Velocity, downstream channel | 3.6 | 2.6 | 3.5 | 2.7 | 2.3 | 1.9 |
| Max Depth, downstream channel | 8.6 | 8.7 | 8.6 | 8.7 | 8.7 | 8.7 |
| **30 KCFS** | | | | | | |
| Avg Velocity, upstream channel | 4.3 | 4.2 | 4.4 | 4.3 | 4.3 | 4.2 |
| Max Depth, upstream channel | 9.8 | 8.5 | 9.4 | 8.1 | 7.6 | 6.9 |
| % cross-section with 1.5-3 m depth | 72% | 62% | 70% | 58% | 51% | 43% |
| Avg Velocity, downstream channel | 3.9 | 3.1 | 3.8 | 3.1 | 2.8 | 2.4 |
| Max Depth, downstream channel | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.6 |
| **40 KCFS** | | | | | | |
| Avg Velocity, upstream channel | 4.7 | 4.7 | 4.8 | 4.8 | 4.7 | 4.7 |

| Plan Name | Bypass 1 | Bypass 2 | Bypass 3 | Bypass 4 | Bypass 5 | Bypass 6 |
|---|---|---|---|---|---|---|
| Max Depth, upstream channel | 11.2 | 9.8 | 10.8 | 9.5 | 8.8 | 8.2 |
| % cross-section with 1.5-3 m depth | 45% | 73% | 48% | 71% | 66% | 59% |
| Avg Velocity, downstream channel | 4.3 | 3.5 | 4.2 | 3.5 | 3.2 | 2.8 |
| Max Depth, downstream channel | 12.0 | 12.1 | 12.0 | 12.1 | 12.1 | 12.1 |
| **70 KCFS** | | | | | | |
| Avg Velocity, upstream channel | 5.7 | 5.7 | 5.7 | 5.8 | 5.8 | 5.8 |
| Max Depth, upstream channel | 14.6 | 13.2 | 14.1 | 12.7 | 12.1 | 11.4 |
| % cross-section with 1.5-3 m depth | 21% | 29% | 23% | 33% | 38% | 43% |
| Avg Velocity, downstream channel | 5.1 | 4.5 | 4.9 | 4.4 | 4.1 | 3.8 |
| Max Depth, downstream channel | 15.8 | 15.9 | 15.8 | 15.9 | 16.0 | 16.0 |
| All simulations assume a canal diversion of 1400 cfs. | | | | | | |
| * For the given bypass design and river flow the max irrigation diversion is 1338 cfs. | | | | | | |

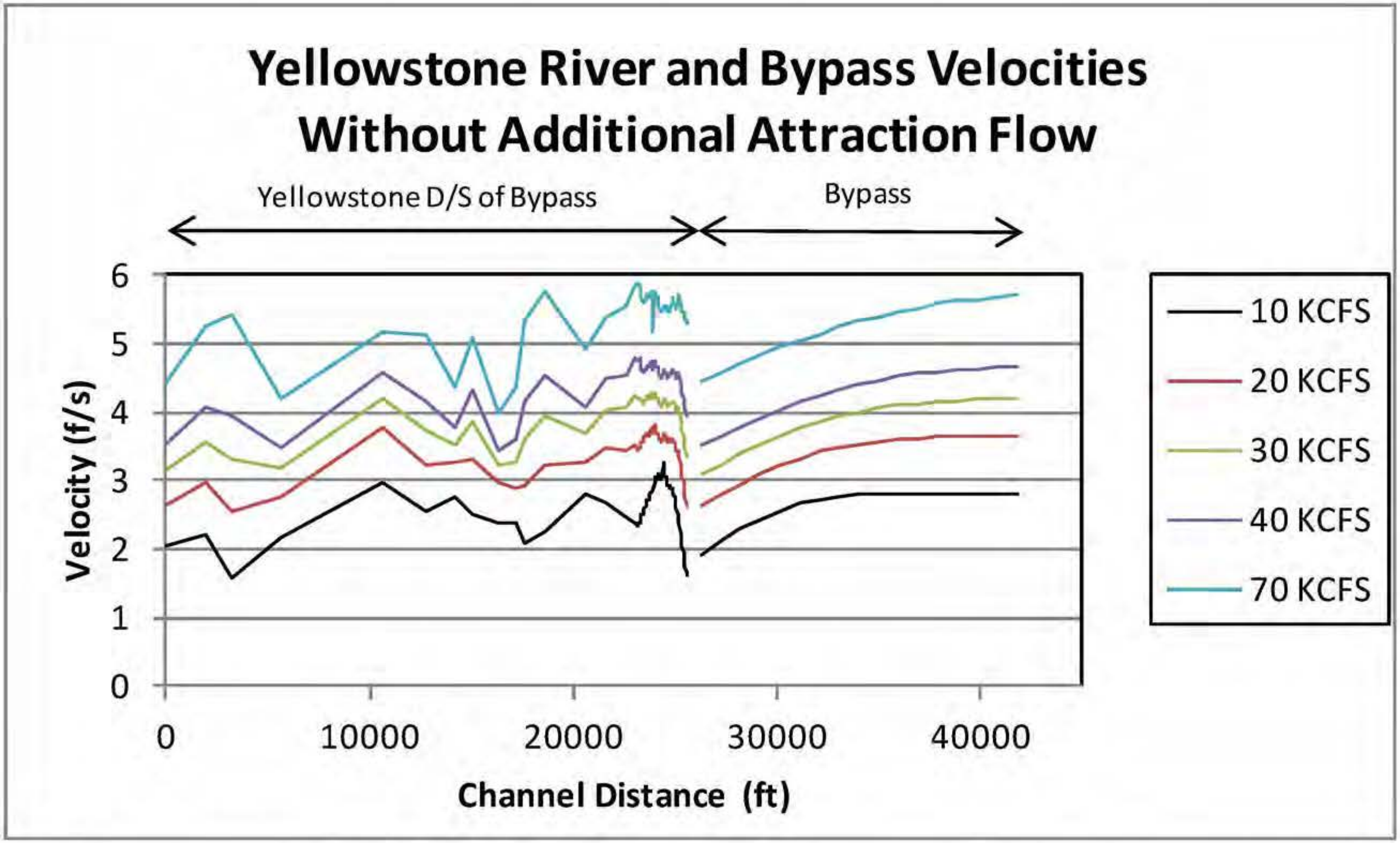



Figure 3 - Average channel velocity in the Yellowstone River downstream of the bypass entrance (left side) and in the bypass (right side).



Return to TOC

## Split-Channel Bypass Exit Design

The bypass channel exit (fish passage exit) is shown at approximately the location of the existing natural high flow channel bifurcation, Figure 1. For pre-appraisal, this location was selected as it provides sufficient separation from the diversion dam to permit a large meandering bypass channel to be constructed at a slope similar to the river. The site is located on the outside of a shallow bend and supports a natural bifurcation to a high flow channel. These factors suggest the location is favorable for achieving a stable bypass channel design. However, further sediment and flow modeling of the bifurcation will be needed to confirm the location. The bypass exit (flow entrance) shown is shaped as a gradual contraction to minimize zones of sharp flow acceleration and shear lines within the flow that could cause upstream migrating fish to become disoriented at the flow split. Behavioral reactions of sturgeon negotiating flow transitions are poorly understood, therefore, the design of the bypass channel exit attempts to make the flow split as hydraulically smooth as possible. Plan and sections for the proposed bypass exit are given as Drawings 5-8.

## Auxiliary Flow Lateral Weir Option

Two alternatives that include a lateral weir located in the entrance of the bypass channel were developed as options for increasing bypass channel flow for fish attraction. The lateral weir alternatives presented are designed as an extension of the right abutment of the diversion dam. Proper alignment of the lateral weir to the bypass channel and effective dissipation of flow energy passing over the weir are necessary to achieve improved attraction without creating shear flows that may misguide or significantly delay fish movement.

Several weir crest elevations, weir lengths and weir alignments were investigated for this study. A weir crest elevation of 1992.1 matching the elevation of the diversion dam at the right abutment was selected for the lateral weir. Flow over the weir crest commences at a river flow measured upstream of the bypass exit of about 10,000 $ft^3/s$. This crest elevation prevents the side-channel flow from impacting the ability of the diversion headworks to divert at full capacity for all river flows above 5,000 $ft^3/s$ (measured upstream of the bypass exit). Plan and section views of the two lateral weir options developed are shown on Drawings 9-11 (Option 1) and 12-14 (Option 2). The options vary only in their alignment to the diversion dam. Option 1 is aligned at an angle to the diversion dam and approximately parallel with the bypass channel. This alignment attempts to reduce false attraction to the weir flow for fish by minimizing channel length between the bypass and weir. The option 2 weir is aligned at a right angle to the diversion dam providing greater length for dissipation of flow energy, but may increase false attraction for fish to the weir flow.

### HEC-RAS Modeling of Lateral Weir for Auxiliary Attraction Flow

A lateral weir located on river right immediately upstream of Intake dam was added to the HEC-RAS Model for Bypass 2 (see Table 2). Various lengths and elevations of the weir were analyzed. A weir with a crest length of 150 ft at elevation 1992.1 was selected to achieve between 5 percent and 10 percent auxiliary flow augmentation to the bypass channel entrance without impacting irrigation diversion. The default coefficient for a broad crested lateral weir in

HEC-RAS is 2.0. Assuming an ogee crest, the lateral weir discharge coefficient can increase to around 3.3. For this study, simulations were conducted with discharge coefficients of both 2.0 and 3.0 to determine the possible range of auxiliary attraction flow. Results of model runs with lateral weir coefficients of 2.0 and 3.0 are presented in Table 3.

A plot of average channel velocity in the bypass channel, through the bypass channel entrance with a 150 ft lateral weir and continuing along the downstream river is presented in Figure 4. Flow over the lateral weir at river flows above about 20,000 $ft^3/s$ yield a strong increase in bypass channel velocity in the bypass mouth. With the addition of weir flow, flow velocity at the mouth of the entrance rises to about the level of that of the downstream river. The 150 ft long weir provides from 2 percent (10,000 $ft^3/s$ river) to 7 percent (70,000 $ft^3/s$ river) additional river flow to the bypass channel entrance using a weir coefficient of 2.0.

Table 3 - Bypass channel and weir flows with a weir coefficient of 2 and 3

Weir Elevation= 1992.1
Weir Length= 150
**Weir coefficient= 2**

| River Flow, $ft^3/s$ | Bypass Flow, $ft^3/s$ | Weir Flow, $ft^3/s$ | Canal Flow, $ft^3/s$ | Bypass Flow as % of River Flow | Weir Flow as % of River Flow | Bypass & Weir Flow as % of River Flow |
|---|---|---|---|---|---|---|
| 5000 | 558.9 | 0.0 | 1399.3 | 15.5% | 0.0% | 15.5% |
| 10000 | 1305.8 | 145.5 | 1400.0 | 15.2% | 1.7% | 16.9% |
| 20000 | 2884.0 | 843.8 | 1400.8 | 15.5% | 4.5% | 20.0% |
| 30000 | 4428.4 | 1608.6 | 1400.0 | 15.5% | 5.6% | 21.1% |
| 40000 | 6037.6 | 2401.4 | 1400.3 | 15.6% | 6.2% | 21.9% |
| 70000 | 11052.1 | 4755.7 | 1400.0 | 16.1% | 6.9% | 23.0% |

Weir Elevation= 1992.1
Weir Length= 150
**Weir coefficient= 3**

| River Flow, $ft^3/s$ | Bypass Flow, $ft^3/s$ | Weir Flow, $ft^3/s$ | Canal Flow, $ft^3/s$ | Bypass Flow as % of River Flow | Weir Flow as % of River Flow | Bypass & Weir Flow as % of River Flow |
|---|---|---|---|---|---|---|
| 5000 | 552.2 | 0.0 | 1401.4 | 15.3% | 0.0% | 15.3% |
| 10000 | 1304.8 | 210.1 | 1400.2 | 15.2% | 2.4% | 17.6% |
| 20000 | 2883.8 | 1208.3 | 1402.2 | 15.5% | 6.5% | 22.0% |
| 30000 | 4414.4 | 2301.1 | 1401.7 | 15.4% | 8.0% | 23.5% |
| 40000 | 6018.9 | 3433.8 | 1400.0 | 15.6% | 8.9% | 24.5% |
| 70000 | 10976.6 | 6774.9 | 1400.1 | 16.0% | 9.9% | 25.9% |

Both options are shown with 1 ft high stepped aprons on the downstream side of the weir. The stepped aprons were included assuming roller compacted concrete construction would be used for the weir. The steps will help dissipate a portion of the flow energy on the apron and breakup the flow nappe before it merges with bypass channel flow. However, weir height to critical depth on the weir is less than 10 and therefore, the steps contribute relatively little to energy dissipation of flow on the apron. Table 4 presents the elevation drop between the river and bypass channel water surfaces, weir unit discharge, head on the weir and the estimated residual energy at the bypass water surface.

Table 4 - Lateral weir flow parameters

Weir Elevation= 1992.1
Weir Length= 150
**Weir coefficient= 2**

| River Flow | River WSEL | Bypass WSEL | Difference | Unit Discharge | Head on Weir | $H_{residual}/H_{max}$ [1] |
|---|---|---|---|---|---|---|
| $ft^3/s$ | ft | ft | ft | $ft^3/s$ | ft | |
| 10000 | 1992.8 | 1987.2 | 5.6 | 0.97 | 0.7 | 0.5 |
| 20000 | 1994.2 | 1989.7 | 4.5 | 5.62 | 2.1 | 0.83 |
| 30000 | 1995.3 | 1991.6 | 3.8 | 10.7 | 3.2 | 0.94 |
| 40000 | 1996.3 | 1993.1 | 3.2 | 16.0 | 4.3 | 0.95 |
| 70000 | 1998.8 | 1997.0 | 1.8 | 31.7 | 4.9 | ~1 |

Weir Elevation= 1992.1
Weir Length= 150
**Weir coefficient= 3**

| River Flow | River WSEL | Bypass WSEL | Difference | Unit Discharge | Head on Weir | $H_{residual}/H_{max}$ [1] |
|---|---|---|---|---|---|---|
| $ft^3/s$ | ft | ft | ft | $ft^3/s$ | ft | |
| 10000 | 1992.8 | 1987.2 | 5.5 | 1.4 | 0.7 | 0.52 |
| 20000 | 1994.2 | 1989.7 | 4.5 | 8.0 | 2.1 | 0.86 |
| 30000 | 1995.3 | 1991.6 | 3.7 | 15.3 | 3.2 | 0.95 |
| 40000 | 1996.2 | 1993.1 | 3.0 | 22.9 | 4.3 | 0.97 |
| 70000 | 1998.6 | 1997.0 | 1.6 | 45.2 | 4.9 | ~1 |

[1] Reference Boes and Hager (2003) "Design of stepped spillways", ASCE Journal of Hydraulics Engineering, Sept.
* River data at station 28062 (50 ft upstream of dam), bypass data at station 194.7 (station where LW flow enters).

This study does not provide detail on the merging of flows from the bypass channel, lateral weir and river. This will need to be investigated using physical and three dimensional numeric models. Limited 3-dimensional numerical flow modeling was conducted for this study to identify major flow patterns for developing the initial alignment of the bypass entrance and lateral weir option.

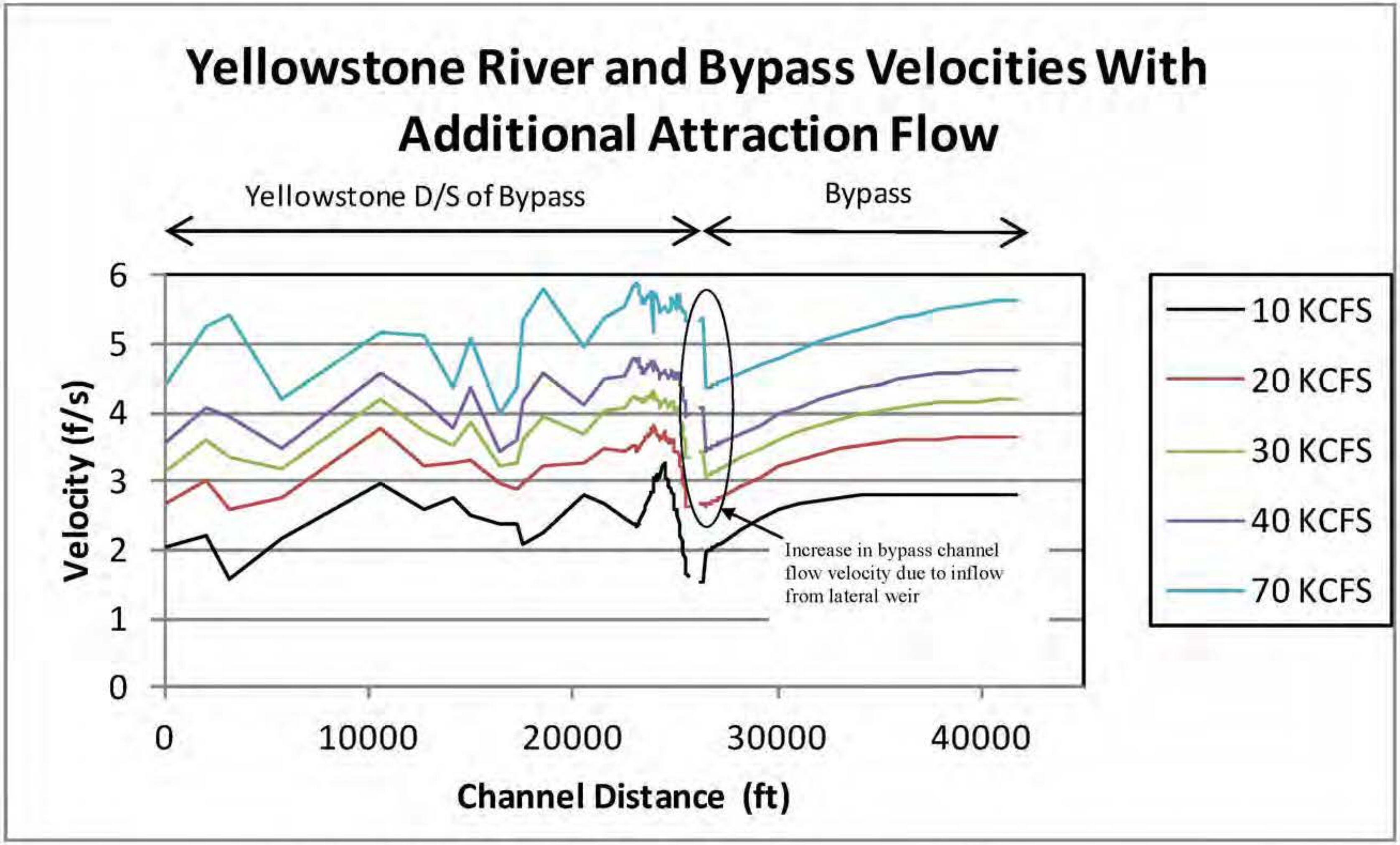



Figure 4 - Average channel velocity in the Yellowstone River downstream of the bypass entrance (left side) and in the bypass (right side) with additional attraction flow from lateral weir

## CFD Modeling

Preliminary Flow3D[1] modeling of the bypass entrance with a lateral weir was conducted to determine major flow patterns associated with merging bypass channel flow, lateral weir flow and river flow. The model was not run to stabilization and results should not be used to make any quantitative conclusions. Figure 5 shows a plan view of the velocity magnitudes in ft/s that occur at a river flow of 40,000 $ft^3/s$ (upstream of the bypass exit). Although a course-grid model was used containing many assumptions, the complex interaction that occurs when the bypass re-enters the river for lateral weir option 1 suggests that favorable approach conditions to the bypass can be achieved with further analysis. Due to the limitations of CFD modeling to quickly look at multiple weir alignments it is recommended that a physical model be used to further analyze the bypass entrance conditions.

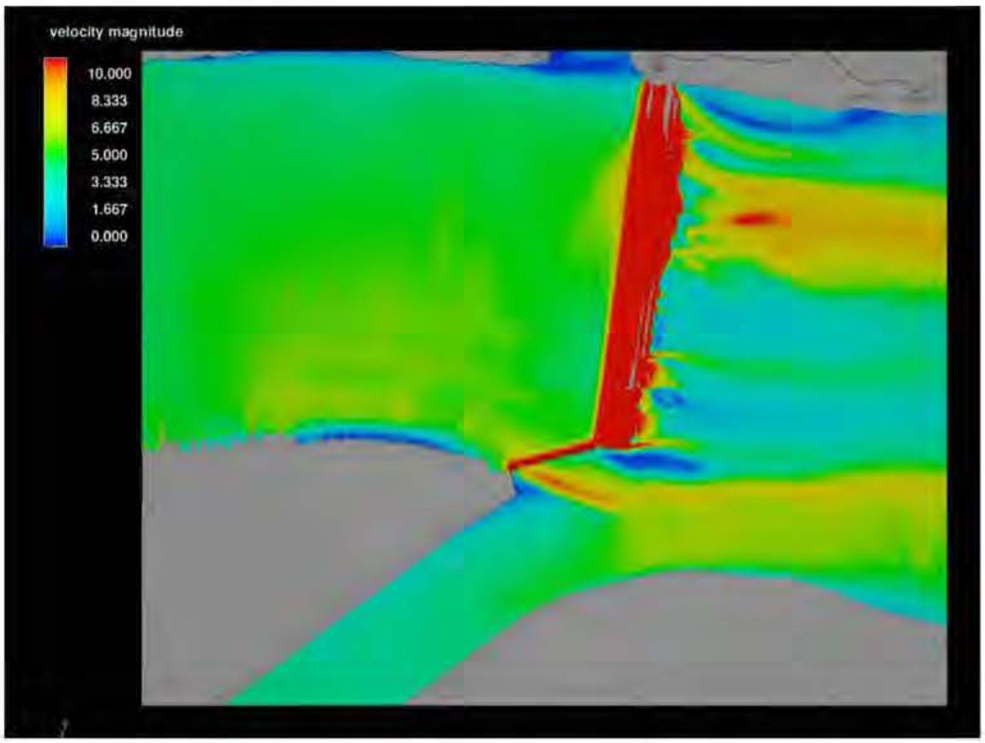



Figure 5 - Flow3D model of the fish bypass entrance and river confluence (flow is from left to right)

# Drawings

Preliminary bypass channel alignments were provided by the Corps. Reclamation used the initial layouts and created a dynamic AutoCAD Civil3D model which allowed refinement of the entrance and exit geometries. Considering that the Corps uses different modeling programs and cannot open Civil3D files, the dynamic models were converted to standard AutoCAD files and

[1] a commercially available computation fluid dynamics (CFD) program

PDF's. Drawings include plan and section views for the bypass entrance without a lateral weir, bypass exit and two different configurations of the bypass entrance with a lateral weir. For the drawings, it was assumed that the new crest geometry will be placed in approximately the same location as the existing dam. All drawings can be found at the end of the report.

## References

Bramblett, G.R., 1996, "Habitats and Movements of Pallid and Shovelnose Sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota," PhD thesis, Biological Sciences, Montana State University-Bozeman

Elser, A. A., et al., July 1977, "The Effect of Altered Streamflow on Fish of the Yellowstone and Tongue Rivers, Montana," Montana Department of Natural Resources and Conservation Water Resources Division, Technical Report No. 8.

## List of Drawings

Bypass Channel Entrance with no Lateral Weir

1. Fish Passage Inlet Sheet 1 – Plan
2. Sheet 2 – Sections 0+00 to 1+50
3. Sheet 3 – Sections 2+00 to 3+50
4. Sheet 4 – Sections 4+00 to 4+50

Bypass Channel Exit

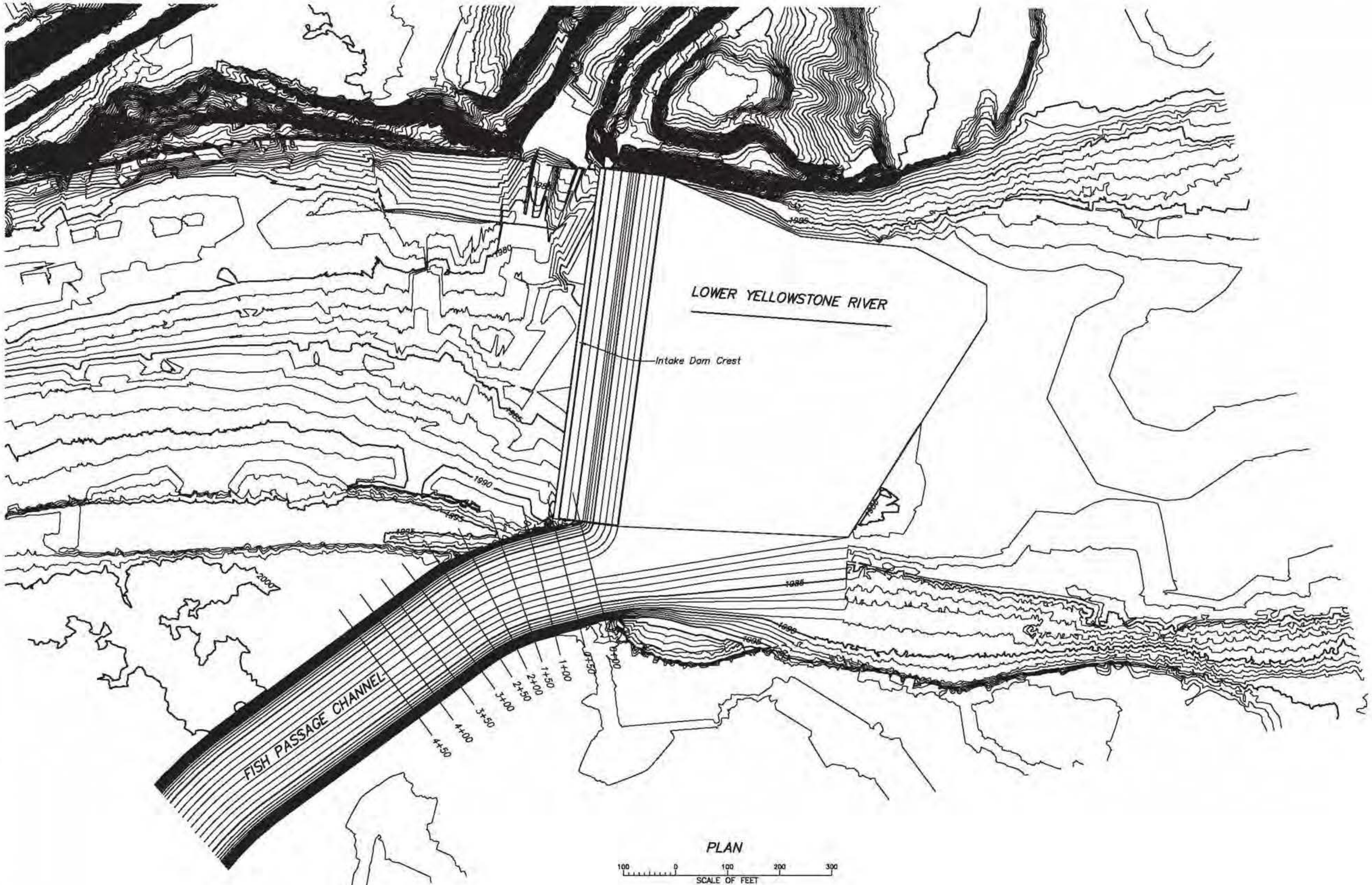
5. Fish Passage Outlet Sheet 1 – Plan
6. Sheet 2 – Sections 155+50 to 157+00
7. Sheet 3 – Sections 157+50 to 158+50
8. Sheet 4 – Sections 159+00 to 159+50

Bypass Channel Entrance with Lateral Weir Option 1

9. Fish Passage Option 1 Sheet 1 - Plan and Typical Section
10. Sheet 2 – Sections 0+00 to 0+75
11. Sheet 3 – Sections 1+00 to 1+50

Bypass Channel Entrance with Lateral Weir Option 2

12. Fish Passage Option 2 Sheet 1 - Plan and Typical Section
13. Sheet 2 – Sections 0+00 to 0+75
14. Sheet 3 – Sections 1+00 to 1+50

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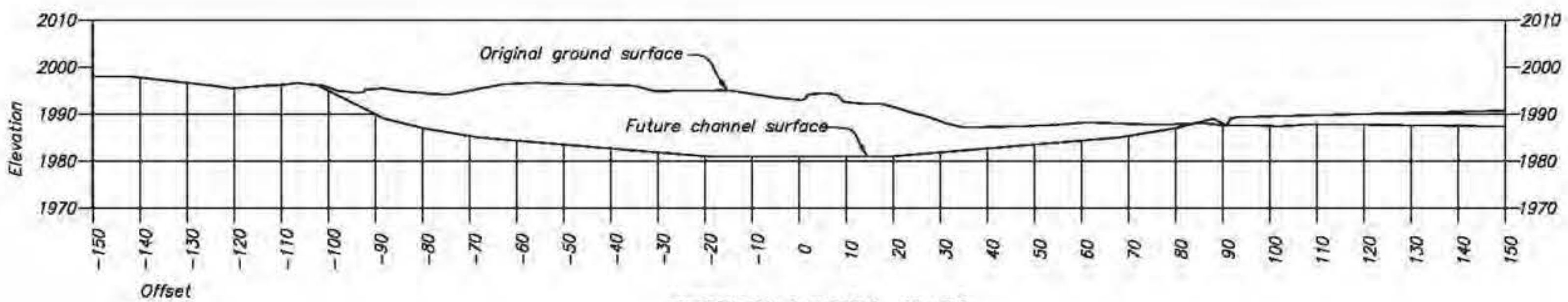


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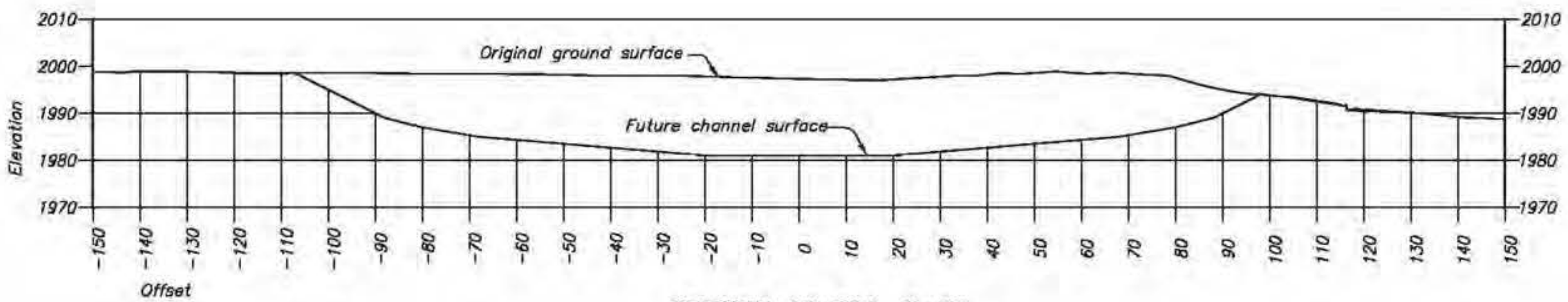


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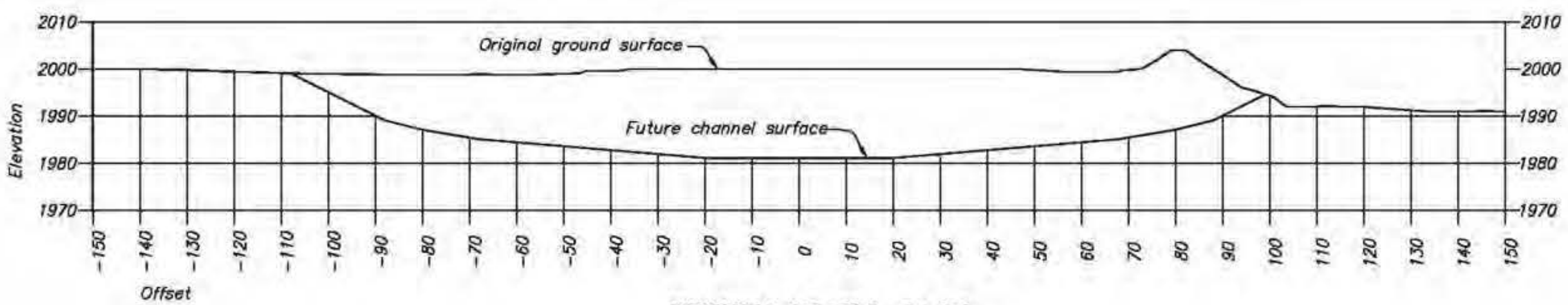


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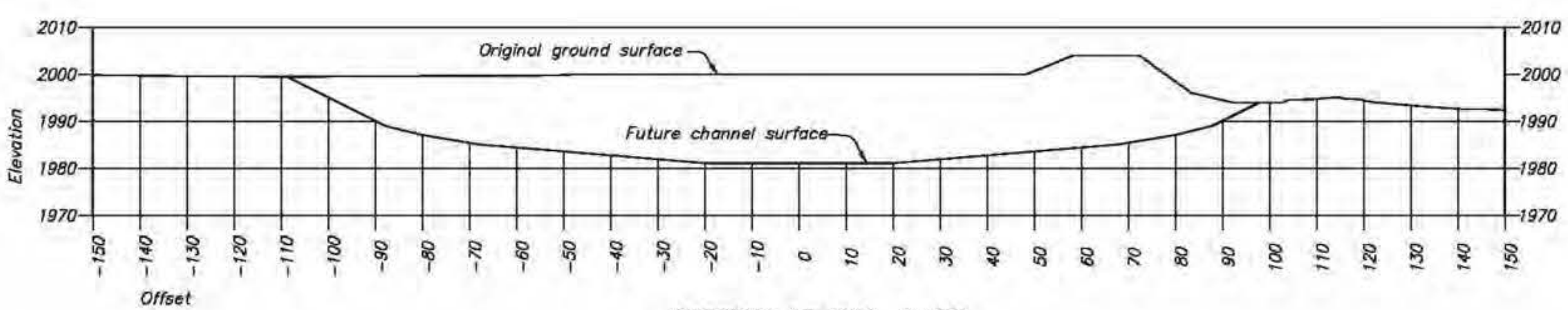


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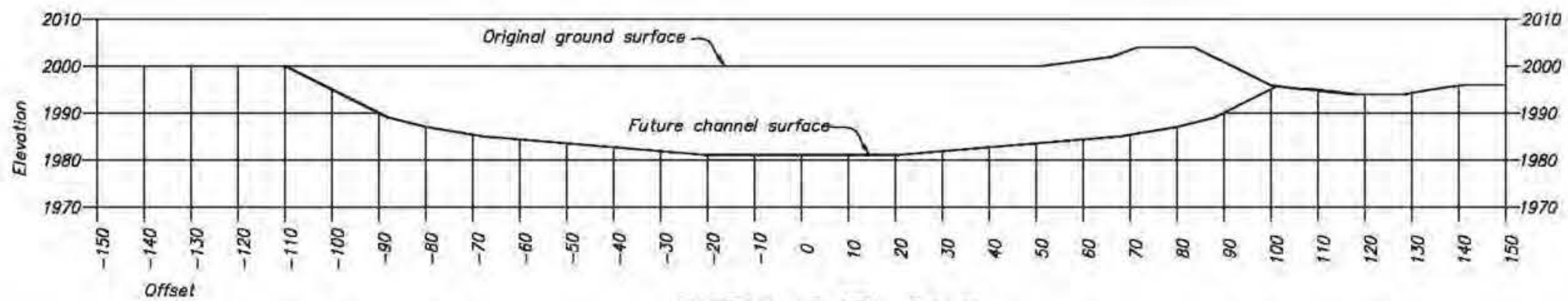


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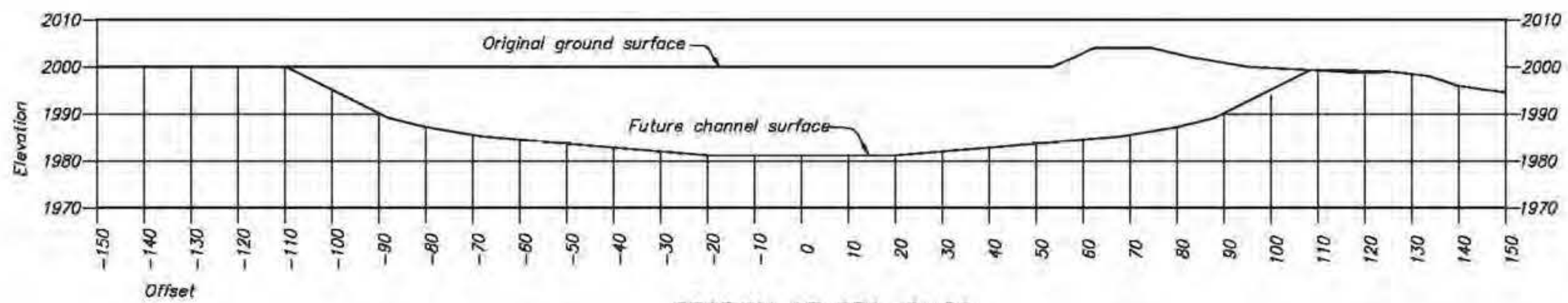


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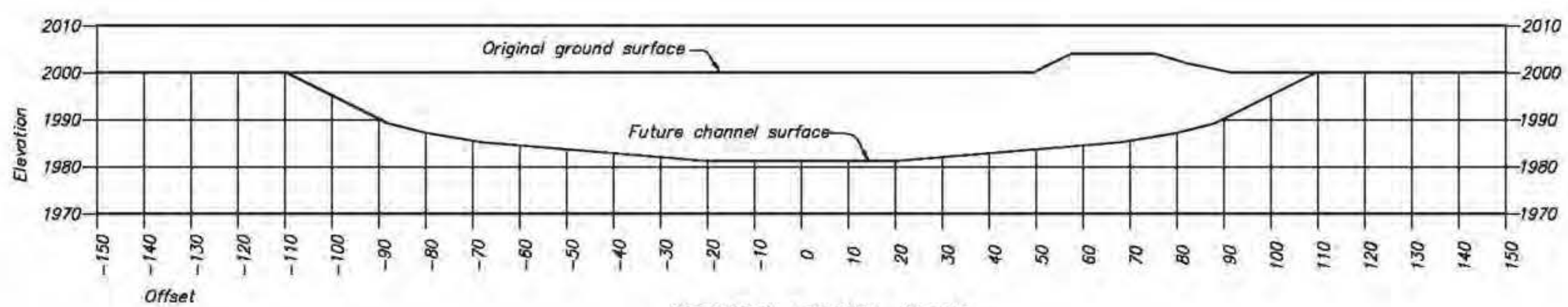


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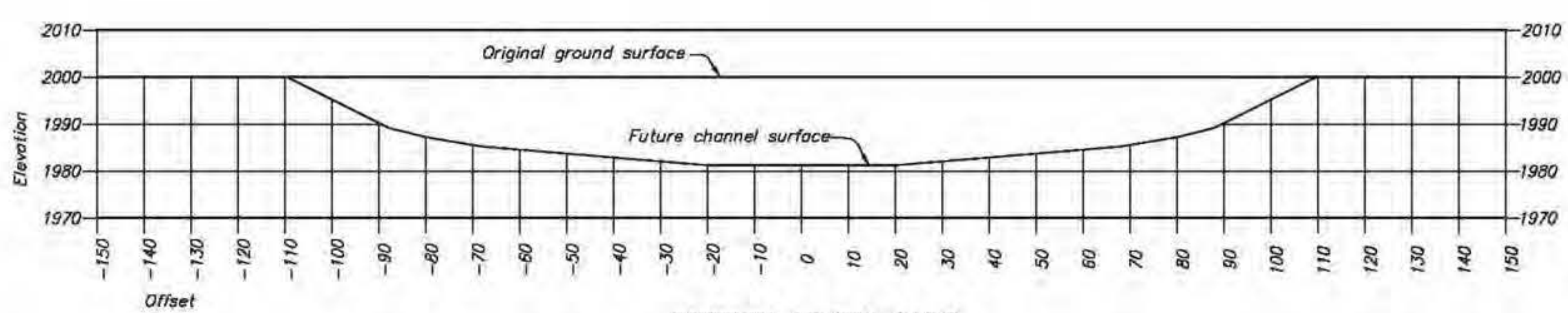


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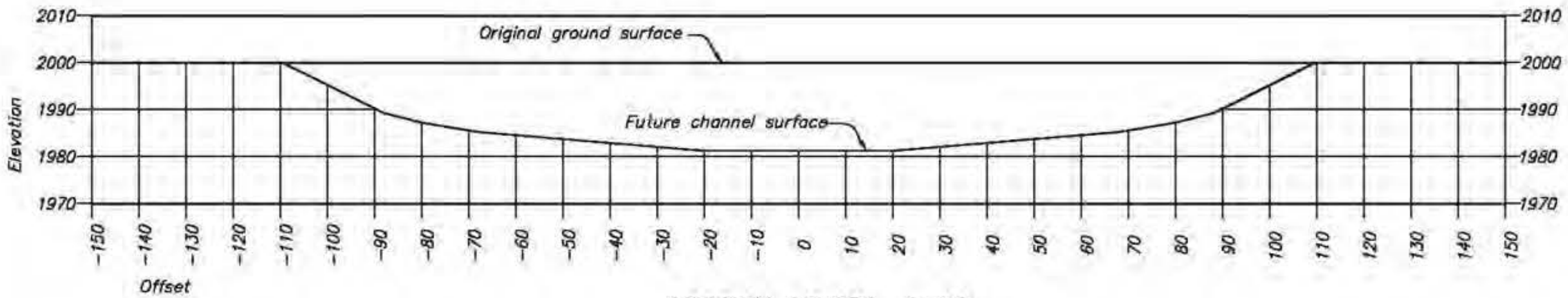


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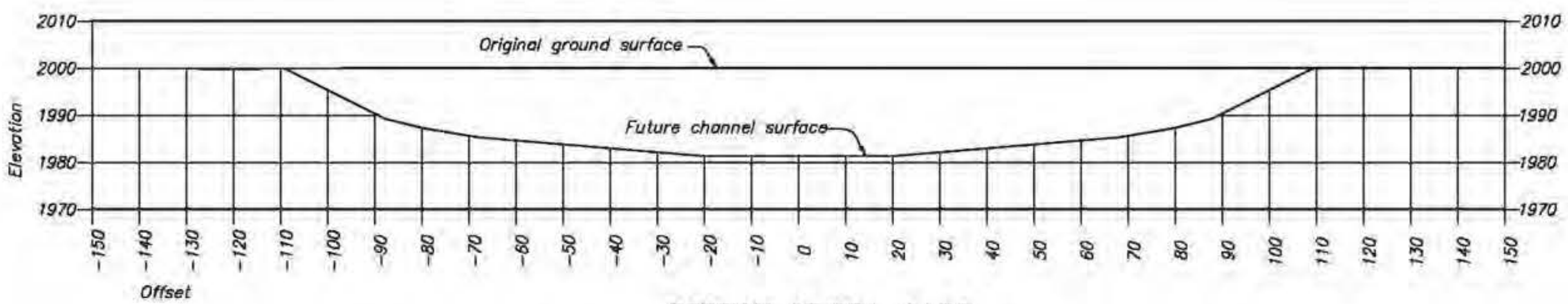


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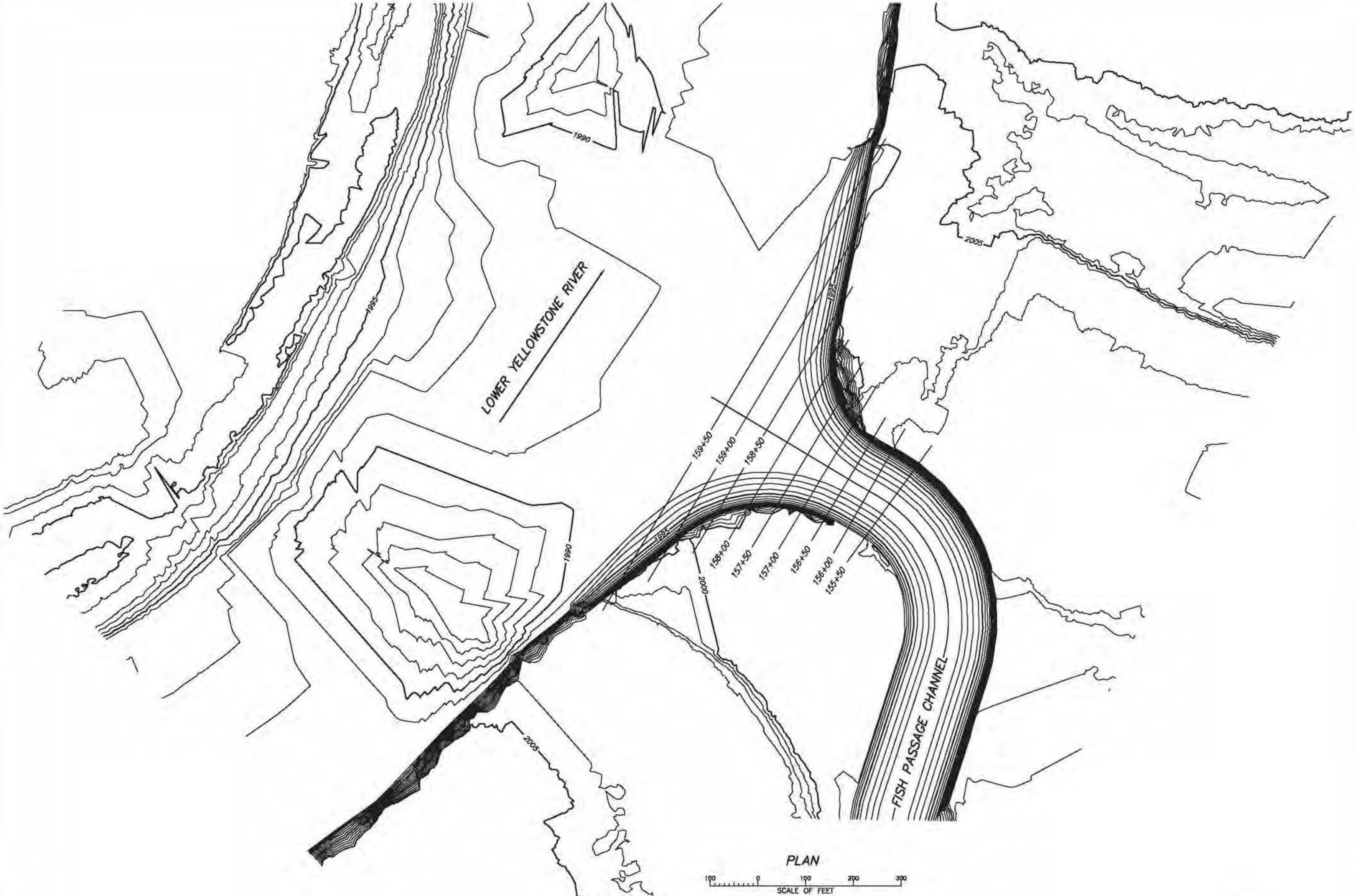


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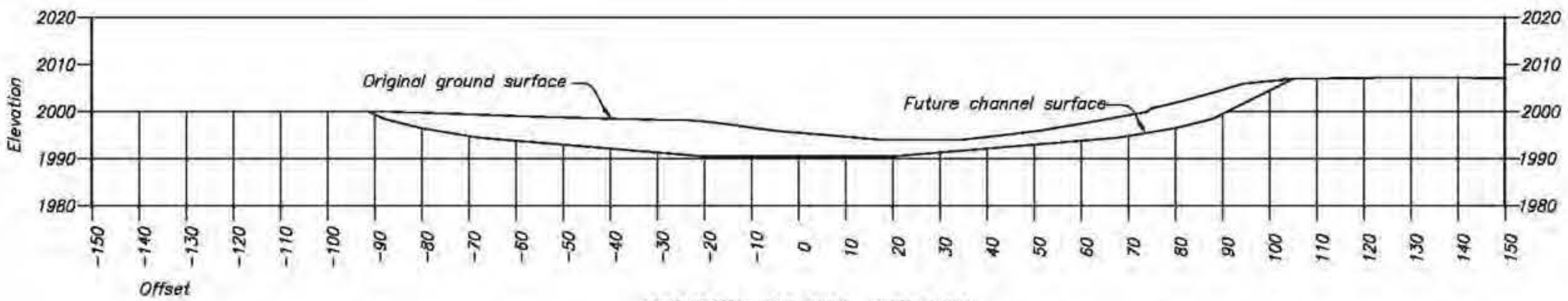


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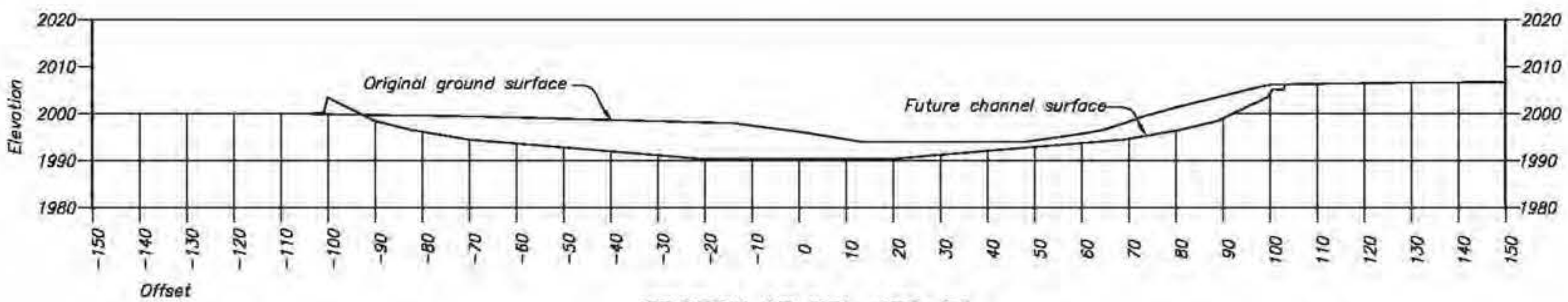


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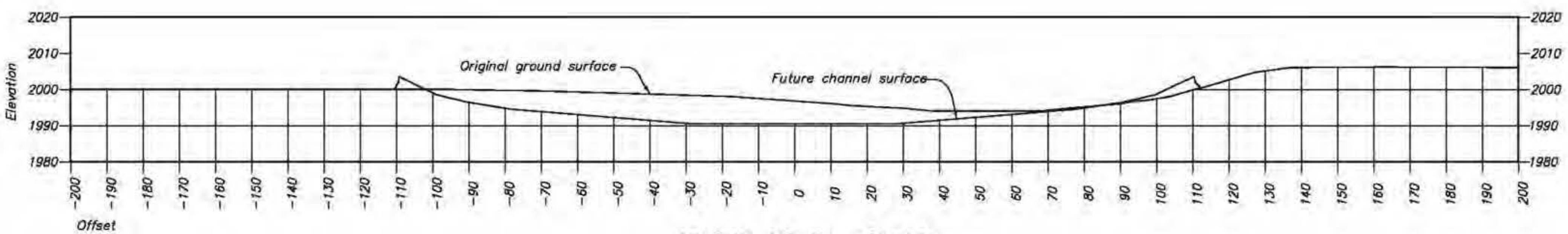


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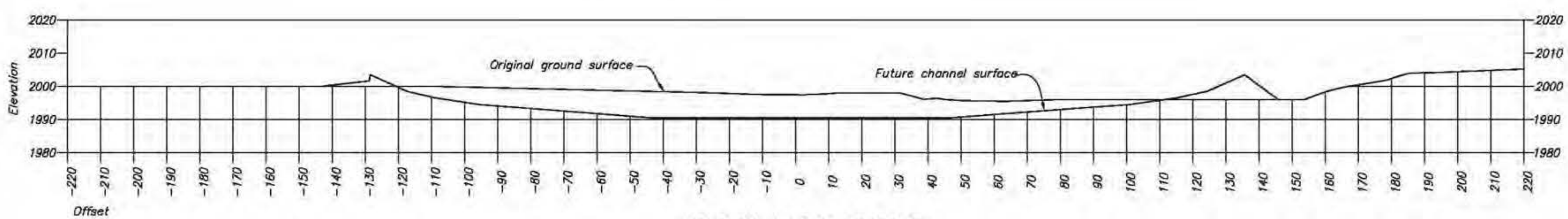


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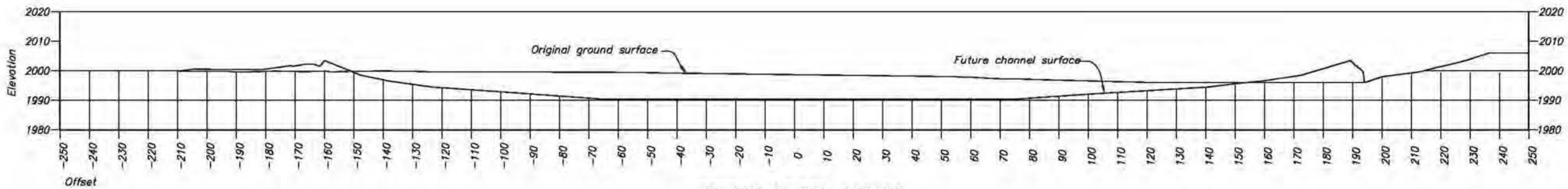


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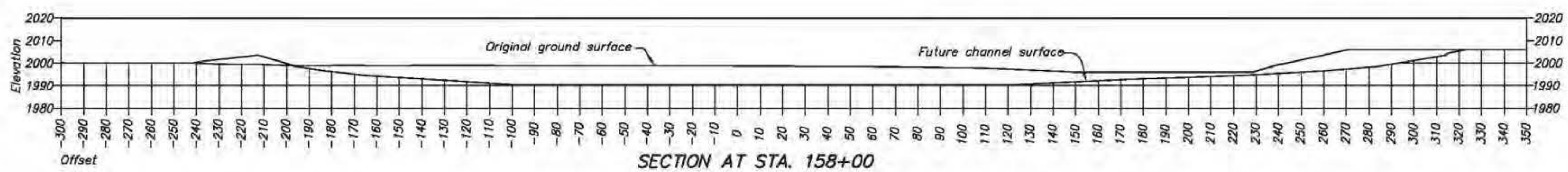


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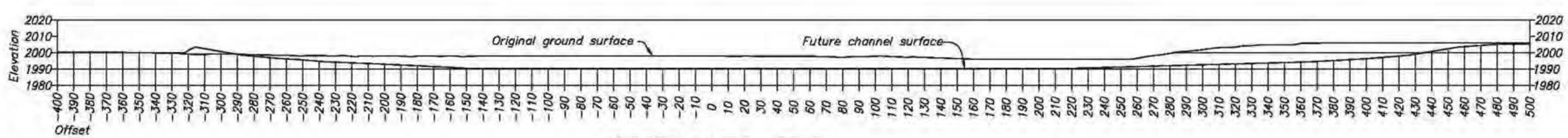


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Drawing No. 7
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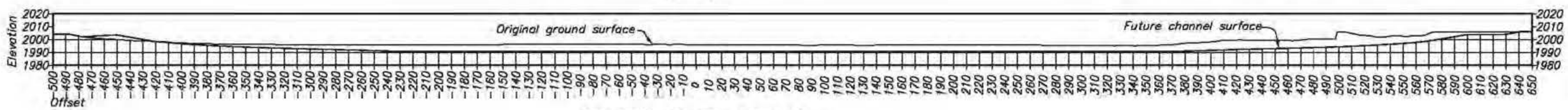


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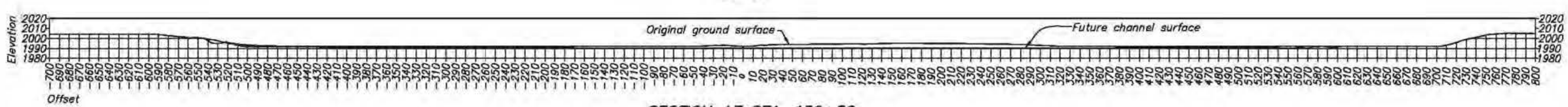


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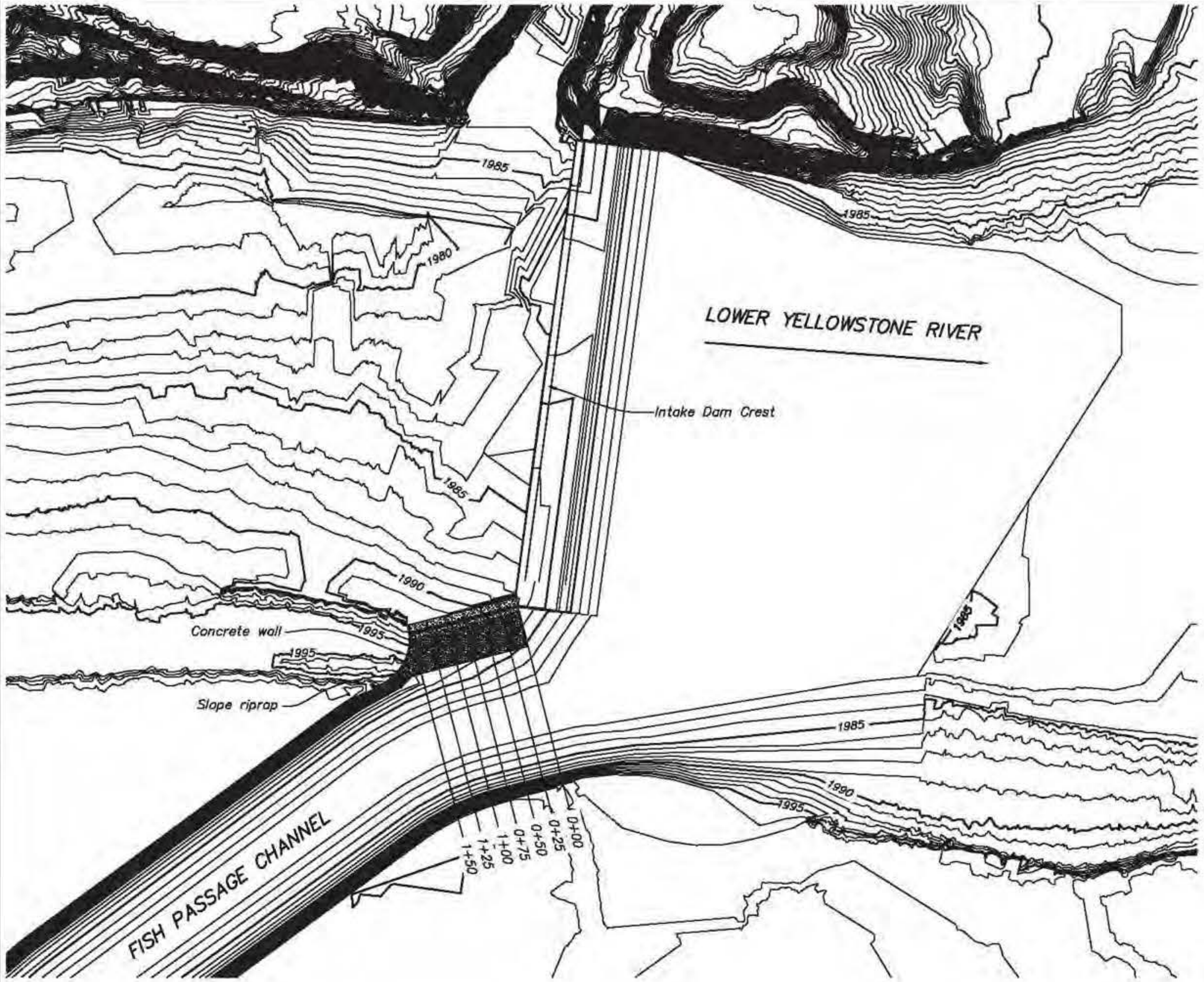
SHEET 4 OF 4

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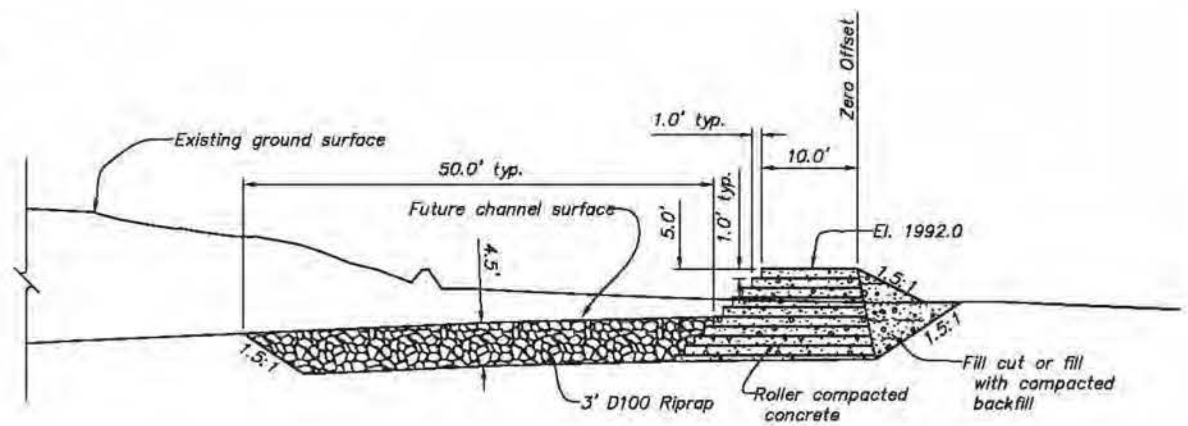


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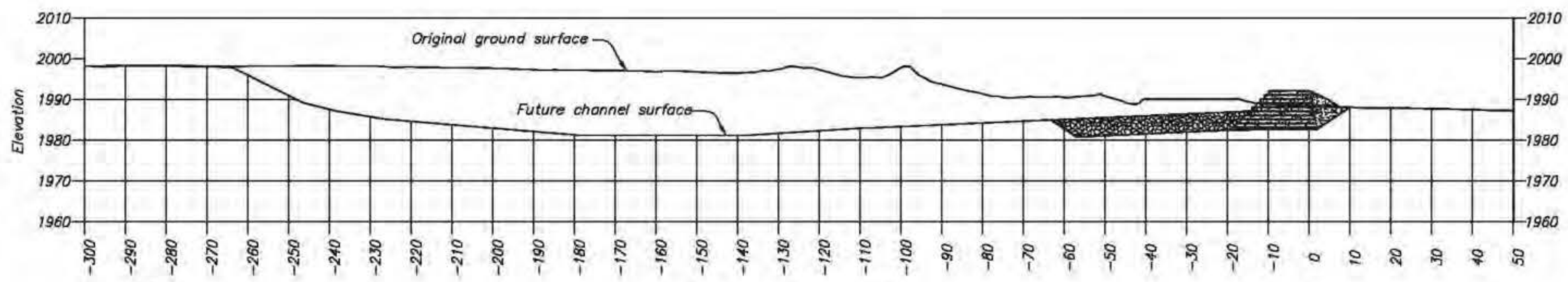


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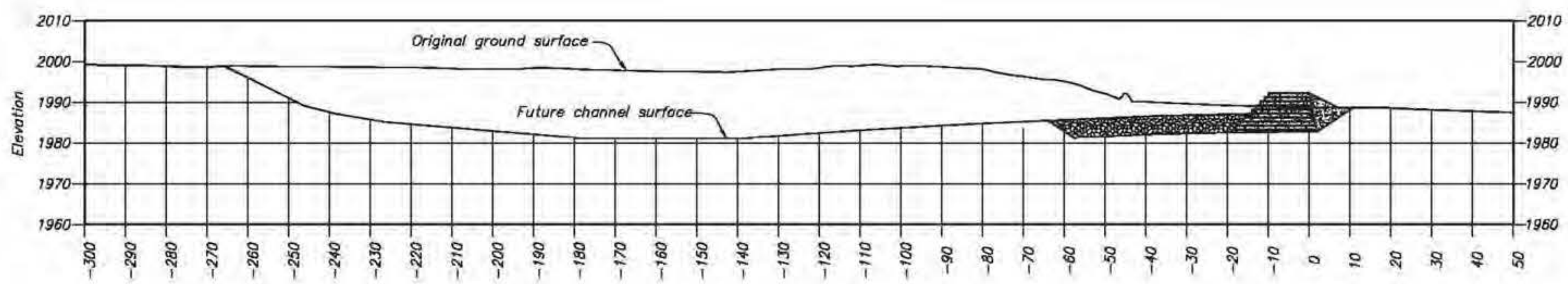


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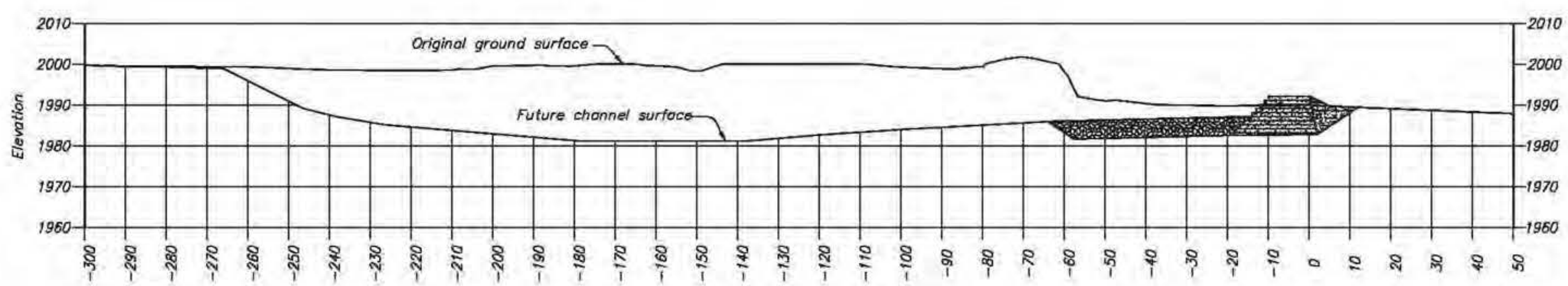


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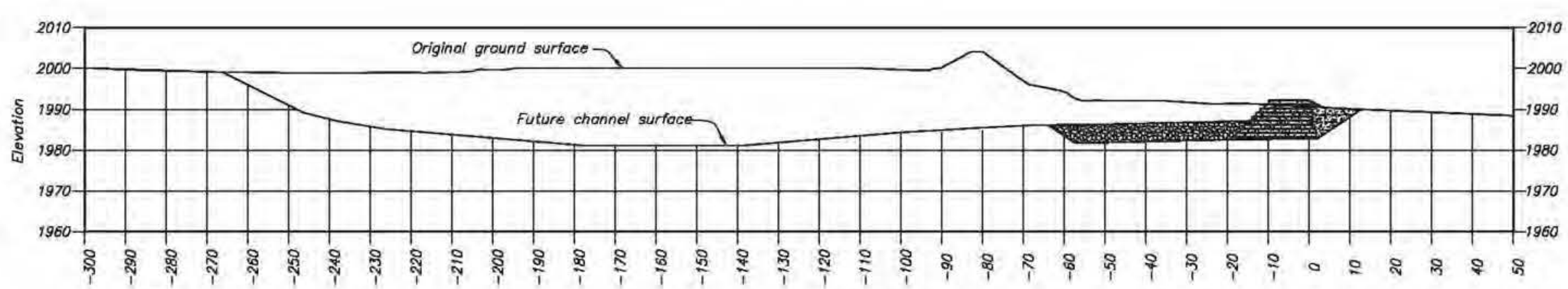


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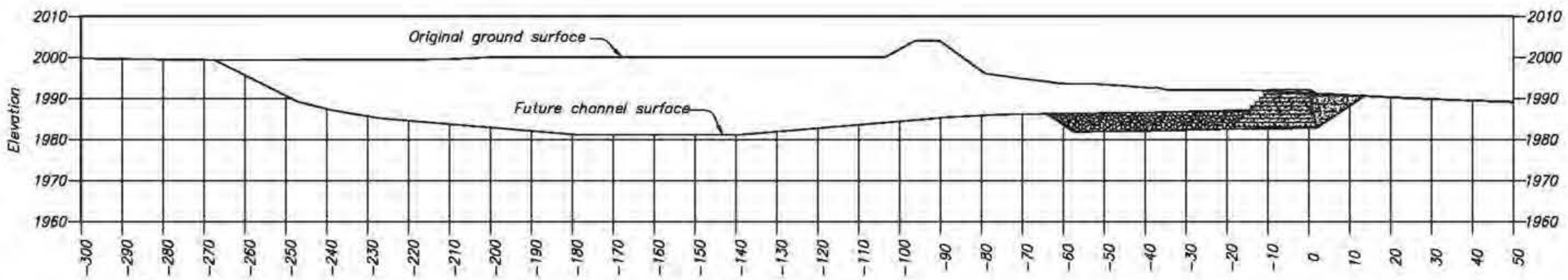
SHEET 2 OF 3

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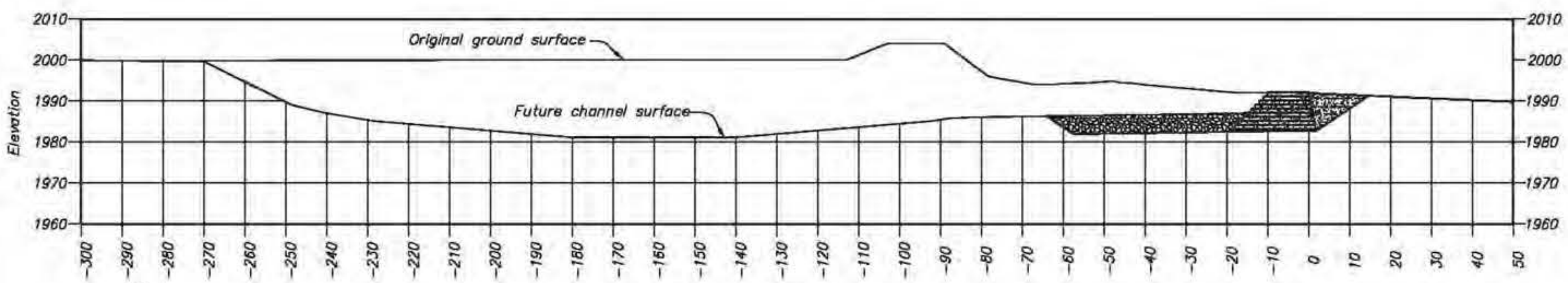


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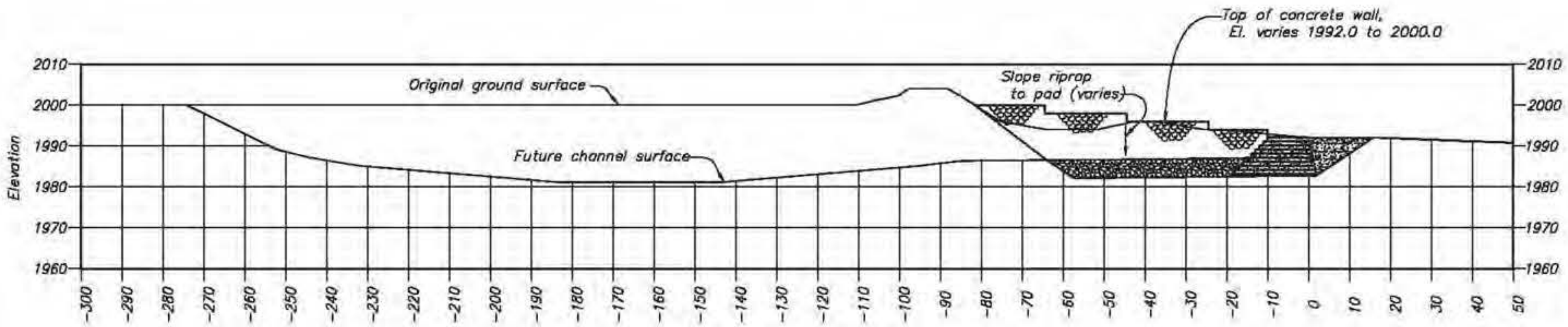


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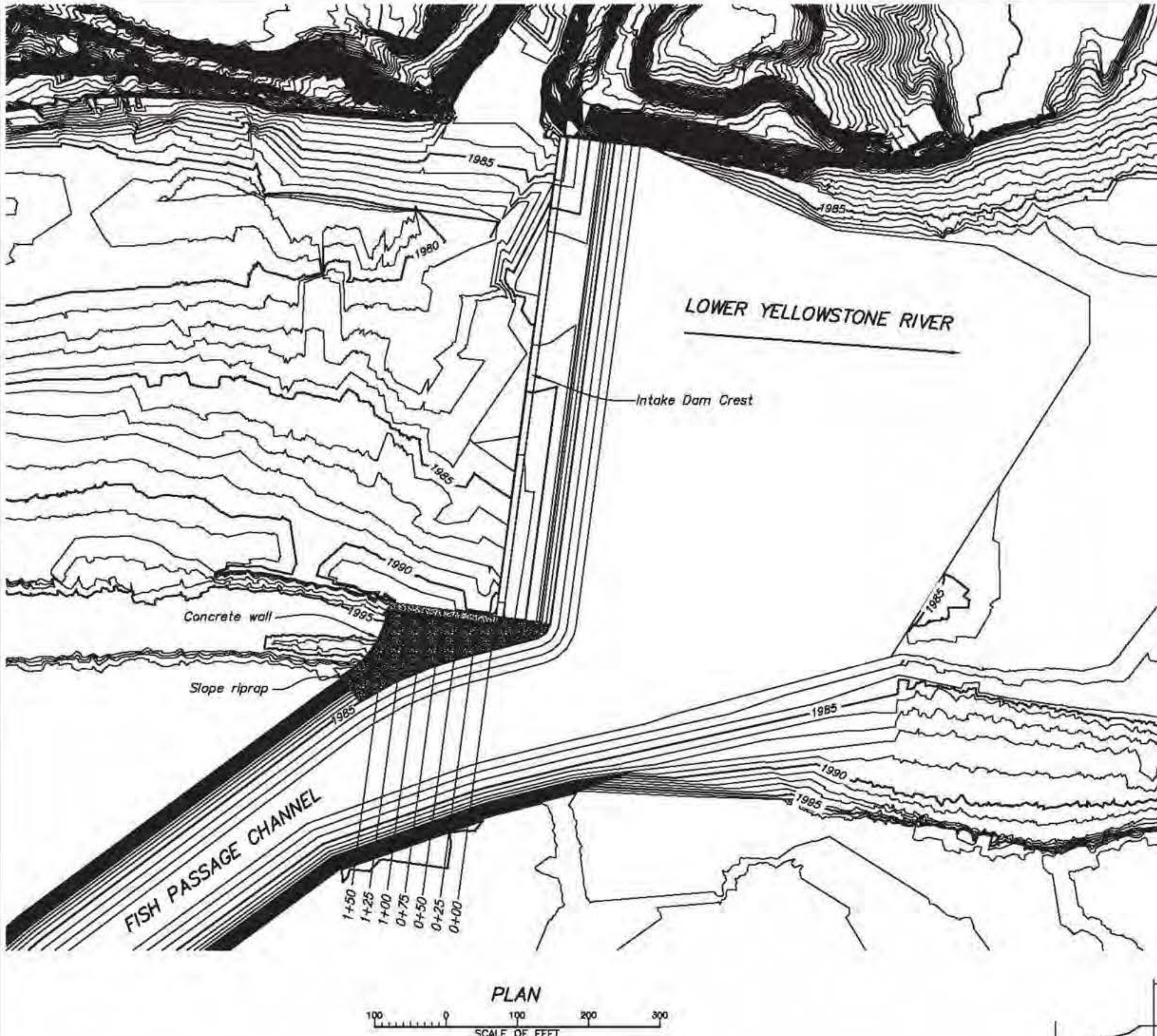


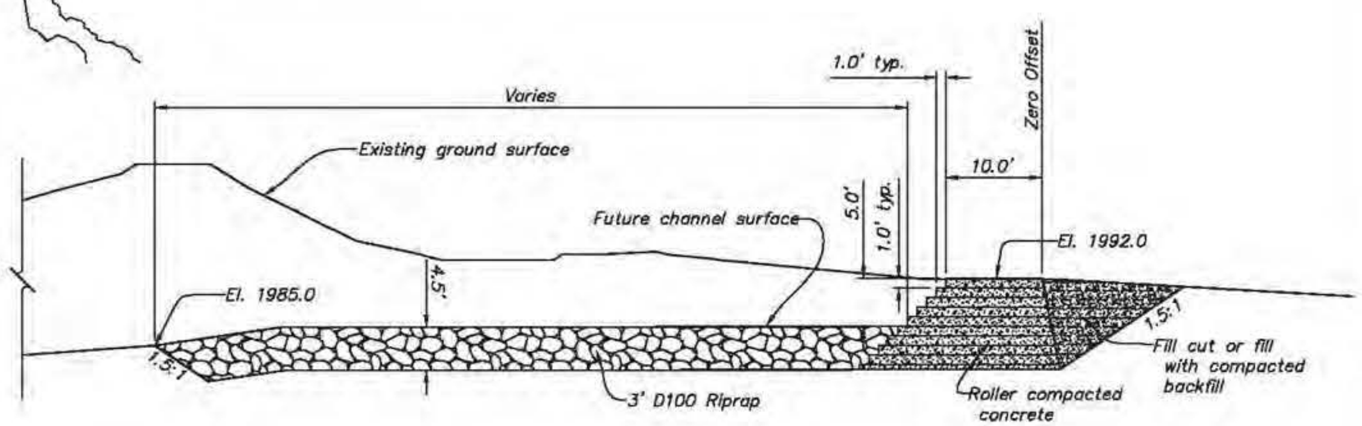


TYPICAL SECTION
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INTAKE DAM
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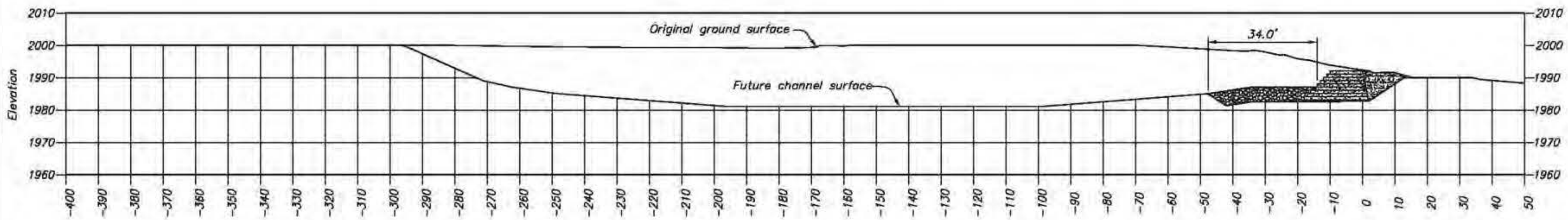

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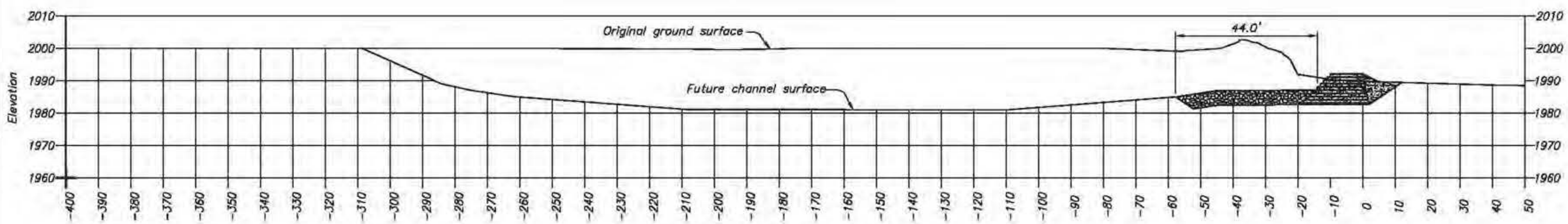

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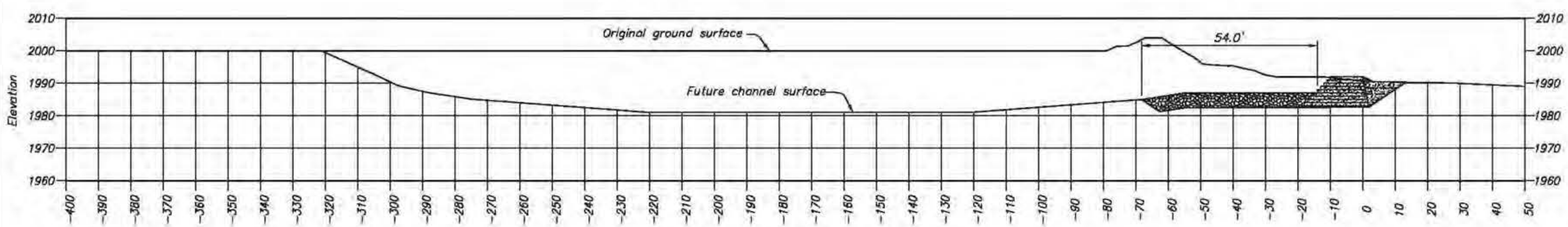

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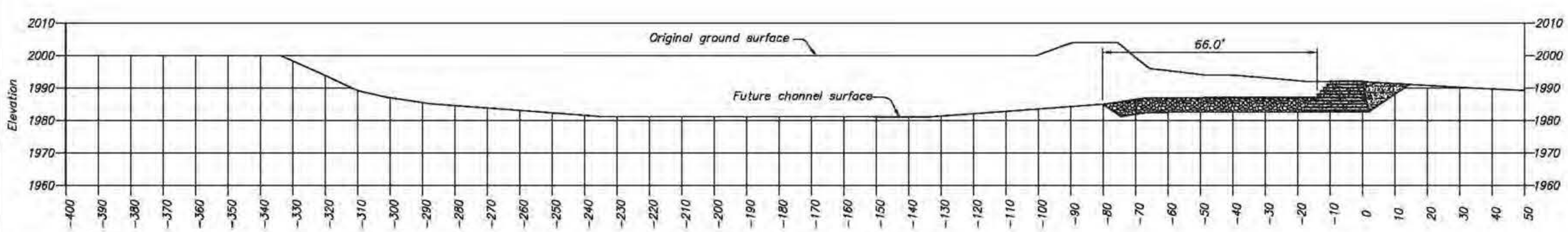

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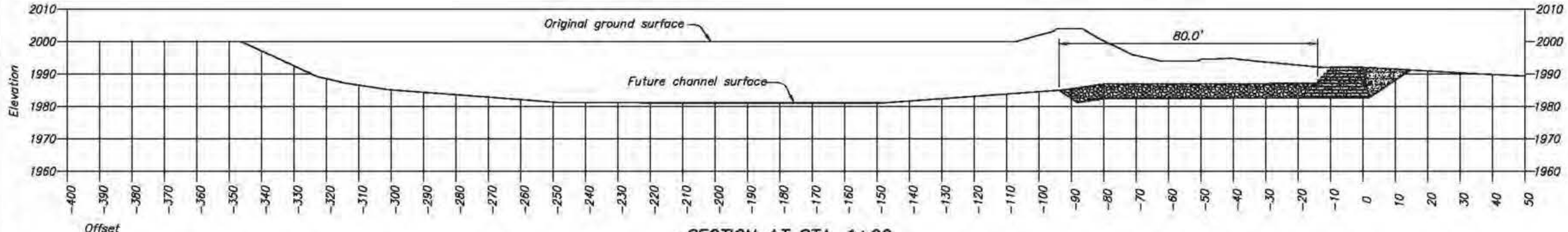


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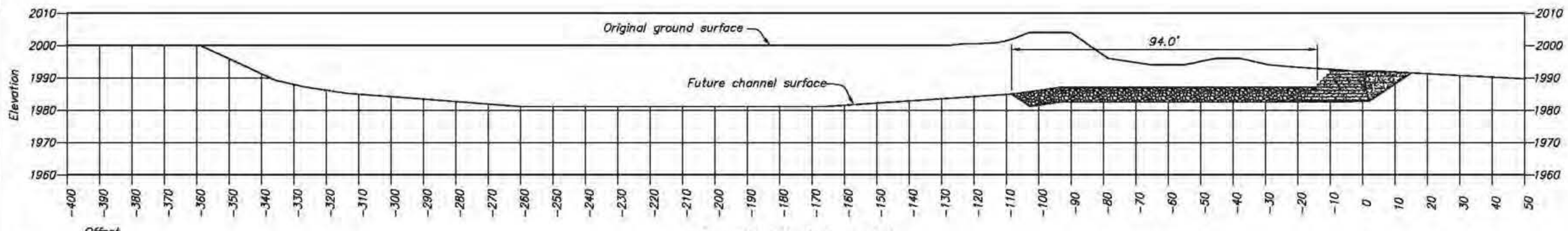


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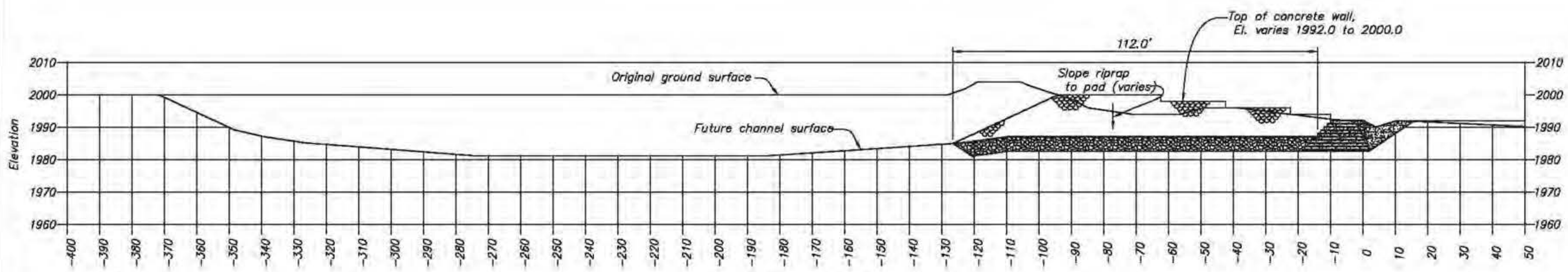


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INTAKE DAM
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**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Decision Document**
**April 2011**
**Updated JULY2012**

**Attachment 7**

# Concrete Structures



Return to TOC

# Concrete Structures
# April 2011

## 1. Introduction.

Concrete structures consist of the Dam, the Upstream Control Structure, and the Flow Augmentation Structure. The Dam is required for either the Rock Ramp scenario or the Bypass scenario to ensure adequate head at the new headworks structure to provide the irrigation district's full water rights. The Upstream Control Structure is required for the Bypass scenario only. The Flow Augmentation Structure is an option for the Bypass scenario only.

## 2. Dam (Rock Ramp & Bypass Scenarios)

### 2.1 Existing Operation and 404 Concerns.

In the past, the irrigation district has replaced rock riprap on the dam as needed to increase head at the headworks to allow the irrigation district to obtain it's full water right during the low flow months. Head requirements at the new headworks are approximately 1 ft greater than that for the old structure due to head loss through the new screens.

After implementation of a rock ramp alternative, addition of rock riprap to the dam to maintain the required head would negatively impact performance of the ramp as ice and water flow relocated rock from the dam onto the ramp necessitating the need for a concrete structure.

Continued placement of rock on the dam crest as part of implementation of a bypass channel option would necessitate construction of an access bridge or low water crossing to facilitate stockpiling of rock adjacent to the dam crest. Neither structure is desirable from a fish passage standpoint and the bridge option would likely prove to be expensive. The irrigation district has also indicated that the trolley system used to place rock is nearing the end of it's functional life. In addition, Movement of rock from the crest over time could result in impacts to any attractive flow structures that may be required at the outlet of the chute or result in partial plugging and increased O&M of the bypass.

For these reasons, replacing the existing rock dam with a concrete dam is proposed. Two options for concrete dams are described below, one of which requires a cofferdam for construction. Construction of a cofferdam significantly adds to the cost of the structure.

### 2.2 Dam Constructed Behind a Coffer Dam.

A concrete dam as shown in Figure 1 requires use of a cofferdam to dewater the site. The front face is sloped 1 vertical to 3 horizontal to facilitate ice to pass over the dam. The large size of the dam, and the weight required for stability make cast-in-place concrete more feasible than precast concrete, although precast hollow sections that are filled with concrete after placement may be possible. Floating in precast sections and sinking them may not be feasible because the tolerance limits for top elevation require placement on a firm, level foundation. Risks associated with construction of a concrete dam are delays due to overtopping of the cofferdam during



Return to TOC

construction, ice damage to the cofferdam, and undetected areas of soft subgrade. Long term risks are settlement due to soft subgrade, or displacement due to ice forces much larger than predicted.

### 2.2.1 Coffer Dam for Construction of Dam (Rock Ramp Scenario)

The cofferdam used for construction of the existing dam consisted of timber sheet piles with timber bracing. Because that cofferdam was placed before the dam and rock, it was not as high as a cofferdam would need to be for construction of a new dam, and in fact construction was delayed at least once due to overtopping of the cofferdam. A timber cofferdam is not practical for the new cofferdam. Several options were evaluated for a cofferdam:

- Option 1 - A coffer dam and bypass using the existing chute with a levee to provide flow conveyance
- Option 2 - A coffer dam plus a short excavated bypass channel with a levee
- Option 3 - A coffer dam with sheet pile separation in channel to dewater half of the channel at a time

The cofferdam is required to remain in place during winter. A sheet pile cofferdam cannot resist ice floes in the river. Therefore, an earthen (various size stone/gravel) cofferdam with sheet pile cutoff wall is the most practical type of cofferdam. If a temporary bypass is excavated, cofferdams could be used upstream and downstream of the dam for construction in one season. Or, cofferdams could be used to dewater one-half of the river at a time. Soil borings do not indicate boulders at the proposed dam site upstream from the existing dam. Rock downstream from the existing dam would have to be removed at the location of the sheet pile cutoff dividing the river to enable pile driving. There remains some risk of encountering deeper boulders that would impede driving of the sheet pile cutoff wall. Other construction risks are damage from ice, and overtopping.

### 2.2.2 Coffer Dam for Construction of Dam (Bypass Scenario)

The cofferdam cannot be installed until low flow after the fish migration season when in-water work is prohibited. This does not allow time for construction of the dam in one year, therefore the cofferdam is required to remain in place during winter. A sheet pile cofferdam cannot resist ice floes in the river. Therefore, an earthen (various size stone/gravel) cofferdam with sheet pile cutoff wall is the most practical type of cofferdam . If a temporary bypass is excavated, cofferdams could be used upstream and downstream of the dam for construction in one season. Or, cofferdams could be used to dewater one-half of the river at a time. Soil borings do not indicate boulders at the proposed dam site upstream from the existing dam. There remains some risk of encountering deeper boulders that would impede driving of the sheet pile cutoff wall. Other construction risks are damage from ice, and overtopping.

## 2.3 Dam with Integral Sheetpile:

If use of permanent steel sheet pile is acceptable, two lines of sheet pile could be placed without dewatering, thus eliminating the need for a cofferdam. Concrete would be tremied underwater in the 24 foot space between the two lines of sheet pile to form a mass of concrete capable of resisting ice forces as shown in Figure 2. Rock fill would be placed to form a sloping face upstream of the concrete block, and the rock ramp placed downstream of the dam. This option also has the risk of encountering boulders that would impede driving sheet pile. Long term risks



Return to TOC

are displacement from ice forces much larger than predicted. There is also concern that the Pallid Sturgeon may be electroreceptive which could adversely impact pallid passage over the structure. The sheetpile could be coated with form release agent or otherwise modified to facilitate pulling the sheetpile after the concrete has cured. If pulling the pile failed, it could be cut off a few feet below the top of the rock layer - that may make this option infeasible for use either with a rock ramp passage option. Potential impacts to passage from steel sheet pile have not been fully evaluated. It is possible that sheet pile cut off at a sufficient depth below the passage zone may allow for successful passage if if electoreceptivity is an issue.

The current plan would be to would have the sheet pile form walls spaced at 24 feet extending from the existing headworks and to the right bank. The alignment would be upstream of the existing diversion dam but as close as possible to it will allowing for the maintenance of current rock pile slope so as to avoid making passage over the existing rock field for other native fish that may utilize it worse than it already is . The construction process would involve driving the sheet pile in a paired parallel wall configuration to create a 50 feet long segment of the dam utilizing T-connection sheet pile installed at the ends with other sheets to complete the cell. The cell would not be dewatered by pumping The concrete will be placed with pumper hose below water in the cell. As the concrete fills it would displace the water and the water would flow over the sheet pile cell. The sheet pile lengths used would be 40 feet. The top elevation of the sheet pile would be approximately 4.5’ above the final crest elevation of 1990.5. After the concrete has set, the sheet piles would be pulled for reuse or cut-off below the final crest elevation. The next cell would be started and the process repeated. A triangular riprap section on the upstream side would be placed from the crest to the river bottom, this would allow for ice to slide up and over the crest. The area between the new crest and the old diversion dam would be filled with coarse material and capped with riprap layer. The sequencing of the cells in 50-foot lengths would allow for river flows to pass without coffering or diverting water. This work would involve both barge (where draft is available) and conventional construction equipment (at river banks) for creating ramps for access and construction platforms. Risks during construction are delays caused by floods, encountering deeper boulders that would impede driving of the sheet pile, or inability to pull sheet pile if presence of buried steel is unacceptable. Long term risks are settlement due to soft subgrade, or displacement due to ice forces much larger than predicted.

### 2.4 Dam VE Alternative (not recommended at this time)

An alternative to construct a precast concrete dam placed on driven steel piles as shown in Figure 3 is being evaluated. At this time the feasibility of this alternative is not 57
certain because it is not know if the piles or the precast to pile connection would have the capacity to resist the force of ice floes in the river. Other risks associated with this alternative are encountering boulders that would impede driving steel pile. Long term risks are displacement from ice forces much larger than predicted.

## 3. Upstream Control Structure Concrete Slab (Bypass Scenario)

The Upstream Control Structure requires a concrete slab 30 feet long (upstream to downstream) to provide stable grade control that will not be moved by ice floes. A 6-foot thick concrete slab is required for stability against the expected ice forces. The slab can be constructed of roller compacted concrete place in a dewatered excavation as shown in Figure 4. Risks associated with this construction method are increased dewatering cost due to groundwater seepage much larger than predicted,. Long term risks are displacement due to ice forces much larger than predicted.



Return to TOC

See Attachment 6 *Bypass Channel*, Appendix C-*30% Design Features* for details pertaining to the upstream control structure, including the concrete slab and associated riprap tieback features."

## 4. Flow Augmentation Structure (Bypass Scenario)

The Flow Augmentation Structure is an option that could be constructed near in downstream end of the bypass to provide additional attraction flow. The structure can be constructed of roller compacted concrete place in a dewatered excavation as shown in Figure 5. Risks associated with this construction method are increased dewatering cost due to groundwater seepage much larger than predicted. Long term risks are settlement due to soft subgrade, or displacement due to ice forces much larger than predicted.

## 5. Ice Forces

The ice loads used for structural design are as recommended by the Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) as summarized in Table 1.

**Table 1. Summary of Ice Loads on Structures**

| | | | Whichever produces the greater force | |
|---|---|---|---|---|
| Structure | Material | Reference | Impact acting as horizontal line load | Shear acting as horizontal friction on top surface. (Need not exceed the impact line load.) |
| Existng Dam Crest | Riprap | a. Para 6.4 | 15 klf | 2 ksf |
| Upstream Control Structure | Concrete | b. Para 6.a. | 10 klf | NA |
| Channel Plug | Riprap | b. Para 6.b. | NA | NA |
| Armoring at Channel Bends | Riprap | b. Para 6.c. | NA | NA |
| Vertical Control Structures in Bypass Channel and Outlet | Riprap | b. Para 6.d. | NA | NA |
| Downstream Lateral Stability Structure | Riprap | b. Para 6.f. | NA | NA |
| New Dam Crest | Concrete | b. Para 6.g. | 15 klf | 2 ksf |
| Flow Augmentation Structure | Concrete | b. Para 6.h. | 10 klf | 2 ksf |

References

a. Ice Forces on Intake Dam, Lower Yellowstone River: 30 Percent Design, Andrew M. Tuthill, CRREL

b. Evaluation of Ice Impacts on Fish Bypass Channel at Intake Dam, Lower Yellowstone River, Andrew M. Tuthill, Meredith L. Carr, CRREL, Feb 12, 2012



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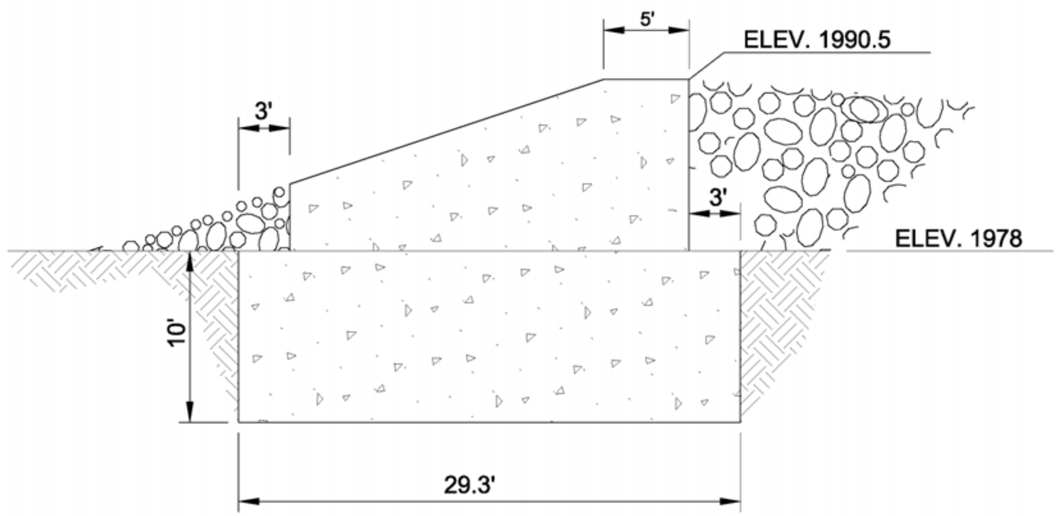


**Figure 1 Cast-in-Place Reinforced Concrete Dam**

**(Reinforcement not shown, a cofferdam is required for construction)**



Return to TOC

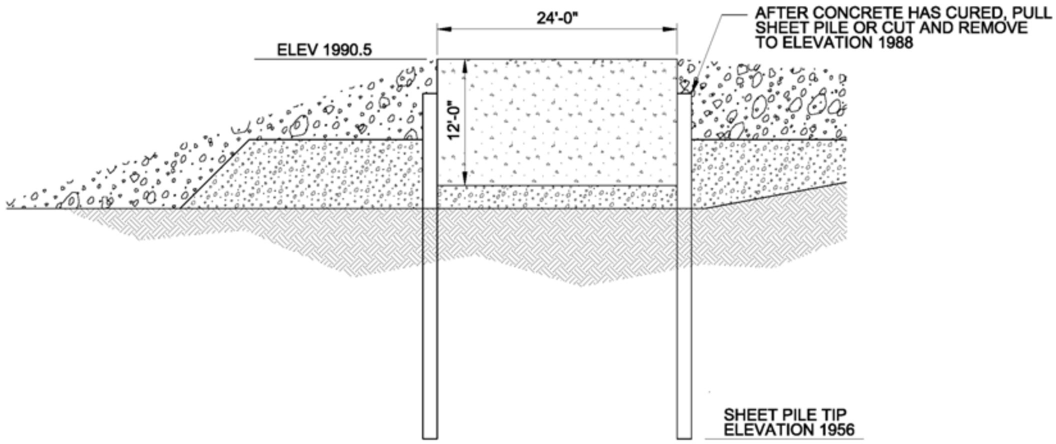


**Figure 2 Concrete Dam**
**(Concrete Placed Underwater without Cofferdam)**



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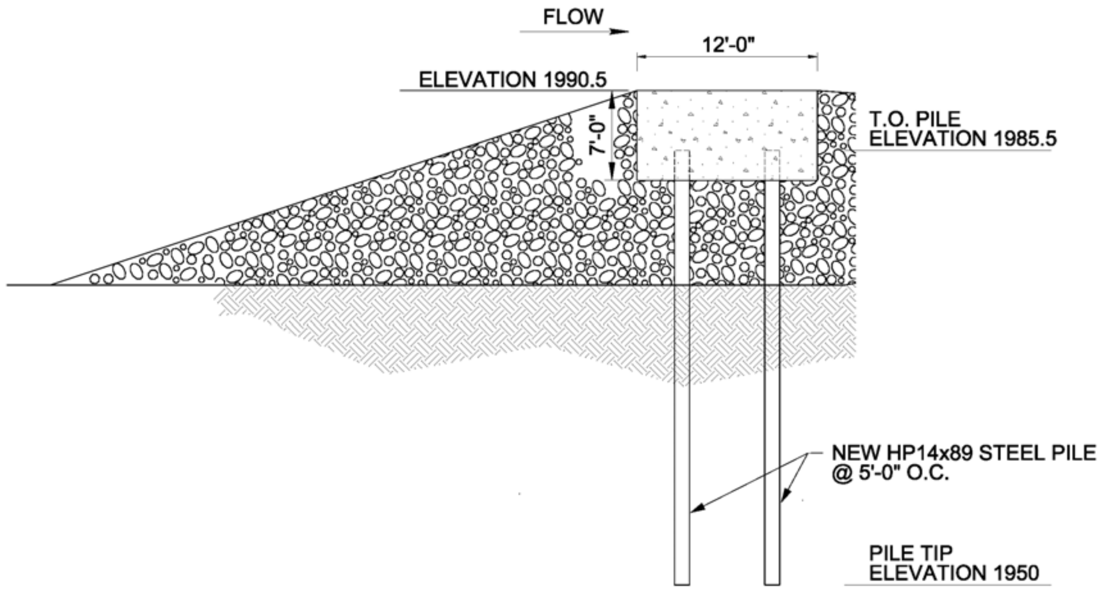


**Figure 3 Precast Dam on Steel Piles**
**(VE Alternative not yet fully evaluated)**



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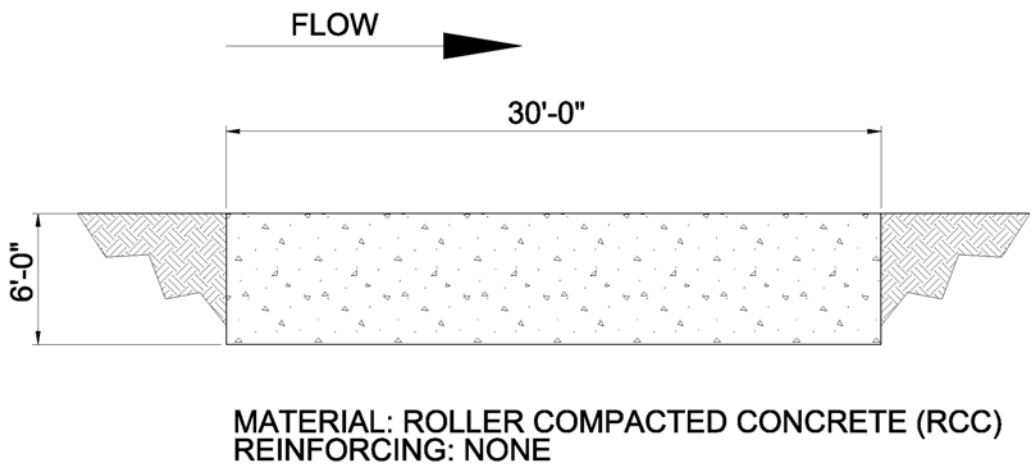


**Figure 4 Slab at Upstream Control Structure**



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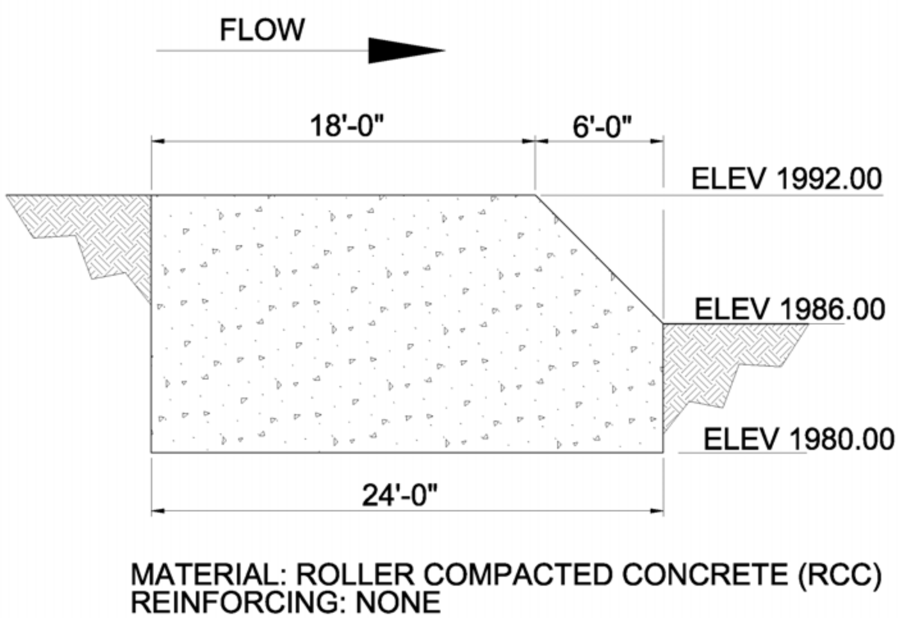


**Figure 5 Flow Augmentation Structure**



Return to TOC

# Intake Diversion Dam Modification
# Lower Yellowstone Project, Montana

## Intake Fish Bypass Option Evaluation Summary
## May 2012

## Attachment 8

## Material Management and Logistics Risks and Uncertainties



Return to TOC

# Material Management and Logistics Risks and Uncertainties
# May 2012

## Introduction

A brief review was performed to identify and evaluate the significant risks and uncertainties associated with material management and logistics for both the ramp and chute options.

## Rock Source.

The rock ramp alternative cost estimate developed for ATR certification and submission to the ASA(CW) was based on the assumption that stone from a nearby quarry would be used for construction of the project. This stone has been used historically for regular maintenance of the existing dam crest height following degradation of the crest by ice effects. Given the size requirements for the rip rap in the ramp design it was determined that the local rock would not be suitable due to availability, identification of fracturing of in-place rock on the ramp, and assumptions about likely durability made prior to testing of the stone for compliance with COE specifications.

The local stone source was inspected 6 April 2011 and samples were collected for submission for geotechnical analysis. The land is privately owned and rock used for the irrigation weir is collected from stone which has fallen naturally from the cliff face. The property owner has indicated a willingness to discuss operation of a quarry on that property to the COE construction representative on the Headworks project. The stone occurs as a cap rock in a shale formation with several feet of soil overburden. The cap rock is approximately 25-30 ft above the toe of the slope with good access to the area. Haul roads and working areas would need to be prepared to facilitate sizing, sorting and hauling of rock at a scale required to make use of the quarry feasible.

The cap rock unit comprises a fine grained sand stone with distinct bedding. Bedding failure and cross bedding fractures appear to control the maximum size of the boulders available. Inspection of the slope at the toe of the unit reveals an average maximum rock size of approximately 2 ft in diameter. Reclamation has selectively harvested larger rock up to 3 ft in diameter for use on the existing dam.

The sandstone contains a mixture of quartz, feldspar, amphibole and some mica. There is evidence of significant mineral alteration in hand samples and along bedding surfaces. There appears to be at least moderate porosity/permeability in the exposed hand samples which could contribute to adverse freeze thaw response. The exposed rock surface shows significant fracturing which would preclude obtaining the larger rock sizes. Some of the larger stones stockpiled near the tramway by Reclamation show low permeability and more competence suggesting that active quarrying away from the weathering surface could encounter better rock. Large rock placed along the river banks downstream from the dam show some sign of breakage.

This local stone, has recently undergone ASTM testing for durability and freeze thaw characteristics and, for the size of rock naturally accumulating at the base of the outcrop, was found to meet USACE specifications for rip rap. Given the prevalence of vertical fractures and bedding plane fractures seen in the outcrop, and the evidence of breakage seen in the larger stones placed in the existing crest structure, the assumption that the quarry local source would not be feasible for material for a rock ramp is probably still valid. Testing was performed on a very



Return to TOC

limited sample and additional investigation would be required to confirm the viability of this outcrop as a rip-rap quarry.

In addition to questionable rock quality for larger rocks, the limited available volume and limited maximum rock size may preclude use of the local stone for major components of the ramp. Use of smaller stone gradations could be justifiable for toe protection in the outer bends of a bypass chute option or in scour holes if use of the rock was also supported by the economics of quarry development. If full quarry development is not found to be cost effective, collection of naturally fallen rock would still likely provide some quantity of material at a lower cost than would be the case with imported rock. High quality stone is required for the inlet and outlet grade controls on the bypass chute as well as for the plug between the bypass chute and the existing high flow channel. If a local quarry is developed and if local rock quantity limitations are identified which require importation of additional rock the imported rock would be utilized for the more critical structures. Local rock should be used for all O&M and repair of any structures.

Prior to confirming the potential for utilization of the local rock additional investigation would be required into quarry permitting requirements for the site. Negotiations with the landowner as to compensation and site restoration requirements would need to be undertaken prior to determining actual cost for the rock. Additional NEPA investigations into potential cultural resource impacts in the area of the potential quarry will be required and operation and restoration plans will need to be developed.

## Bypass Channel Excavation Spoils

Excavation of a bypass channel capable of passing 15% of the Yellowstone River flow would result in approximately 1.2M cubic yards of spoils. Test pits excavated in the proposed bypass alignment during the fall of 2011 revealed that the stratigraphy comprises an upper zone of 3-8 ft of silts to fine sand in lens and bedded geometries. This fine material overlays a deeper unit of rounded, often platy, river cobble with a maximum diameter of approximately 4 inches. The matrix varies from silt to well graded sand and gravel. The planned total depth of the test pits was encountered only in one excavation due to sideslope failure in all of the others.

Some of the cobbles could be screened on site to generate an engineered armor layer for the bottom of the channel, some could help fill the area between the old and new weirs and some could potentially be used as a concrete aggregate if an on-site batch plant was deemed cost effective. All other material will need to be disposed of. A preliminary call to Fisher Sand and Gravel in Glendive Mt revealed that if imported rip rap is required and obtained through Fisher they would be willing to backhaul some of the gravel and cobble as a marketable material at no charge with the potential open to offset some of the rip rap haul cost. This arrangement, provided trucks were direct loaded at the excavation, would reduce the cost of rip rap by the amount it would take to move and place the material onsite. The aggregate would require additional testing to determine suitability.

A potential spoil area has been identified immediately to the west of the entrance to Joes Island off the pave surface road along the bluff. Recent investigation into ownership of the property shows it to be held by BOR. All generated spoils could be placed in that area leading to approximately 12 ft of fill placed over 60 acres though there are concerns with potential infilling of existing drainage ways that may require specific traffic and fill plans designed to avoid those areas.



Return to TOC

## Material Transport Logistics.

Use of the local rock source would facilitate direct transportation from the quarry to the construction site from the south of the construction site. The 30% design cost estimate is built on use of imported stone obtained from quarries in Montana and Wyoming to use the most conservative and certain sources. Use of imported stone would require transportation by rail or truck to Glendive Mt and then by truck to the site. The riprap for the 15% flow diversion channel structures and toe protection would required approximately 50,000 tons of rock plus bedding material. Pending complete feasibility analysis of quarrying local stone it must be assumed that imported rock will be required for a majority of the rock requirement

## Railroad Siding Concerns.

To facilitate railroad transport of rock for a ramp alternative an eight to ten car rail siding exists on the north side of the project site which potentially could be expanded depending on site ownership and available space. The limits of expansion and the costs for expansion have not been captured at this time. Based on communications with construction personnel who have worked with offloading rock from rail cars approximately 30 cars could be unloaded in a work day dependent on site conditions. The limitations on the rail siding appears to prevent efficient use of unloading equipment at the site unless a way was found to provide a continuous supply of rail cars. Preliminary communication with rail representatives suggests that trains would be expected to be cycled through the area on approximately5 day intervals. This turnaround time could possible improve once negotiations for a contract were actually initiated. Use of this siding is only feasible for the rock ramp option Provision of riprap for a bypass channel would necessitate trucking the rock to Joe's Island either from a railroad siding in Glendive or direct from the quarry.

## Rock Delivery and Staging for Construction.

**Rock Ramp**

Several options were evaluated for delivery of rock and possible rock staging methods at the construction site.

Due to the need to work in non-flow conditions behind a partial cofferdam in the wet construction option, or to the presence of a center channel sheet pile wall in the half channel diversion method, delivery of rock to the construction area from one side of the site only is only feasible with total stream diversion and dry construction. To facilitate placement from both sides under the first two construction options requires material to be either trucked from the site siding or the quarry to the opposite side of the channel, trucked from the siding at Glendive (if available), or trucked directly from a quarry.

Trucking material into the south side of the project will require traversing existing unimproved roads across "Joes Island". Use of unimproved haul roads by trucks, especially over the road trucks will require significant upgrading and regular maintenance of the road as well as dust control for visibility and safety concerns. Dust control and maintenance could be a significant cost potentially not fully captured in the cost estimate as it is weather dependent to a degree.

If over the road haul trucks are used for any component of rock transportation for ramp construction it is likely that multiple handling of the rock will become necessary as it is unlikely that construction of haul roads sufficient to allow those kinds of trucks to transverse the ramp would be possible except maybe for dry construction. Multiple handling of rock could have adverse impacts on gradations as well as add cost.



Return to TOC

**Fish Bypass Channel**

For construction of rock structures in a bypass channel option haul roads created to support the channel excavation would be utilized to truck rock to the structure locations. It is anticipated that the roads can be maintained sufficiently to allow for direct haul to the area of placement without needing to double handle rock. Haul road maintenance to allow over the road truck traffic would be at a higher degree than would be required for off road trucks. To reduce maintenance costs over time it may be cost effective to stage construction so that rock placement occurs during focused time windows. The county road accessing the site from the highway is also a gravel surface road which would require maintenance and potentially some post project restoration to address damage from the relatively large number of haul trucks importing stone.



Return to TOC

**Intake Diversion Dam Modification**
**Lower Yellowstone Project, Montana**

**Intake Fish Bypass Option Evaluation Summary**
**May 2012**

# Attachment 9

# Real Estate



Return to TOC

# Real Estate
# May 2012

## 1. Introduction

Real estate property acquisition and/or easements will be required for any construction features on the south bank of the Lower Yellowstone River or on Joe's Island. The Bureau of Reclamation is responsible for the real estate actions for this project to move into the construction phase.

## 2. Property Ownerships

A search of the Montana Cadastral Survey resulted in four known ownerships and one unknown ownership in the Joe's Island footprint. The ownerships are the Burlington Northern Santa Fe Railway (BNSF RR), the Bureau of Land Management (BLM), the State of Montana, Gentry Land & Livestock Inc., and a potential unknown owner of the Turtle Island property on the south bank of the river (see Figure 1.). The Bureau of Reclamation or the irrigation district may have maintenance easements on some of these properties, but construction acquisition is a certainty with some of the project components analyzed.

## 3. Impacted Properties

The bypass of water, and the Bypass Channel for fish components, will require some type of real estate action on the Bureau of Land Management and State of Montana ownerships and a possible unknown owner of Turtle Island. A small portion of the BNSF RR property will be affected by the bypass of water by channel option. Construction access from the south for the rock ramp options will be on the State of Montana and BLM properties, and possibly the BNSF RR property. It is likely that all of these properties may have leases to farmers and ranchers for cattle grazing that will be affected.



Return to TOC


**Figure 1**



Return to TOC

# Appendix C – List of Federally Listed Species and State Species of Special Concern

## Introduction

This appendix lists status and common and scientific names used of federally listed species and species of special concern discussed in the EA and in the appendixes. Names appear alphabetically by common name, followed by scientific name.

**Table C.1 - Species of Concern**

| Common Name | Scientific Name | MT[1] | ND[2] | ESA |
|---|---|---|---|---|
| Bald eagle | *Haliaeetus leucocephalus* | X | X | |
| Baird's sparrow | *Ammodramus bairdii* | X | X | |
| Blue sucker | *Cycleptus elongatus* | X | X | |
| Bobolink | *Dolichonyx oryzivorus* | X | | |
| Bractless blazingstar | *Mentzelia nuda* | X | | |
| Brimstone clubtail | *Stylurus intricatus* | X | | |
| Chestnut collared longspur | *Calcarius ornatus* | X | | |
| Dwarf shrew | *Sorex nanus* | X | | |
| Golden eagle | *Aquila chrysaetos* | | X | |
| Grasshopper sparrow | *Ammodramus savannarum* | X | | |
| Hayden's yellowcress | *Rorippa calycina* | | X | |
| Lake chub | *Couesius plumbeus* | | X | |
| Least tern | *Sterna antillarum* | | X | MT and ND |
| Loggerhead shrike | *Lanius ludovicianus* | X | | |
| Long-billed curlew | *Numenius americanus* | X | | |
| Mayfly sp. | *Lachlania saskatchewanensis* | X | | |
| Mayfly sp. | *Homoeoneuria alleni* | X | | |
| Mayfly sp. | *Macdunnoa nipawinia* | | | |
| Meadow jumping mouse | *Zapus hudsonius* | X | | |
| Milksnake | *Lampropeltis triangulum* | X | | |
| Narrowleaf penstemon | *Penstemon angustifolius* | X | | |
| Nine-anther prairie clover | *Dalea enneandra* | X | | |
| Paddlefish | *Polyodon spathula* | X | | |
| Pale-spike lobelia | *Lobelia spicata* | X | | |
| Pallid Sturgeon | *Scaphirhynchus albus* | | | MT and ND |
| Poison suckleya | *Suckleya suckleyana* | X | | |
| Prairie goldenrod | *Oligoneuron album* | X | | |
| Preble's shrew | *Sorex preblei* | X | | |
| Red-headed woodpecker | *Melanerpes erythrocephalus* | X | | |
| Sagebrush lizard | *Sceloporus graciosus* | X | | |
| Sauger | *Sander canadensis* | X | | |
| Short-horned lizard | *Phrynosoma hernandesi* | X | | |
| Sicklefin chub | *Macrhybopsis meeki* | X | X | |
| Silky Prairie-clover | *Dalea villosa* | X | | |
| Snapping Turtle | *Chelydra serpentina* | X | | |
| Sprague's pipit | *Anthus spragueii* | X | | |

| | | | | |
|---|---|---|---|---|
| Spiny Softshell | *Apalone spinifera* | X | | |
| Sturgeon chub | *Macrhybopsis gelida* | X | | |
| Townsend's big-eared bat | *Corynorhinus townsendii* | X | | |
| Western Hog-nosed Snake | *Heterodon nasicus* | X | | |
| Whooping Crane | *Grus americana* | | | MT and ND |

1 MT species of special concern include taxa that are at-risk or potentially at-risk due to rarity, restricted distribution, habitat loss, and/or other factors. Data for the Project area come from Montana Natural Heritage Program database as of January 2009. These data are not exhaustive or comprehensive inventories of rare species.

2 Species ranked by the North Dakota Natural Heritage Program as S1, S2, and S3. Data for the Project area come from North Dakota Natural Heritage Program database as of February 2009. These data are not exhaustive or comprehensive inventories of rare species.

# Appendix D – Biological Assessment for Operations

In October of 2009, the Service sent a letter to the Corps to formally revise portions of the Reasonable and Prudent Alternative (RPA) in the Service's 2003 Biological Opinion (BiOp) to the Corps. The letter substituted a new RPA element at Intake Dam and irrigation headworks on the Yellowstone River, Montana, for one which was originally identified to be taken at Ft. Peck Dam. Because the Service has already considered the biological effects of the construction of a fish passage project at Intake in the development of the RPA for the BiOp, and determined that it is an integral component to avoid jeopardy to listed species, Section 7 consultation for the construction of this project has been completed. Therefore, the Corps is not required to prepare a Biological Assessment (BA) for the construction of this project.

It was agreed that a formal consultation process would continue on the operation of the Lower Yellowstone Project, including the proposed fish passage and entrainment structures, which would be evaluated in a separate BA. This second consultation would be completed prior to completion of construction of the new Intake Project. After the Corps and Reclamation complete this EA evaluating construction of the Intake Project and Reclamation completes a second BA on operation of that Intake Project, the Service will prepare a BiOp on operation of the new fish passage.

# Cost Effectiveness Incremental Cost Analysis

A cost-effectiveness incremental cost analysis (CE/ICA) is completed to compare the alternatives under consideration for the project site. The purpose of the analysis is to evaluate the effectiveness and efficiency of the site alternatives at producing environmental outputs, so the costs of the alternatives and the expected environmental outputs are inputs for CE/ICA. Since the No Action Alternative was assumed to continue operation of the existing Intake structure, a comparison of the average annual costs of the preferred alternative to the average annual benefits from irrigation was not completed. Instead the CE/ICA focuses on fish passage and habitat as expressed by HU's. Guidance on completing CE/ICA is in the Institute for Water Resource (IWR) Report #95-R-1, USACE, May 1995.

As described in previous sections, three plan alternatives are considered: the No Action Alternative, the Rock Ramp Alternative and the Bypass Channel Alternative. As shown in Table 1, different options exist for how management measures and scales are combined to construct either the Rock Ramp Alternative or the Bypass Channel Alternative. For CE/ICA, the various combinations of management measures and scales are referred to as 'plan alternatives' rather than just 'alternatives.' There are 12 plan alternatives associated with the Rock Ramp Alternative, and four plan alternatives associated with the Bypass Channel Alternative.

The following section provides a summary of the benefits used to evaluate environmental output and is followed by a section describing costs. Next the results of the CE/ICA are provided, including an evaluation of the effect of adaptive management (AM) on the CE/ICA results.

## Benefits

The Fish Passage Connectivity Index (FPCI) is a simple arithmetic index that was originally developed to evaluate ecosystem outputs of plan alternatives for fish passage improvements at locks and dams on the Upper Mississippi River System. This model, with slight adjustments, is used to compare the benefits of plan alternatives for providing fish passage at the Intake Dam. Habitat units (HU's) are calculated by multiplying the FPCI by the total acres of available preferred habitat upstream of the Intake Dam, by species. A detailed description of the calculation of HU's is provided as an attachment to this analysis.

Table 1 shows the estimated HU's by plan alternative, organized by Rock Ramp Plan alternatives and Bypass Channel Plan alternatives. Refer to Appendix A1 Plan Formulation, for more details on the plan alternative configurations. The average annual net HU's are the values used for CE/ICA, and are net of the habitat units estimated for the No Action Plan Alternative.

**Table 1. Habitat Units by Alternative Plan**

| Plan alternatives | Average Annual Habit Units | Average Annual Net Habitat Units |
|---|---|---|
| No Action Plan Alternative | 978 | 0 |
| Rock Ramp Plan Alternatives | | |
| Original Rock Ramp with Crest 1 and Coffer Dam 1 | 8,627 | 7,649 |
| Original Rock Ramp with Crest 1 and Coffer Dam 2 | 8,627 | 7,649 |
| Original Rock Ramp with Crest 1 and Coffer Dam 3 | 8,627 | 7,649 |
| *Original Rock Ramp with Crest 2 | 8,627 | 7,649 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 1 | 5,657 | 4,679 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 2 | 5,657 | 4,679 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 3 | 5,657 | 4,679 |
| Shortened Rock Ramp with Crest 2 | 5,657 | 4,679 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 1 | 3,126 | 2,148 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 2 | 3,126 | 2,148 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 3 | 3,126 | 2,148 |
| Double Slope Rock Ramp with Crest 2 | 3,126 | 2,148 |
| Bypass Channel Plan Alternatives | | |
| Bypass Channel 15% Diversion, Weir 1 | 8,447 | 7,469 |
| *Bypass Channel 15% Diversion, Weir 2 | 8,447 | 7,469 |
| Bypass Channel 10% Diversion, Weir 1 | 7,087 | 6,109 |
| Bypass Channel 10% Diversion, Weir 2 | 7,087 | 6,109 |

*Alternatives ultimately carried forward in EA

As described in the Social and Economic Existing Conditions and Social and Economic Impacts sections of the report, the Rock Ramp Alternative and Bypass Channel Alternative are part of a larger project aimed at ensuring continued irrigation of agricultural lands from the Yellowstone Intake Dam while avoiding jeopardy of ESA listed species. It's estimated that approximately 58,000 acres are irrigated with net annual revenues of $3.25 million (2009 dollars). Additionally, the Social and Economic Impacts sections evaluated regional economic impacts to the local economy due to increased expenditures stemming from the construction of the project. Therefore the benefits of this project include HU's, along with continued agricultural production, and the regional economic impacts that would occur during project construction.

## Costs

Based upon the engineering designs for the various alternative configurations, project cost estimates were developed. Cost estimates were also calculated for interest during construction (IDC), operations and maintenance (O&M), monitoring, and AM features. Project cost estimates for two alternatives, a bypass alternative and a rock ramp alternative, were reviewed by the Cost Engineering Center of Expertise (Cost PCX). Based upon the updated cost estimates for the bypass alternative and the rock ramp alternative reviewed by the Cost PCX, a percentage adjustment was made to all bypass alternatives to adjust the cost of the alternatives in a manner similar to the reviewed bypass alternative, and likewise an adjustment was made to all other rock ramp alternatives. The adjustment was a 7.34% increase for rock ramp alternatives and 27.05% for bypass alternatives.

Table 2 shows the total construction costs, Interest During Construction (IDC) cost, and total project costs, as well as average annual costs for O&M, average annual monitoring costs and amortized average annual costs. IDC represents the opportunity cost of capital during the construction period. The total project cost, or investment cost is the sum of construction costs plus interest during construction. Average annual O&M costs were estimated based upon the management measures and scales that comprise the plan alternatives. Monitoring is anticipated for the project for the first 8 years only, and varies between $75,000 per year to $425,000 per year, with an annual average of $250,000 for the Rock Ramp Plan Alternative and $255,000 for the Bypass Channel Plan Alternative. The average annual cost includes the total project cost amortized over a 50-year period of analysis plus O&M and monitoring. O&M for both the bypass channel alternatives and the rock ramp alternatives include a combination of concrete weir repair, bank repairs, and one to five percent of rock replacement annually.

### Table 2. Costs by Plan Alternatives

| Plan Alternatives | Total Construction Cost | IDC (2 years, at 4.0%) | Total Project Cost | Average Annual O&M Cost | Average Annual Monitoring Cost (first 8 years only) | Average Annual Cost (amortized over 50 years, 4.0%) |
|---|---|---|---|---|---|---|
| Rock Ramp Plan Alternatives | | | | | | |
| Original Rock Ramp with Crest 1 and Coffer Dam 1 | $91,893,035 | $3,828,876 | $95,721,912 | $282,028 | $250,000 | $4,724,645 |
| Original Rock Ramp with Crest 1 and Coffer Dam 2 | $93,537,038 | $3,897,377 | $97,434,415 | $282,028 | $250,000 | $4,804,125 |
| Original Rock Ramp with Crest 1 and Coffer Dam 3 | $85,468,426 | $3,561,184 | $89,029,610 | $282,028 | $250,000 | $4,414,044 |
| *Original Rock Ramp with Crest 2 | $77,088,181 | $3,212,008 | $80,300,189 | $282,028 | $250,000 | $4,008,897 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 1 | $77,387,879 | $3,224,495 | $80,612,374 | $248,128 | $250,000 | $3,989,486 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 2 | $79,031,881 | $3,292,995 | $82,324,876 | $248,128 | $250,000 | $4,068,966 |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 3 | $70,963,269 | $2,956,803 | $73,920,072 | $248,128 | $250,000 | $3,678,884 |
| Shortened Rock Ramp with Crest 2 | $62,583,024 | $2,607,626 | $65,190,650 | $248,128 | $250,000 | $3,273,737 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 1 | $70,400,022 | $2,933,334 | $73,333,356 | $231,028 | $250,000 | $3,634,554 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 2 | $72,044,024 | $3,001,834 | $75,045,858 | $231,028 | $250,000 | $3,714,034 |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 3 | $63,975,412 | $2,665,642 | $66,641,054 | $231,028 | $250,000 | $3,323,953 |
| Double Slope Rock Ramp with Crest 2 | $55,595,167 | $2,316,465 | $57,911,633 | $231,028 | $250,000 | $2,918,805 |
| Bypass Channel Plan Alternatives without Adaptive Management | | | | | | |
| Bypass Channel 15% Diversion, Weir 1 | $53,927,667 | $2,246,986 | $56,174,654 | $220,216 | $255,000 | $2,827,377 |
| *Bypass Channel 15% Diversion, Weir 2 | $52,198,027 | $2,174,918 | $54,372,945 | $220,216 | $255,000 | $2,743,757 |
| Bypass Channel 10% Diversion, Weir 1 | $50,915,340 | $2,121,473 | $53,036,813 | $217,372 | $255,000 | $2,678,901 |
| Bypass Channel 10% Diversion, Weir 2 | $49,185,700 | $2,049,404 | $51,235,104 | $217,372 | $255,000 | $2,595,280 |

* Alternatives ultimately carried forward in EA

## Cost-Effectiveness/Incremental Cost Analysis (CE/ICA)

Average annual HU's and the average annual costs are the inputs into IWR Planning Suite 2.0.6.0. CE/ICA results in the identification of cost-effective plan alternatives. A cost-effective plan alternative is defined as one where no other plan alternative can achieve the same level of output at a lower cost, or a greater level of output at the same or less cost. A sub-set of cost-effective plan alternatives are identified as 'best buy plans.' Best buy plans are cost-effective plan alternatives that provide the greatest increase in environmental output for the least increase in cost per HU. The plan alternative with the lowest incremental costs per unit of output of all plans is therefore considered the first best buy plan. After the first best buy plan is identified, all larger cost-effective plan alternatives are compared to the first best buy plan in terms of increases in (increments of) cost and increases in (increments of) output. The plan alternative with the lowest incremental cost per unit of output (for all cost-effective plans larger than the first best buy plan) is the second best buy plan. This process of comparison continues until all best buy plan alternatives are identified.

The results of the cost-effective analysis completed for the plan alternatives are shown in Figure 1 and Table 3. The figure shows that there are four cost-effective plan alternatives within the array of 17 plan alternatives, and three of these four plan alternatives are best buy plan alternatives. The first best buy alternative identified in CE/ICA is always the No Action Plan Alternative. The second best buy alternative is the Bypass Channel Plan Alternative with 15% diversion and weir design two. The third best buy alternative is the Rock Ramp Plan Alternative with the original ramp design and crest design two. The Bypass Channel Plan Alternative with 10% diversion and weir design two is a cost-effective alternative, but because the Bypass Channel Plan Alternative with 15% diversion and weir design two has a lower cost per habit unit output it is not a best buy plan alternative.

**Figure 1. CE/ICA Results for Yellowstone Intake Plan Alternatives**

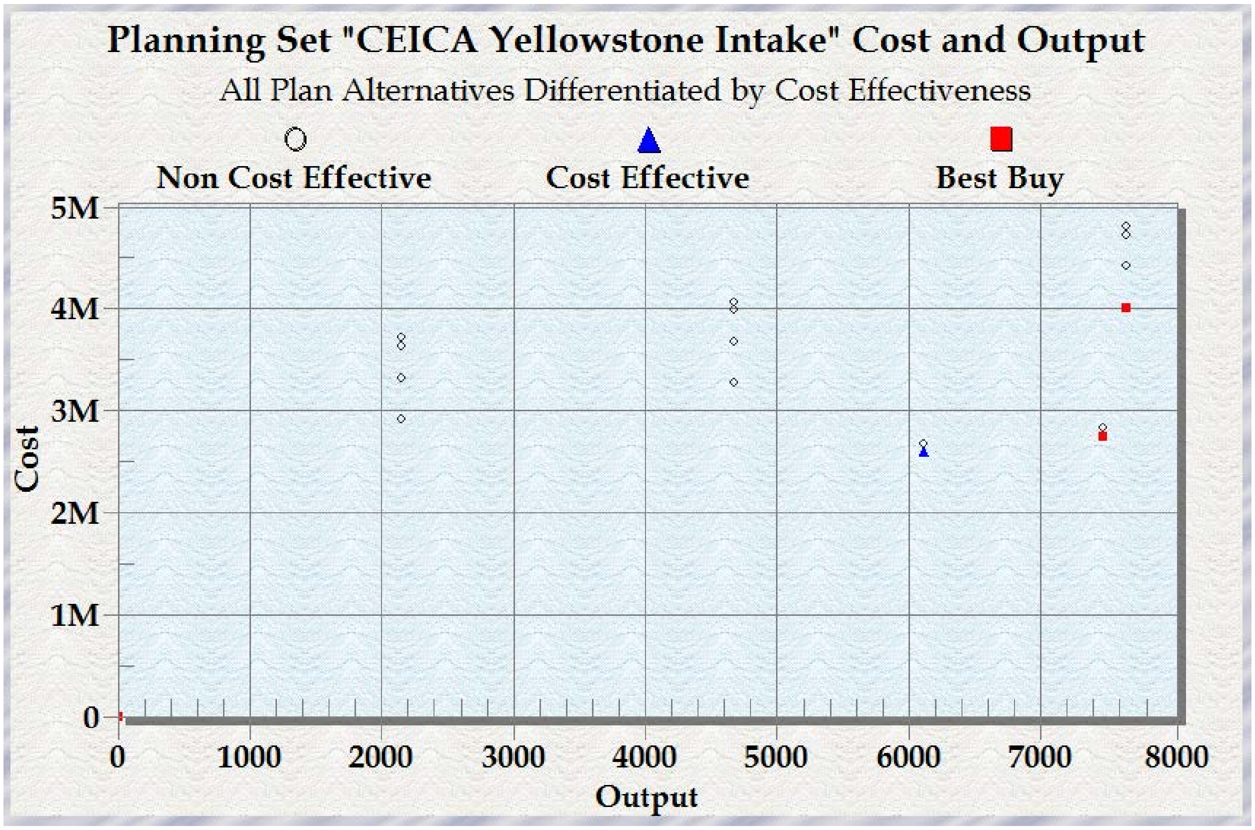

**Table 3. CE/ICA Results for Yellowstone Intake Plan Alternatives**

| Plan Alternatives | Average Annual Cost | Output (HU's) | Cost Effective |
|---|---|---|---|
| No Action Plan | $0 | 0 | Best Buy |
| Double Slope Rock Ramp with Crest 2 | $2,918,805 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 3 | $3,323,953 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 1 | $3,634,554 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 2 | $3,714,034 | 2,148 | No |
| Shortened Rock Ramp with Crest 2 | $3,273,737 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 3 | $3,678,884 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 1 | $3,989,486 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 2 | $4,068,966 | 4,679 | No |
| Bypass Channel 10% Diversion, Weir 2 | $2,595,280 | 6,109 | Yes |
| Bypass Channel 10% Diversion, Weir 1 | $2,678,901 | 6,109 | No |
| Bypass Channel 15% Diversion, Weir 2 | $2,743,757 | 7,469 | Best Buy |
| Bypass Channel 15% Diversion, Weir 1 | $2,827,377 | 7,469 | No |
| Original Rock Ramp with Crest 2 | $4,008,897 | 7,649 | Best Buy |
| Original Rock Ramp with Crest 1 and Coffer Dam 3 | $4,414,044 | 7,649 | No |
| Original Rock Ramp with Crest 1 and Coffer Dam 1 | $4,724,645 | 7,649 | No |
| Original Rock Ramp with Crest 1 and Coffer Dam 2 | $4,804,125 | 7,649 | No |

Incremental cost analysis was completed on the two plan alternatives identified as best buys through the cost-effective analysis. The first increment is the best buy plan alternative for the Bypass Channel Plan Alternative and the second increment is the best buy plan alternative for the Rock Ramp Plan Alternative. As shown in Figure 2 and Table 4, there is a steep increase in the cost per HU between the Bypass Channel Plan Alternative and the Rock Ramp Plan Alternative. The Bypass Channel Plan Alternative provides 7,469 HU's at an incremental cost per HU of $367, while the Rock Ramp Plan Alternative provides an additional 180 HU's (beyond the 7,469 HU's) at an incremental cost per HU of $7,029. Based upon the incremental cost analysis, along with consideration of the overall cost of the plan alternatives, the recommended plan for implementation is the Bypass Channel Plan Alternative with 15% diversion and weir option two. The total project cost for the Rock Ramp Plan Alternative with the original rock ramp and crest option 2 is $77,088,181, while the total project cost for the Bypass Channel Plan Alternative with a 15% diversion and weir option 2 is $52,198,027.

Figure 2. Incremental Cost Analysis for Best Buy Plan Alternatives

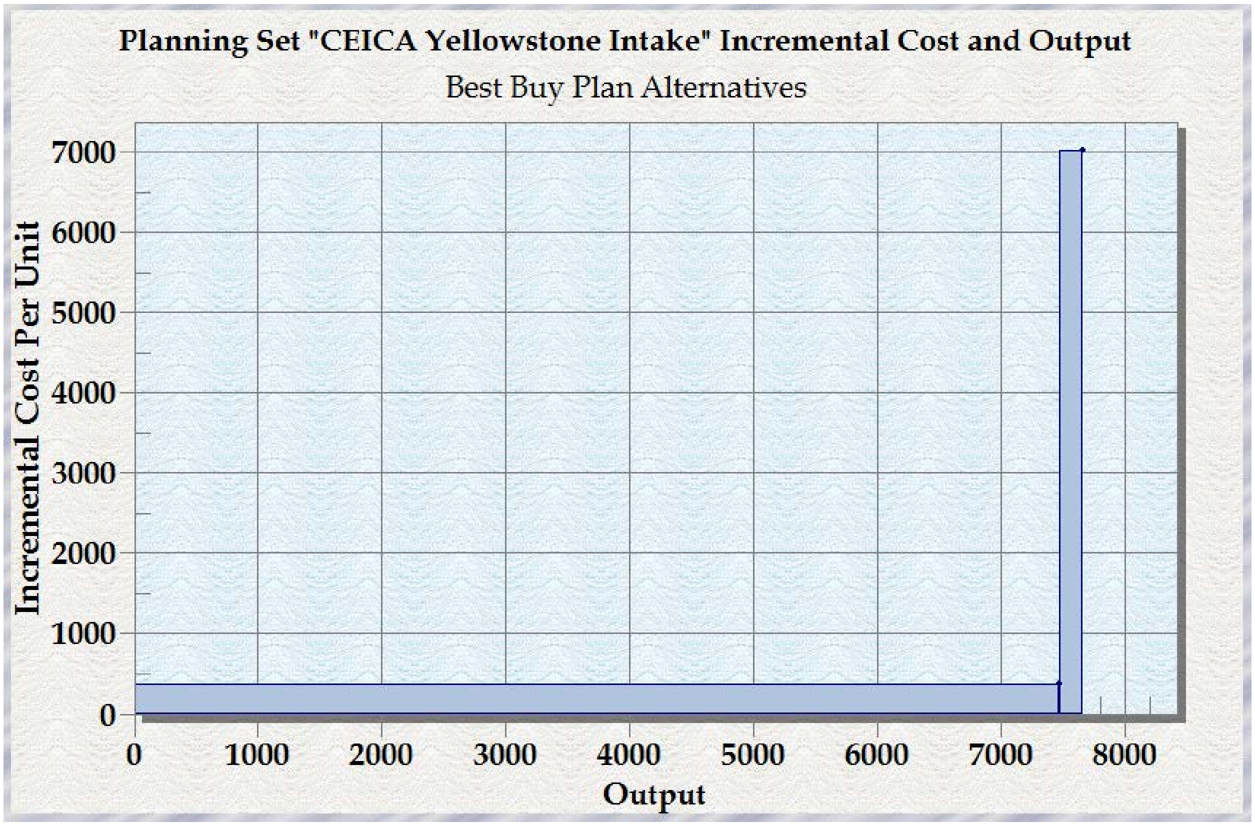


Table 4. Incremental Cost Analysis Results

| Alternative Plan | Output (HU's) | Average Annual Cost ($1,000) | Average Cost ($1,000/HU) | Incremental Cost | Incremental Output (HU's) | Incremental Cost per Output |
|---|---|---|---|---|---|---|
| No Action | 0 | 0 | | | | |
| Bypass Channel 15% Diversion, Weir 2 | 7,469 | $2,743,757 | $367 | $2,743,757 | 7469 | $367 |
| Original Rock Ramp with Crest 2 | 7,649 | $4,008,897 | $524 | $1,265,140 | 180 | $7,029 |

## CE/ICA with Bypass Channel Adaptive Management

As mentioned previously, monitoring of the project is anticipated. Monitoring will be conducted to determine if the project is functioning as expected and to see if any adjustments are needed. If necessary, changes to structures may be required to ensure that the desired project outcome is achieved. These changes are described in the AM Plan in Appendix J.

In order to evaluate the sensitivity of the CE/ICA results to the potential adoption of AM actions, the CE/ICA was recalculated with AM measures added to the Bypass Channel Plan Alternatives only. AM was added to these plans only to see how it would change the CE/ICA results in relation to the Rock Ramp Plan Alternatives with no AM. It should be noted, that AM features may also be needed, therefore a Rock Ramp Alternative Plan was constructed, but since the Rock Ramp Alternative Plan is not the preferred alternative, this analysis focused on verifying whether or not a Bypass Channel Alternative Plan would remain the preferred alternative even if AM features are required, rather than evaluating how all alternatives change with AM.

Monitoring of fish species, particularly pallid sturgeon, will be conducted for 8 years after construction is completed. Depending upon the monitoring results, potential AM measures may need to be completed to ensure the Bypass Channel Alternative is operating as expected. The AM measures and scales currently under consideration along with their associated costs are shown in Table 5. One or all of the options may be required, so for the purposes of the CE/ICA the total AM cost is included.

**Table 5. Bypass Channel Adaptive Management**

| Adaptive Management Measures and Scales | Cost |
|---|---|
| Option 1 - Flow Augmentation Structure | $4,011,407 |
| Option 2 - Rock Manipulation 1,000 ton | $102,223 |
| Option 3 - Rock Manipulation 10,000 ton | $271,802 |
| Option 4 - Riprap Replacement | $256,028 |
| Total | $4,641,460 |

Table 6 shows the cost of the Bypass Channel Alternative Plans with the AM cost included. Since AM options would be added to the project, based upon monitoring results, it is assumed that the AM options would be constructed during year five of the project. This additional cost for year five has been factored in to the annual average cost amortized over the 50-year period of analysis, increasing the expected average annual cost for all Bypass Channel Alternative Plans by approximately $170,271 annually, over their average annual cost without AM features.

The results of the cost-effective analysis completed including AM for the Bypass Channel Plan Alternatives are show in Figure 3 and Table 7. Similar to previous results, the figure shows there are four cost-effective plan alternatives, with three of these four plan alternatives identified as a best buy alternative. The first best buy plan alternative identified in CE/ICA is always the No Action Plan Alternative. The second best buy plan alternative is the Bypass Channel Plan Alternative with 15% diversion and weir design two and AM options included. The third best buy plan alternative is the Rock Ramp Plan Alternative with the original ramp design and crest design two. The Bypass Channel Plan Alternative with 10% diversion, weir design two with AM, is a cost-effective alternative, but because the Bypass Channel Plan Alternative with 15% diversion and weir design two with AM has a lower cost per habit unit output it is not a best buy alternative.

**Table 6. Costs by Alternative with Adaptive Management**

| Plan Alternatives | Total Construction Cost | Interest During Construction (2 years at 4 percent) | Total Project Cost | AM Cost | Average Annual O&M Costs | Average Annual Monitoring (first 8 years only) | Annual Average Costs (amortized over 50 years, 4.0%) |
|---|---|---|---|---|---|---|---|
| Bypass Channel Plan alternatives with AM | | | | | | | |
| Bypass Channel 15% Diversion, Weir 1 with AM | $58,381,631 | $2,432,568 | $60,814,199 | $4,453,963 | $220,216 | $255,000 | $2,997,648 |
| Bypass Channel 15% Diversion, Weir 2 with AM | $56,651,990 | $2,360,500 | $59,012,490 | $4,453,963 | $220,216 | $255,000 | $2,914,028 |
| Bypass Channel 10% Diversion, Weir 1 with AM | $55,369,304 | $2,307,054 | $57,676,358 | $4,453,963 | $217,372 | $255,000 | $2,849,280 |
| Bypass Channel 10% Diversion, Weir 2 with AM | $53,639,663 | $2,234,986 | $55,874,649 | $4,453,963 | $217,372 | $255,000 | $2,765,660 |

**Figure 3. CEICA Results for Yellowstone Intake Plan Alternatives with Bypass Channel Plan Alternatives including Adaptive Management**

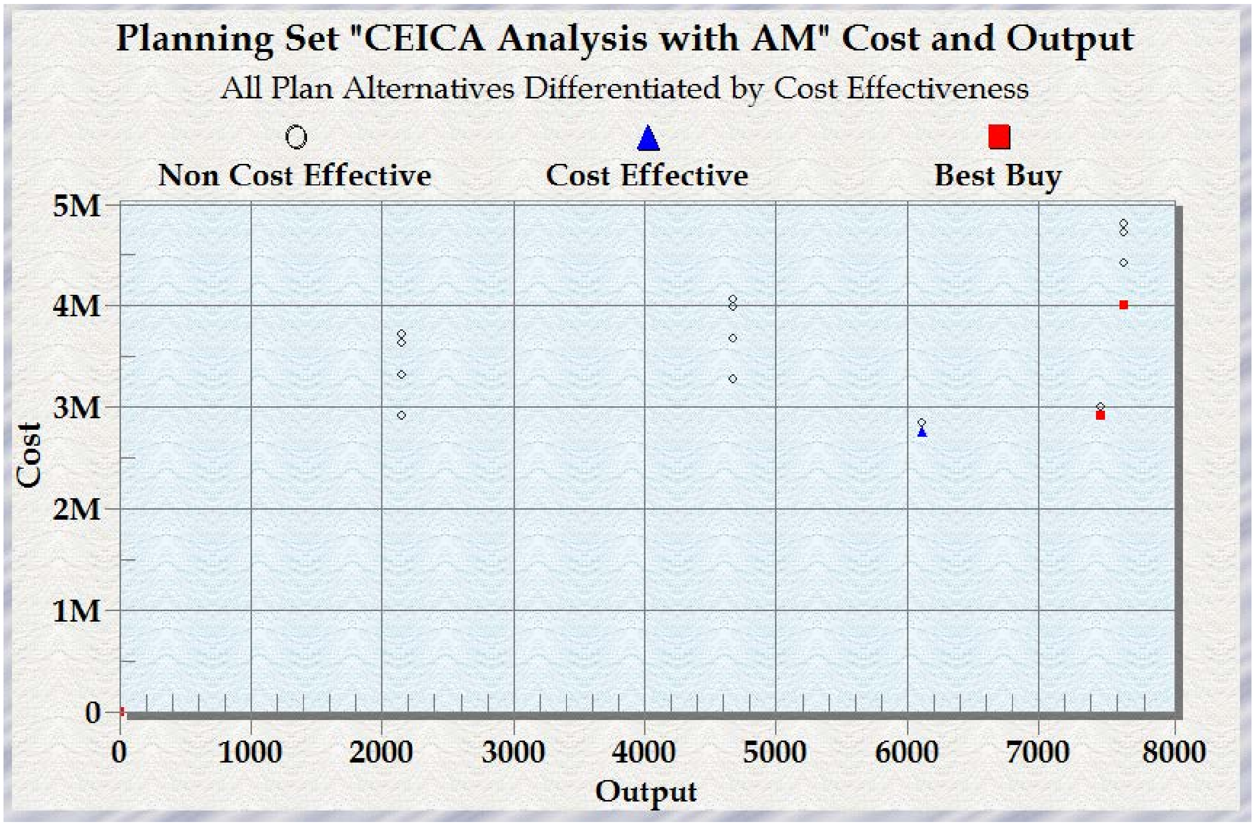

**Table 7. CEICA Results for Yellowstone Intake Plan Alternatives, Bypass Channel Plan Alternatives with AM**

| Name | Average Annual Cost | Average Annual Net Output | Cost Effective |
|---|---|---|---|
| No Action Plan | $0 | - | Best Buy |
| Double Slope Rock Ramp with Crest 2 | $2,918,805 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 3 | $3,323,953 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 1 | $3,634,554 | 2,148 | No |
| Double Slope Rock Ramp with Crest 1 and Coffer Dam 2 | $3,714,034 | 2,148 | No |
| Shortened Rock Ramp with Crest 2 | $3,273,737 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 3 | $3,678,884 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 1 | $3,989,486 | 4,679 | No |
| Shortened Rock Ramp with Crest 1 and Coffer Dam 2 | $4,068,966 | 4,679 | No |
| Bypass Channel 10% Diversion, Weir 2 with AM | $2,765,660 | 6,109 | Yes |
| Bypass Channel 10% Diversion, Weir 1 with AM | $2,849,280 | 6,109 | No |
| Bypass Channel 15% Diversion, Weir 2 with AM | $2,914,028 | 7,469 | Best Buy |
| Bypass Channel 15% Diversion, Weir 1 with AM | $2,997,648 | 7,469 | No |
| Original Rock Ramp with Crest 2 | $4,008,897 | 7,649 | Best Buy |
| Original Rock Ramp with Crest 1 and Coffer Dam 3 | $4,414,044 | 7,649 | No |
| Original Rock Ramp with Crest 1 and Coffer Dam 1 | $4,724,645 | 7,649 | No |
| Original Rock Ramp with Crest 1 and Coffer Dam 2 | $4,804,125 | 7,649 | No |

Similar to the previous incremental cost analysis, incremental cost analysis was completed on the two plan alternatives identified as best buys through the cost-effective analysis. The first increment is the best buy plan alternative for the Bypass Channel Plan Alternative with AM and the second increment is the best buy alternative for the Rock Ramp Plan Alternative (without AM). As shown in Figure 4 and Table 8, there is still a steep increase in the cost per HU between the Bypass Channel Plan Alternative with AM and the Rock Ramp Plan Alternative. The Bypass Channel Plan Alternative with AM provides 7,469 HU's at per unit cost of $390, while the Rock Ramp Plan Alternative provides an additional 180 HU's (beyond the 7,469 HU's) at a per unit cost of $6,083. The original incremental cost analysis reported similar results, with the first 7,469 HU's with the Bypass Channel Plan Alternative (without AM) costing of $367, and the Rock Ramp Plan Alternative providing an additional 180 HU's with a per unit cost of $7,029. Thus, even with AM, a similar relationship exists between the two best buy plan alternatives, with the Rock Ramp Plan Alternative requiring a steep increase in expenditures in order to achieve a small increase in HU outputs.

**Figure 4. Incremental Cost Analysis for Best Buy Plan Alternatives, Bypass Channel Plan Alternatives with AM**

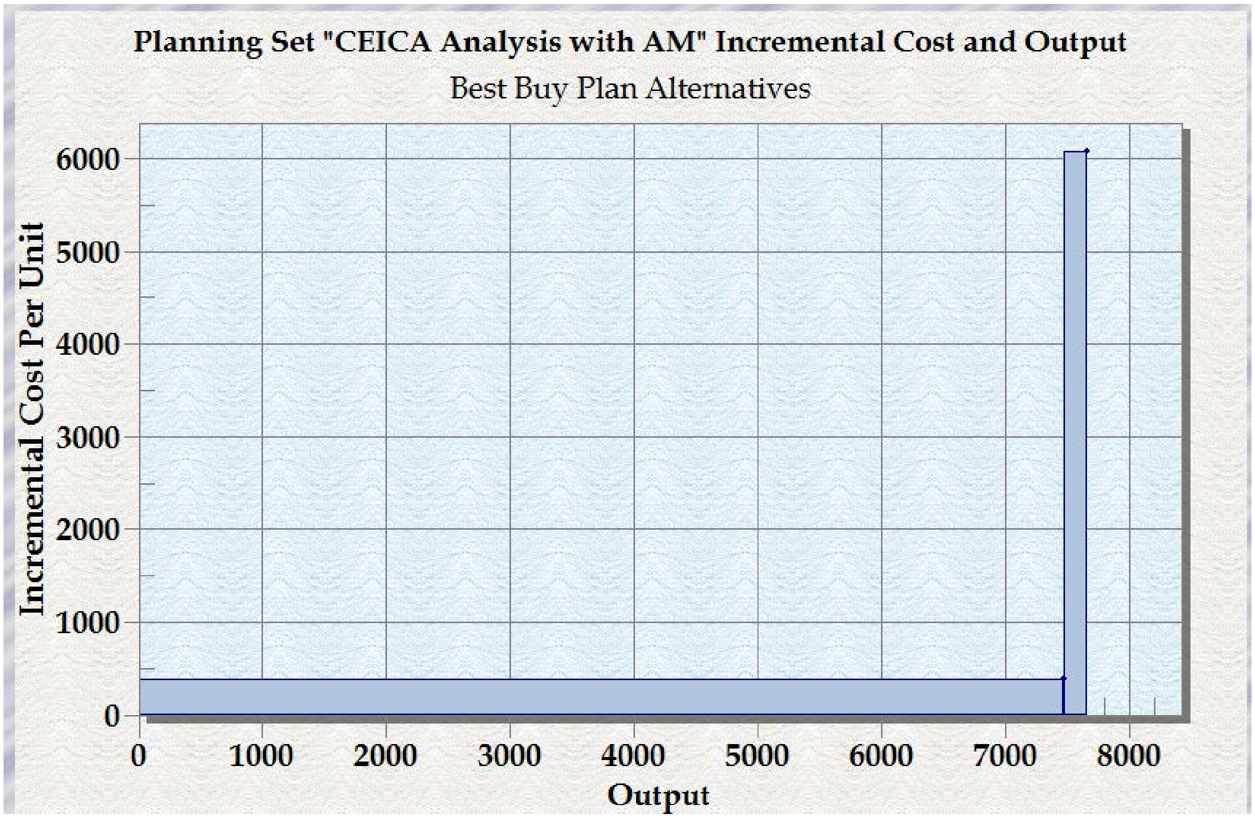


**Table 8. Incremental Cost Analysis for Best Buy Plan Alternatives, Bypass Channel Plan Alternatives with AM**

| Name | Output (HU's) | Average Annual Cost ($1000) | Average Cost ($1,000/HU) | Incremental Cost | Incremental Output (HU) | Incremental Cost per Output |
|---|---|---|---|---|---|---|
| No Action | 0 | 0 | | | | |
| Bypass Channel 15% Diversion, Weir 2 | 7,469 | $2,914,028 | $390 | $2,921,028 | 7,469 | $390 |
| Original Rock Ramp with Crest 2 | 7,649 | $4,008,897 | $524 | $1,094,869 | 180 | $6,083 |

## Conclusions

The CE/ICA was completed to compare plan alternatives under consideration for the project site. The average annual cost for the Bypass Channel Plan Alternative is between $2.7 million to $2.9 million annually depending upon whether AM measures are required. As discussed in the previous sections, the Bypass Channel Plan Alternative would provide 7,469 HU's, for an incremental cost between $367 to $390 depending on whether or not AM measures are necessary, while the Rock Ramp Plan Alternative would provide 7,649 HU's total for an incremental cost of between $6,083 to $7,029 for the 180 additional HU's. Considering the steep increase in incremental cost to achieve a slightly higher level of HU outputs, the Bypass Channel Plan Alternative with 15 percent diversion and weir design two is the preferred alternative, even if AM measures are required.

Because the No Action Alternative was assumed to continue operation of the existing Intake structure, no effort was made to compare average annual costs of the preferred alternative to average annual benefits from irrigation. Instead the CE/ICA focused on fish passage and habitat as expressed by HU's.

# Appendix F – Species Common and Scientific Names

## Introduction

This appendix lists common and scientific names used of species discussed in the EA and in the appendixes. The names are organized according to the following categories: mammals, birds, reptiles and amphibians, fish, macroinvertebrates, mollusks, plants, and noxious weeds. Names appear alphabetically by common name, followed by scientific name. Species with a special status are noted in the third column, and a key of status categories appears at the end of this appendix. For more information on special status species, see Appendix D (biological assessment).

**Table F.1 – Common and Scientific Names Used.**

| Common Name | Scientific Name | Status |
|---|---|---|
| **Mammals** | | |
| Antelope | *Antilocapra americana* | NS |
| Badger | *Taxidea taxus* | NS |
| Beaver | *Castor canadensis* | NS |
| Big brown bat | *Eptesicus fuscus* | NS |
| Desert cottontail | *Sylvilagus audubonii* | NS |
| Dwarf shrew | *Sorex nanus* | MT S |
| Eastern cottontail | *Sylvilagus floridanus* | NS |
| Eastern fox squirrel | *Sciurus niger* | NS |
| Eastern red bat | *Lasiurus borealis* | NS |
| Mountain cottontail | *Sylvilagus nuttallii* | NS |
| Hayden's shrew | *Sorex haydeni* | NS |
| Hoary bat | *Lasiurus cinereus* | NS |
| Least weasel | *Mustela nivalis* | NS |
| Long-eared myotis | *Myotis evotis* | NS |
| Little brown myotis | *Myotis lucifugus* | NS |
| Long-legged myotis | *Myotis volans* | NS |
| Long-tailed weasel | *Mustela frenata* | NS |
| Meadow vole | *Microtus pennsylvanicus* | NS |
| Meadow jumping mouse | *Zapus hudsonius* | MT S |
| Mink | *Mustela vison* | NS |
| Mule deer | *Odocoileus hemionus* | NS |
| Muskrat | *Ondatra zibethicus* | NS |
| Olive-backed pocket mouse | *Perognathus fasciatus* | NS |
| Ord's kangaroo rat | *Dipodomys ordii* | NS |
| Porcupine | *Erethizon dorsatum* | NS |
| Prairie vole | *Microtus ochrogaster* | NS |
| Preble's shrew | *Sorex preblei* | MT S |
| Northern Pocket Gopher | *Thomomys talpoides* | NS |
| Raccoon | *Procyon lotor* | NS |
| Silver-haired bat | *Lasionycteris noctivagans* | NS |
| Snowshoe hare | *Lepus americanus* | NS |

| Common Name | Scientific Name | Status |
|---|---|---|
| Striped skunk | *Mephitis mephitis* | NS |
| Thirteen-lined ground squirrel | *Spermophilus tridecemlineatus* | NS |
| Townsend's big-eared bat | *Corynorhinus townsendii* | MT S |
| Western jumping mouse | *Zapus princeps* | NS |
| Western small-footed myotis | *Myotis ciliolabrum* | NS |
| White-tailed deer | *Odocoileus virginianus* | NS |
| White-tailed jackrabbit | *Lepus townsendii* | NS |
| **Birds** | | |
| American redstart | *Setophaga ruticilla* | |
| American robin | *Turdus migratorius* | |
| Bald eagle | *Haliaeetus leucocephalus* | ND C MN S |
| Baird's sparrow | *Ammodramus bairdii* | ND C MN S |
| Black-billed magpie | *Pica hudsonia* | |
| Black-capped chickadee | *Poecile atricapillus* | |
| Black-headed grosbeak | *Pheucticus melanocephalus* | |
| Bobolink | *Dolichonyx oryzivorus* | MT S |
| Brown-headed cowbird | *Molothrus ater* | |
| Chestnut-collared longspur | *Calcarius ornatus* | MT S |
| Common Crow | *Corvus brachyrhynchos* | |
| Downy woodpecker | *Picoides pubescens* | |
| Golden eagle | *Aquila chrysaetos* | ND C |
| Grasshopper sparrow | *Ammodramus savannarum* | MT S |
| Great horned owl | *Bubo virginianus* | |
| Hairy woodpecker | *Picoides villosus* | |
| Horned lark | *Eremophila alpestris* | |
| Interior least tern | *Sterna antillarum* | US F |
| Lazuli bunting | *Passerina amoena* | |
| Least flycatcher | *Empidonax minimus* | |
| Loggerhead shrike | *Lanius ludovicianus* | MT S |
| Long-billed curlew | *Numenius americanus* | ND C |
| Northern flicker | *Colaptes auratus* | |
| Ovenbird | *Seiurus aurocapilla* | |
| Red-eyed vireo | *Vireo olivaceus* | |
| Red-headed woodpecker | *Melanerpes erythrocephalus* | MT S |
| Red-tailed hawk | *Buteo jamaicensis* | |
| Sharp-tailed grouse | *Tympanuchus phasianellus* | |
| Sprague's pipit | *Anthus spragueii* | MT S |
| Spotted towhee | *Pipilo maculatus* | |
| Warbling vireo | *Vireo gilvus* | |
| Western meadowlark | *Sturnella neglecta* | |
| Whooping crane | *Grus americana* | US F |
| Yellow warbler | *Dendroica petechia* | |
| **Reptiles and Amphibians** | | |
| Boreal chorus frog | *Pseudacris maculata* | NS |
| Common gartersnake | *Thamnophis sirtalis* | NS |
| Eastern racer | *Coluber constrictor* | NS |
| Milksnake | *Lampropeltis triangulum* | MT S |
| Painted turtle | *Chrysemys picta* | NS |
| Plains gartersnake | *Thamnophis radix* | NS |
| Sagebrush lizard | *Sceloporus graciosus* | MT S |
| Snapping turtle | *Chelydra serpentine* | MT S |
| Spiny softshell turtle | *Apalone spinifera* | MT S |
| Tiger salamander | *Amystoma tigrinum* | NS |

| Common Name | Scientific Name | Status |
|---|---|---|
| Western hog-nose snake | *Heterodon nasicus* | MT S |
| Woodhouse's toad | *Bufo woodhousii* | NS |
| **Fish** | | |
| Bighead carp | *Hypophthalmichthys nobilis* | |
| Bigmouth shiner | *Notropis dorsalis* | |
| Black bullhead | *Ameiurus melas* | |
| Black crappie | *Pomoxis nigromaculatus* | |
| Blackside darter | *Percina maculata* | |
| Blue gill | *Lepomis macrochirus* | |
| Blue sucker | *Cycleptus elongatus* | MT S, ND C |
| Bluntnose minnow | *Pimephales notatus* | |
| Brook stickleback | *Culaea inconstans* | |
| Brook trout | *Salvelinus fontinalis* | |
| Brown bullhead | *Ameiurus natalis* | |
| Brown trout | *Salmo trutta* | |
| Common carp | *Cyprinus carpio* | |
| Channel catfish | *Ictalurus punctatus* | |
| Chinook salmon | *Oncorhynchus tshawytscha* | |
| Cisco | *Coregonus artedi* | |
| Common shiner | *Luxilus cornutus* | |
| Crappie | *Pomoxis spp.* | |
| Creek chub | *Semotilus atromaculatus* | |
| Dace | *Rhinichthys spp.* | |
| Emerald shiner | *Notropis atherinoides* | |
| Fathead minnow | *Pimephales promelas* | |
| Flathead chub | *Platygobio gracilis* | |
| Gizzard shad | *Dorosoma cepedianum* | |
| Goldeye | *Hiodon alosoides* | |
| Golden redhorse | *Moxostoma erythrurum* | |
| Hornyhead chub | *Nocomis biguttatus* | |
| Iowa darter | *Etheostoma exile* | |
| Jonny darter | *Etheostoma nigrum* | |
| Lake chub | *Couesius plumbeus* | ND C |
| Lake trout | *Salvelinus namaycush* | |
| Largemouth bass | *Micropterus salmoides* | |
| Least darter | *Etheostoma microperca* | |
| Logperch | *Percina caprodes* | |
| Longnose dace | *Rhinichthys cataractae* | |
| Mooneye | *Hiodon tergisus* | |
| Muskellunge | *Esox masquinongy* | |
| Northern pike | *Esox lucius* | |
| Northern redbelly dace | *Phoxinus eos* | |
| Orangespotted sunfish | *Lepomis humilis* | |
| Pallid sturgeon | *Scaphirhynchus albus* | US F |
| Paddlefish | *Polydon spathula* | MT S |
| Pearl dace | *Margariscus margarita* | ND C |
| Pugnose shiner | *Notropis anogenus* | |
| Pumpkinseed sunfish | *Lepomis gibbosus* | |
| Rainbow smelt | *Osmerus mordax* | |
| Rainbow trout | *Oncorhynchus mykiss* | |
| River carpsucker | *Carpiodes carpio* | |
| Rock bass | *Ambloplites rupestris* | |
| Shiner | *Notropis sp.* | |
| Sand shiner | *Notropis stramineus* | |
| Sauger | *Sander canadense* | MT S |
| Shorthead redhorse | *Moxostoma macrolepidotum* | |

| Common Name | Scientific Name | Status |
|---|---|---|
| Shovelnose sturgeon | *Scaphirhynchus platorynchus* | |
| Sicklefin chub | *Macrhybopsis meeki* | MT S, ND C |
| Silver chub | *Macrhybopsis storeriana* | Can F |
| Smallmouth bass | *Micropterus dolomieu* | |
| Spotfin shiner | *Cyprinella spiloptera* | |
| Sturgeon | *Acipenser sp.* | |
| Sturgeon chub | *Macrhybopsis gelida* | MT S |
| Sucker | *Catostomus sp.* | |
| Sunfish | *Lepomis sp.* | |
| Tiger muskie | *Esox masquinongy x Esox lucius* | |
| Utah chub | *Gila atraria* | |
| Walleye | *Stizostedion vitreum* | |
| White bass | *Morone chrysops* | |
| White crappie | *Pomoxis annularis* | |
| White sucker | *Catostomus commersoni* | |
| Yellow bullhead | *Ameiurus natalis* | |
| Yellow perch | *Perca flavescens* | |
| Zander | *Stizostedion lucioperca* | |
| **Macroinvertebrates** | | |
| Brimstone clubtail | *Stylurus intricatus* | MT S |
| Caddisflies | *Trichoptera* | |
| Mayfly sp. | *Lachlania saskatchewanensis* | |
| Mayfly sp. | *Homoeoneuria alleni* | MT S |
| Mayfly sp. | *Macdunnoa nipawinia* | MT S |
| True flies | *Diptera* | |
| Non-biting midges | *Chironomidae* | |
| Sand-dwelling mayfly | *Homoeoneuria alleni and Macdunnoa nipawinia* | MT S |
| Stoneflies | *Plecoptera* | |
| True bugs | *Hemiptera* | |
| Water beetles | *Coleoptera* | |
| Midges | *Chironomidae* | |
| **Mollusks** | | |
| Fatmucket | *Lampsilis siliquoidea* | |
| Mapleleaf | *Quadrula quadrula* | |
| **Plants** | | |
| Box elder | *Acer negundo* | NS |
| Bractless blazingstar | *Mentzelia nuda* | MT S |
| Buffaloberry | *Shepherdia argentea* | NS |
| Buffalo grass | *Buchloe dactyloides* | NS |
| Chokecherry | *Prunus virginiana* | NS |
| Cottonwood | *Populus deltoides* | NS |
| Green ash | *Fraxinus pennsylvanica* | NS |
| Hayden's yellowcress | *Rorippa calycina* | MT S |
| Juniper | *Juniperus scopulorum or J. virginiana* | NS |
| Little blue stem | *Schizachyrium scoparium* | NS |
| Narrowleaf penstemon | *Penstemon angustifolius* | MT S |
| Needle and thread grass | *Stipa comata* | NS |
| Nine-anther prairie clover | *Dalea enneandra* | MT S |
| Pale-spike lobelia | *Lobelia spicata* | MT S |
| Poison suckleya | *Suckleya suckleyana* | MT S |
| Ponderosa pine | *Pinus ponderosa* | NS |
| Prairie goldenrod | *Oligoneuron album* | MT S |
| Russian olive | *Elaeagnus angustifolia* | NS |

| Common Name | Scientific Name | Status |
|---|---|---|
| Silky Prairie-clover | *Dalea villosa* | MT S |
| Silver sagebrush | *Artemisia cana* | NS |
| Threadleaf sedge | *Carex filifolia* | NS |
| Wheatgrass | *Pascopyrum smithii* | NS |
| Willows | *Salix spp.* | NS |
| **Noxious Weeds** | | |
| Absinth wormwood | *Artemisia absinthium* | NX - ND |
| Canada thistle | *Cirsium arvensis* | NX - ND, MT |
| Common tansy | *Tanacetum vulgare* | NX - MT |
| Dalmation toadflax | *Linaria dalmatica* | NX - MT |
| Dyers woad | *Isatis tinctoria* | NX - MT |
| Field bindweed | *Convolvulus arvensis* | NX - MT |
| Hoary cress | *Cardaria draba* | NX - MT |
| Houndstongue | *Cynoglossum officinale* | NX - MT |
| Leafy spurge | *Euphoria esula* | NX - MT, ND |
| Musk thistle | *Cardus nutans* | NX - ND |
| Purple loosestrife | *Lythrum salicaria, L. virgatum* or hybrids | NX - MT |
| Russian knapweed | *Centaurea repens* | NX - MT, ND |
| Salt cedar | *Tamarix sp* | NX - MT, ND |
| Spotted knapweed | *Centaurea maculosa* | NX - MT, ND |
| Yellow toadflax | *Linaria vulgaris* | NX - MT |

**Key to Status:**
US F- United States Federally Listed
MT S- Montana Species of Special Concern
ND C- North Dakota Species of Conservation Priority
NS – no status
NX – noxious weed

# Appendix G – National Historic Preservation Act Consultation

## Introduction

Consultation with the Montana State Historic Preservation Office (SHPO) began with a request for a search of files to identify any historic properties previously recorded within the area of potential effects of the Intake Project (table G.1). This file search request was e-mailed on May 1, 2009. The SHPO responded on May 11, 2009 with a list of determinations of eligibility, previously recorded sites, and a list of cultural resources reports in the area of potential effects.

On October 15, 2009, Reclamation sent a letter to the SHPO continuing consultation on the Intake Project (see below). The letter enclosed detailed information about the location of the proposed federal undertaking, identification of historic properties, and effects determination, and proposed mitigation measures. In addition, Reclamation offered to meet to discuss the proposed federal undertaking.

The Montana SHPO concurred with Reclamation's October 15, 2009, consultation letter on November 4, 2009. Consultation on preparation of a formal memorandum of agreement regarding mitigation of adverse effects and treatment of historic properties is ongoing.

**Table G.1 – File Search Request Sent to Montana SHPO on May 1, 2009.**

# STATE HISTORIC PRESERVATION OFFICE

**1410 8th Ave., P.O. Box 201202, Helena, MT 59620-1202**
**Phone: (406)-444-7767**
**Email: dmurdo@mt.gov**
**Attn: Damon Murdo**

## File Search Request Form

*Please complete this form and attach a copy of the appropriate USGS Quad map showing the project location. All fields must be completed in order for your file search request to be processed. The form and accompanying map can be returned to the address above, emailed, or brought directly to the office.*

| | | | |
|---|---|---|---|
| **Individuals Name** | J. Signe Snortland | | |
| **Organization (Agency/Company)** | U.S. Department of the Interior, Bureau of Reclamation | | |
| **Street** | P.O. Box 1017 or 304 East Broadway Avenue | | |
| **City** | Bismarck | State: ND | Zip:58502 |
| **Telephone #** | 701-221-1278 | Fax: 701-250-4590 | |
| **Project Name** | Intake Diversion Dam Modification, Lower Yellowstone Project | | |
| **Government Agency Involved** | Bureau of Reclamation and U.S. Army Corps of Engineers, Omaha District | | |
| **Describe the project. Please identify any work that will involve ground disturbance, or the demolition and modification of existing buildings. If none of these are to occur, please indicate.** | Reclamation and the Corps are proposing to modify Intake Diversion Dam to improve passage for the endangered pallid sturgeon and reduce unintended entrapment of fish in an unscreened irrigation canal system. The two action alternatives under consideration are to: 1) replace the existing historic dam with a concrete weir and rock ramp and the unscreened historic intake with a new screened intake or 2) relocate the main channel of the Yellowstone River around the historic dam and move the irrigation main canal upstream and build a new screened headworks. A No Action Alternative, the future without the proposed federal undertaking, is also under consideration in an environmental assessment. | | |
| **Describe any previous disturbance and the current land use.** | The area of potential effects is currently used for by the Lower Yellowstone Project irrigation districts. Beside the irrigation project intake and main canal is a state-operated recreation area, Intake Fishing Access Site. | | |
| **Approximate date of proposed project initiation.** | If an action alternative is selected, construction of a fish screen and headworks would begin in September 2010, and construction of fish passage would start in March 2011. | | |
| **Land Ownership (Private, State, Federal, etc.)** | Mixed - some land is federal (Reclamation), some state, and some private. A real estate plan is being developed. | | |
| **Remarks/ Special Requests** | Remarks - Most of the area of potential effects has been surveyed previously by the University of North Dakota, as documented in "Lower Yellowstone Irrigation Project, 1996 and 1997 Cultural Resources Inventory, Dawson and Richland Counties, Montana, and McKenzie County, North Dakota" by Cynthia Kordecki, Mary McCormick, Carrie F. Jackson, and Jennifer Bales and Renewable Technologies, Inc.<br><br>Special Requests – If possible, please check to see if consensus determinations have been completed the results of these determinations for 24DW287, 24DW298, 24DW299, 24DW300, 24DW430, 24DW431, 24DW433, 24DW434, 24DW436, 24DW437, 24DW443, 24DW444, 24DW447, and isolated find BA1-29. | | |

**Project Area Location Information (add on if necessary) Projects in cities also require TRS.**

| TOWNSHIP | RANGE | SECTION | COUNTY |
|---|---|---|---|
| T18N | R56E | Sections 25, 35, and 36 | Dawson |
| T18N | R57E | Sections30 and 31 | Dawson |
| T17N | R56E | Sections 1 and 2 | Dawson |
| T17N | R57E | Section 6 | Dawson |

United States Department of the Interior
BUREAU OF RECLAMATION
Great Plains Region
Montana Area Office
P.O. Box 30137
Billings, Montana 59107-0137

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
MT-227
ENV-3.00

OCT 15 2009

Dr. Mark Baumler
State Historic Preservation Office
P.O. Box 201202
1410 8th Ave.
Helena, MT 59620 - 1202

Subject: Consultation on Intake Diversion Dam Modification, Lower Yellowstone Project, and Notification of Potential Adverse Effects on Historic Properties
SHPO Project Designation Number: 2009051102

Dear Dr. Baumler:

In compliance with 36 CFR Parts 800.3, 800.4, and 800.5 the U.S. Department of the Interior, Bureau of Reclamation, is continuing consultation on the Intake Diversion Dam Modification, Lower Yellowstone Project. Reclamation and the U.S. Army Corps of Engineers (Corps) are proposing to modify Intake Diversion Dam. Reclamation is the lead Federal agency and is responsible for compliance with the National Historic Preservation Act (36 CFR Part 800.2[a]) for this proposed Federal undertaking. Reclamation and the Corps are currently preparing a draft environmental assessment for the proposed Federal undertaking.

The proposed Federal undertaking is located at Intake, Dawson County, Montana (see enclosure figure 1). The legal descriptions of the undertaking are Township 18 North, Range 56 East, Sections 25, 35, and 36; Township 18 North, Range 57 East, Sections 30 and 31; Township 17 North, Range 56 East, Sections 1 and 2; and Township 17 North, Range 57 East, Section 6 (see enclosure figure 1). Ownership of land in the area of potential effects (APE) is a mixture of federal, state, and private (see enclosure figure 2).

The proposed action is needed to:

- Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River,
- Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal,
- Continue effective operation of the Lower Yellowstone Project in compliance with the Endangered Species Act, and
- Contribute to restoration of the lower Yellowstone River ecosystem.

Three alternatives are being evaluated in the Intake Diversion Dam Modification, Lower

Yellowstone Project, Draft Environmental Assessment (Intake EA), as described in the enclosure. The Rock Ramp is the preferred alternative, and without mitigation, will result in Adverse Effects to several historic properties. The public has been notified of this proposed Federal undertaking through the National Environmental Policy Act scoping meetings held last fall, and will be given an opportunity to comment on summary cultural resource information in the Intake EA this fall, and to attend public meetings. Along with the public scoping meetings, a total of 25 tribes in the upper Missouri Basin were sent letters notifying them of the proposed project. Follow-up telephone calls were made to each tribe, and none expressed interest in it.

Enclosed is detailed information about the location of the proposed Federal undertaking, alternatives considered, identification of historic properties, effects determination, and proposed mitigation measures. Reclamation is planning to continue consultation with your office, on preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan. If you have any questions about this proposed Federal undertaking or would like to schedule a meeting to discuss it, please feel free to contact me at 406-247-7666.

Sincerely,

**WILLIAM B VINCENT**

William Vincent
Area Archaeologist

Enclosure

cc: Ms. Sandy Barnum
U.S. Army Corps of Engineers
1616 Capitol Ave,
Omaha, NE 68102

bc: 84-53000 (Lincoln)
DK-5000 (Snortland)
GP-42000 (Coutant)
MT-200, MT-221, MT-227, MT-745

WBR:WVincent:JJohnson:10/14/2009:406-247-7666
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United States Department of the Interior

BUREAU OF RECLAMATION
Great Plains Region
Montana Area Office
P.O. Box 30137
Billings, Montana 59107-0137

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BY: SHPO
• Josef
• BOR
• Intake Dam Modification
Lower YL

CONCUR
MONTANA SHPO
DATE 4 Nov 09 SIGNED

Dr. Mark Baumler
State Historic Preservation Office
P.O. Box 201202
1410 8th Ave.
Helena, MT 59620 - 1202

Subject: Consultation on Intake Diversion Dam Modification, Lower Yellowstone Project, and Notification of Potential Adverse Effects on Historic Properties
SHPO Project Designation Number: 2009051102

Dear Dr. Baumler:

In compliance with 36 CFR Parts 800.3, 800.4, and 800.5 the U.S. Department of the Interior, Bureau of Reclamation, is continuing consultation on the Intake Diversion Dam Modification, Lower Yellowstone Project. Reclamation and the U.S. Army Corps of Engineers (Corps) are proposing to modify Intake Diversion Dam. Reclamation is the lead Federal agency and is responsible for compliance with the National Historic Preservation Act (36 CFR Part 800.2[a]) for this proposed Federal undertaking. Reclamation and the Corps are currently preparing a draft environmental assessment for the proposed Federal undertaking.

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Enclosed is detailed information about the location of the proposed Federal undertaking, alternatives considered, identification of historic properties, effects determination, and proposed mitigation measures. Reclamation is planning to continue consultation with your office, on preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan. If you have any questions about this proposed Federal undertaking or would like to schedule a meeting to discuss it, please feel free to contact me at 406-247-7666.

Sincerely,

William Vincent
Area Archaeologist

Enclosure

cc: Ms. Sandy Barnum
U.S. Army Corps of Engineers
1616 Capitol Ave,
Omaha, NE 68102

# Appendix H – Indian Trust Assets

## Introduction

This appendix contains the data and analyses used to determine whether alternatives for the Lower Yellowstone Intake Project would impact Indian trust assets (ITA). ITAs are defined as "...legal interests in property held in trust by the United States for Indian tribes or individuals" (Reclamation, 1993).

The relationship between the Federal government and tribes is defined in the U.S. Constitution. Article 1, Section 8 gives Congress the authority "[t]o regulate commerce with foreign nations, and among the several states, and with the Indian tribes." Until 1871, this relationship with individual tribes was enumerated through treaties, from which the concept of the "trust relationship" originated. According to the Supreme Court decision in *Cherokee Nation v. Georgia* (1831), Indian tribes are considered to constitute "domestic, dependent nations" whose "relationship to the United States resembles that of a ward to his guardian." This decision established the doctrine of federal trusteeship – the trust relationship – in Indian affairs.

All federal agencies, including Reclamation, have a government-to-government relationship with tribes. Federally recognized tribes are to be respected as sovereign governments and federal agencies have a trust responsibility to respect this sovereignty by protecting and maintaining rights reserved by or granted to tribes or individual Indians by treaties, federal court decisions, statutes, and executive orders. The sovereignty of tribes and this trust relationship have been affirmed through treaties, court decisions, legislation, regulations, and policies. The result is that federal agencies are to assess the impacts of their activities on trust assets, to protect and conserve ITAs to the extent possible. This appendix provides the framework for the identification of ITAs that may possibly be affected by the proposed alternatives. It does not attempt to define, regulate, or quantify ITAs or any rights that tribes are entitled to by treaty or law.

### Indian Trust Assets

Examples of possible trust assets include "lands, minerals, hunting and fishing rights, and water rights" (Reclamation, 1993). To this extent, this definition of ITAs parallels that of "trust resources" in 25 CFR Part 1000.352:

(a) Trust resources include property and interests in property:
  (1) That are held in trust by the United States for the benefit of a tribe or individual Indians; or
  (2) That are subject to restrictions upon alienation.

(b) Trust assets include:

> (1) Other assets, trust revenue, royalties, or rental, including natural resources, land, water, minerals, funds, property, assets, or claims, and any intangible right or interest in any of the foregoing;
> (2) Any other property, asset, or interest therein, or treaty right for which the United States is charged with a trust responsibility. For example, water rights and off-reservation hunting and/or fishing rights.

Reclamation developed its ITA policy (Reclamation, 1993) in response to the statement by former President Bush dated June 14, 1991, affirming the government-to-government relationship between federal agencies and tribal governments. Former President Clinton reaffirmed this policy in a memorandum issued on April 29, 1994. Both were incorporated by the Department of the Interior in "Departmental Responsibilities for Indian Trust Resources" (512 Department of the Interior Manual, Chapter 2):

> It is the policy of the Department of the Interior to recognize and fulfill its legal obligations to identify, protect, and conserve the trust resources of federally recognized Indian tribes and tribal members, and to consult with tribes on a government-to-government basis whenever plans or actions affect tribal trust resources, trust assets, or tribal health and safety.

The Department of the Interior Manual and Reclamation's ITA policy require that potential impacts to ITAs need to be identified, considered, and addressed when planning and implementing federal actions. Effects must be identified and addressed in planning and decision documents, especially those prepared in association with the National Environmental Policy Act (NEPA) process. Reclamation's (draft) NEPA Handbook (Reclamation 2000) specifies that all NEPA documents are to address ITAs and whether the proposed action(s) would have an impact on any such asset(s).

## Methods

### Consultation with Tribes to Identify ITAs

Tribes were invited to consult throughout preparation of the EA. In October 2008 Reclamation sent letters to 25 tribes in the Upper Missouri River basins. Follow-up telephone calls were made to each tribe. The tribes identified in that plan are listed in table H.1.

The plan identified 25 tribes in the Missouri River Basin (Figure H.1). Thirteen of the Missouri River Basin tribes are located directly on the Missouri River, while others are scattered throughout the rest of the basin. All of these tribes could directly or indirectly have historic ties to the Project area (Table H.1).

The tribes were contacted in writing, followed by telephone calls. Reclamation requested that the tribes identify any ITAs that could be affected by the Project alternatives and invited them to meet and consult on impacts to any potentially affected ITAs. None of the tribes expressed interest in continuing direct consultations. Some tribes stated they were not interested while others wanted to be kept informed and possibly comment later. Still others did not respond. All of these tribes were sent copies of the scoping package and public notice during the public comment period (see Chapter 5 distribution list).

**Table H.1 – Tribes Located within the Area of Potential Effect**

| Figure H.1 Location Number | Missouri River Tribes |
|---|---|
| 4 | Assiniboine and Sioux Tribes of Fort Peck |
| 13 | Cheyenne River Sioux Tribe |
| 14 | Crow Creek Sioux Tribe |
| 24 | Iowa Tribe of Kansas |
| 15 | Lower Brule Sioux Tribe |
| 23 | Omaha Tribe |
| 20 | Ponca Tribe |
| 25 | Sac and Fox Nation |
| 21 | Santee Sioux Nation |
| 24 | Standing Rock Sioux Tribe |
| 8 | Three Affiliated Tribes (Mandan, Hidatsa, and Arikara) |
| 22 | Winnebago Tribe |
| 18 | Yankton Sioux |
| **Figure H.1 Location Number** | **Missouri Basin Tribes** |
| 1 | Blackfeet Tribe |
| 2 | Chippewa Cree Tribe, Rocky Boy Reservation |
| 5 | Crow Tribe |
| 7 | Eastern Shoshone Tribe |
| 19 | Flandreau Santee Sioux Tribe |
| 3 | Fort Belknap Assiniboine and Gros Ventre Tribes |
| 26 | Kickapoo Tribe |
| 7 | Northern Arapaho Tribe |
| 6 | Northern Cheyenne Tribe |
| 16 | Oglala Sioux Tribe |
| 27 | Prairie Bend of Potawatami Nation |
| 17 | Rosebud Sioux Tribe |

## Treaty Research

The Lower Yellowstone Intake is located in Section 36, Township 18 North, Range 56 East of the Montana Meridian. Reclamation purchased the lands from the state of Montana on April 17, 1908. Section 36 was provided to the State of Montana as a school section under its charter of statehood in November 8, 1889.

Historically, many Indian tribes occupied this area for hunting, fishing, gathering and other purposes. These included but are not limited to the Assiniboine, Arapaho, Arikara, Blackfeet, Cheyenne, Crow, Grow Ventre, Mandan, and Sioux or Lakota Nation.

Reclamation reviewed the treaties with the Missouri River Basin tribes to determine if any ITAs were specified in them (Royce, 1899). The United States entered into at least 54 treaties with these tribes, many of which applied to multiple tribes (Table H.2). Frequently treaties involved land cessions in which the tribes retained certain rights of access, most often for hunting, fishing, and gathering on the ceded lands. U.S. Supreme Court decisions have defined other retained rights not specified in the treaties. These decisions are based on the “reserved rights” doctrine:

"…the treaty was not a grant of rights to the Indians, but a grant of rights from them—a reservation of those not granted" (United States v. Winans 1905).

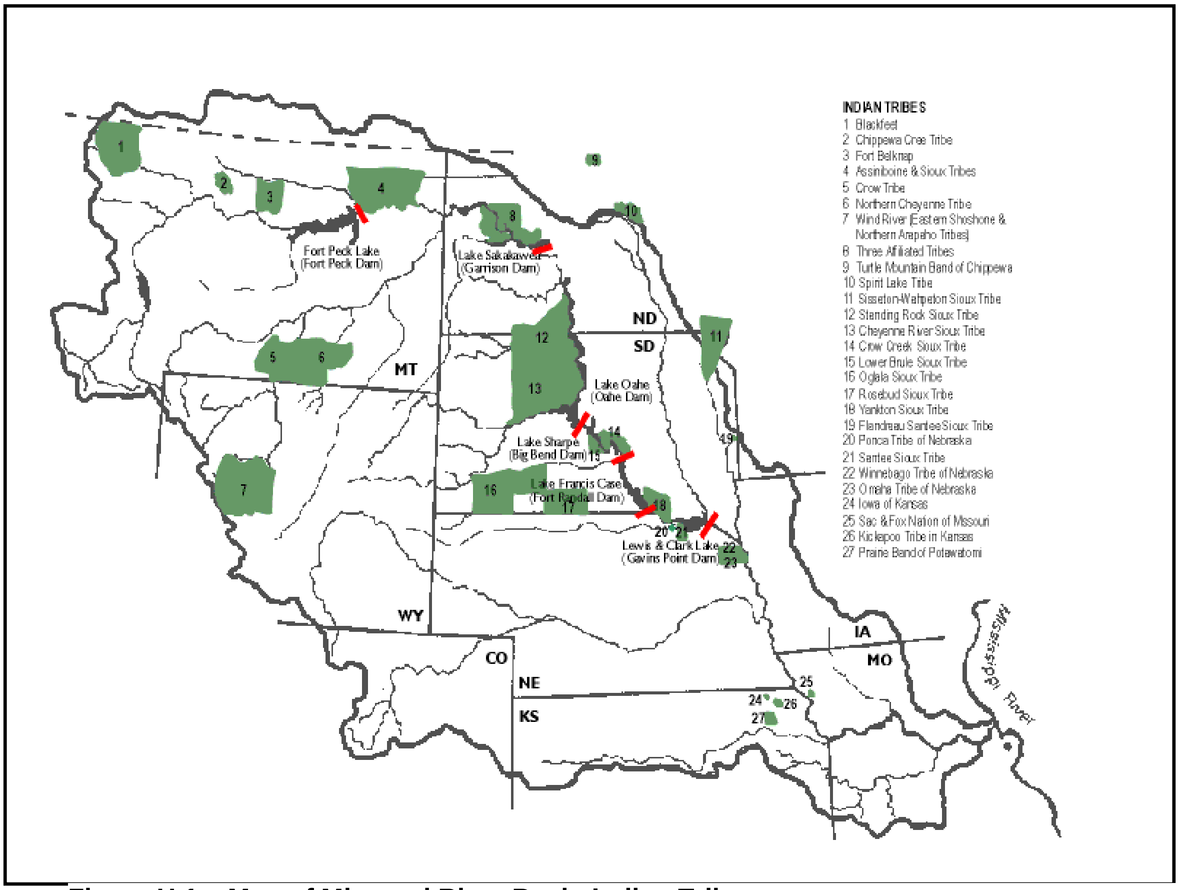



**Figure H.1 – Map of Missouri River Basin Indian Tribes.**

The following discussion addresses potential treaty rights of tribes in this area. The sources used were Indian Land Cessions in the United States by Charles C. Royce; Master Title plat files, Montana Area Office, Reclamation; and the U.S. Indian Claims Commission website, [http://digital.library.okstate.edu/icc/index.html](http://digital.library.okstate.edu/icc/index.html). In addition Joel Ames, Native American Coordinator, Omaha Division, Corp and Brenda Schilf, Bureau of Indian Affairs Realty Specialist provided information.

The Fort Laramie Treaty of 1851 included the area of the Lower Yellowstone in the territories boundaries for several tribes:

- Boundaries of the Gros Ventre, Mandan, and Arikara nations defined as follows: Commencing at the mouth of the Heart River; thence up the Missouri River to the mouth of the Yellowstone River; thence up the Yellowstone River to the mouth of the Powder River, in a southeasterly direction, to the headwater of the Little Missouri River; thence along the Black Hills to the head of Heart River; and thence down Heart River to the place of beginning.

- Boundaries of the Assiniboine: Commencing at the mouth of Yellowstone River; thence up the Missouri River to the mouth of the Muscle-shell River; thence from the mouth of the Muscle-shell River in a southeasterly direction until it strikes the head waters of Big Dry Creek; thence down that creek to where it empties into the Yellowstone River, nearly opposite the mouth of the Powder River; and thence down the Yellowstone River to the place of beginning.

- The Assiniboine ceded this country by treaty in 1866. This treaty was never ratified, but their acceptance of a home on the reserve for the Blackfeet, Blood, Gros Ventre, Piegan, and River Crow, established April 15, 1874, relinquished it in all practicality.

The Fort Laramie Treaty of 1868 redefined the boundaries of the Sioux Nation and Arapahoe Tribe to assure the undisturbed use and occupation of certain lands. No changes were made in the boundaries of lands for the Gros Ventre, Mandan, Arikara, or Assiniboine as noted in the 1851 Ft. Laramie Treaty.

The Executive Order of April 12, 1870, set aside a reservation at Fort Berthold, Dakota Territory, and redefined the Fort Berthold Reservation as described in the 1851 Fort Laramie Treaty by ceding lands south and east of a line extending from the point where the Little Powder River unites with Powder River to a point on the Missouri River four miles below the Indian Village of Berthold.

Executive Orders on July 13, 1880, ceded lands around the intake that were formerly reserved to the Arikara, Mandan and Gros Ventre.

An act of Congress on May 1, 1888, established the Fort Peck and Fort Belknap Reservations for the Gros Ventre and Assiniboine as currently defined and ceded all other lands to the United States.

The Indian Claims Commission addressed tribal land claims during its tenure from 1946 to 1978. Unresolved claims were transferred to the U. S. Court of Claims. There are no known pending cases before the U. S. Court of Claims.

A review of the master title plat files at the Montana Area Office indicates that lands within two miles of the Intake are currently either privately owned or within the jurisdiction of Reclamation.

There are no vacant and unreserved public domain lands or individual Turtle Mountain Chippewa allotments within two miles of the Intake.

Reclamation has consulted with the Rocky Mountain Region of the Bureau of Indian Affairs (BIA) and the Omaha District of the U.S. Army Corps of Engineers (Corps), as well as Reclamation cultural resource specialists. These sources were not aware of any quantified treaty rights in the area of the Intake.

# Results

## Trust Lands

Trust lands are lands set aside for Indians with "…the United States holding naked legal title and the Indians enjoying the beneficial interest" (Canby, 1991). The Bureau of Indian Affairs land database was reviewed, and the tribes listed in Table H.1 were contacted to determine if any trust lands were within the areas of potential effect for the Project alternatives. No trust lands were identified in the Intake Project area.

**Table H.2 – Treaties of Missouri River Basin Tribes and Retained Rights (Royce, 1899)**

| Tribe | Treaty | Retained Rights |
|---|---|---|
| Assiniboine and Sioux Tribes of Fort Peck | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1873 Executive Order established the Fort Peck Reservation<br>1889 Congress established boundaries | 1851-hunting and fishing<br>1868-hunting |
| Blackfeet Tribe | 1855 Treaty with Blackfeet Sioux | 1855-hunting, fishing, gathering, and grazing |
| Cheyenne River Sioux Tribe | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1868-hunting<br>1889-irrigation |
| Chippewa Cree Tribe, Rocky Boy Reservation | 1825 Treaty with the Sioux<br>1916 Executive Order establishing the Reservation boundary | 1825-reciprocal hunting |
| Crow Creek Sioux Tribe | 1825 Treaty with the Sioux<br>1851 Fort Laramie Treaty<br>1863 Executive Order establishing the Reservation boundary<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1825-reciprocal hunting<br>1851-hunting and fishing<br><br>1868-hunting<br>1889-irrigation |
| Crow Tribe | 1826 Treaty<br>1851 Fort Laramie Treaty | <br>1851-hunting and fishing |
| Eastern Shoshone Tribe | 1863 and 1868 Fort Bridger Treaty<br>1872 Brunot Agreement<br>1898 and 1904 McLaughlin Agreement | |

| Tribe | Treaty | Retained Rights |
|---|---|---|
| Flandreau Santee Sioux Tribe | 1851 Fort Laramie Treaty<br>1858 Treaty with the Sioux<br>1863 Executive Order<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty | 1851-hunting and fishing<br><br><br>1868-hunting |
| Fort Belknap Assiniboine and Gros Ventre Tribes | 1851 Fort Laramie Treaty<br>1855 Blackfeet Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1855-hunting, fishing, gathering, and grazing<br>1889-irrigation |
| Iowa Tribe of Kansas | 1825 Treaty with the Sioux<br>1830 Treaty with Sauk, Foxes | 1825-reciprocal hunting |
| Kickapoo Tribe | 1819 Treaty with the Kickapoo<br>1832 Treaty with the Kickapoo<br>1854 Treaty with the Kickapoo<br>1864 Amendment to Treaty with the Kickapoo | |
| Lower Brule Sioux Tribe | 1851 Fort Laramie Treaty<br>1865 Treaty with Sioux Lower Brule Band<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br><br>1868-hunting<br>1889-irrigation |
| Northern Arapaho Business Council | 1863 and 1868 Fort Bridger Treaty<br>1872 Brunot Agreement<br>1898 and 1904 McLaughlin Agreement | |
| Northern Cheyenne Tribe | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux Brule etc/Fort Laramie Treaty<br>1884 Executive Order<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1868-hunting<br><br>1889-irrigation |
| Oglala Sioux Tribe | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux Brule etc/Fort Laramie Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1868-hunting<br>1889-irrigation |
| Omaha Tribe | 1830 Treaty with Sauk, Foxes<br>1836 Treaty with the Oto etc.<br>1854 Treaty with the Omaha | |
| Ponca Tribe | 1817 Treaty with the Ponca<br>1825 Treaty with the Sioux<br>1858 Treaty with the Ponca<br>1865 Treaty with the Ponca<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1881 Act of Congress | <br><br>1825-reciprocal hunting<br><br>1868-hunting |
| Prairie Bend of Potawatami Nation | 1846 Treaty with the Potawatami Nation | |
| Rosebud Sioux Tribe | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux BruleFort Laramie Treaty<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1868-hunting<br>1889-irrigation |
| Sac and Fox Nation | 1825 Treaty with the Sioux, 1830 Treaty with Sauk, Foxes.<br>1832 Treaty of Fort Armstrong | 1825-reciprocal hunting |

| Tribe | Treaty | Retained Rights |
|---|---|---|
| Santee Sioux Nation | 1825 Treaty with the Sioux<br>1830 Treaty with Sauk, Foxes<br>1836 Treaty with the Oto<br>1851 Fort Laramie Treaty<br>1867 Treaty with the Sioux Sisseton and Wahpeton Bands<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty | 1825-reciprocal hunting<br>1851-hunting and fishing<br>1868-hunting |
| Standing Rock Sioux Tribe | 1851 Fort Laramie Treaty<br>1868 Treaty with Sioux Brule etc/Fort Laramie Treaty<br>1882 Agreement with Sioux of various tribes (not ratified)<br>1889 Congressional Act; Great Sioux Settlement | 1851-hunting and fishing<br>1868-hunting<br>1889-irrigation |
| Three Affiliated Tribes (Mandan, Hidatsa, and Arikara) | 1851 Fort Laramie Treaty<br>1866 Fort Berthold Agreement (not ratified)<br>1868 Treaty with Sioux Brule/Fort Laramie Treaty<br>1870 Executive Order<br>1880 Executive Order | 1851-hunting and fishing<br>1868-hunting |
| Winnebago Tribe | 1825 Treaty with the Sioux<br>1830 Treaty with Sauk, Foxes<br>1832 Treaty with Winnebago<br>1837 Treaty with Winnebago<br>1846 Treaty with Winnebago<br>1855 Treaty with Winnebago<br>1859 Treaty with Winnebago<br>1865 Treaty with Winnebago | 1825-reciprocal hunting |
| Yankton Sioux | 1815 Treaty with Yankton Sioux<br>1825 Treaty with the Teton etc.<br>1830 Treaty with Sauk, Foxes<br>1836 Treaty with the Oto<br>1837 Treaty with Yankton Sioux<br>1858 Treaty with Yankton Sioux<br>1865 Treaty with the Sioux Yanktonai<br>1868 Treaty with Sioux Brule/Fort<br>1894 Act of Congress reduced reservation | |

## Hunting, Fishing, and Gathering Rights

According to Reclamation's (1993) ITA policy, hunting and fishing rights and, by extension, gathering rights may qualify as ITAs. This is because in many treaties tribes retained the right to continue hunting, fishing, and gathering on ceded lands (Table H.2). However, no court has ruled on whether these activities collectively constitute ITAs although the U.S. Supreme Court ruled in *Minnesota v. Mille Lacs* (1999) that hunting, fishing, and gathering were usufructuary rights.

***Usufructuary rights*** are those rights to obtain food, water, and other necessities on ceded lands, which include the right to use the ceded property to hunt, fish and gather on the land.

## Indian Water Rights

The United States government has recognized that tribes in the western United States (west of the Mississippi) may hold rights to water in streams running through or alongside the boundaries of their reservations. The basis for Indian water rights stems from the U. S. Supreme Court decision *Winters v. United States* (1908), which enunciated the Winters Doctrine. According to the Winters Doctrine, implicit in the establishment of an Indian reservation was a reservation of sufficient water to fulfill the purposes for which the reservation was created, with the priority date being the date the reservation was established. As such, Indian water rights for both surface water and groundwater, when quantified, constitute an ITA.

When a reservation is established with expressed or implicit purposes beyond agriculture, such as to preserve fishing, then water may also be reserved in quantities to sustain use. The U.S. Supreme Court upheld this concept in *Arizona v. California* (1963). The Court held that tribes need not confine the actual use of water to agricultural pursuits, regardless of the wording in the document establishing the reservation. However, the amount of water quantified was still determined by the amount of water necessary to irrigate the "practicably irrigable acreage" on a reservation. The Court also held that the water allocated should be sufficient to meet both present and future needs of the reservation to assure the viability of the reservation as a homeland. Case law also supports the premise that Indian reserved water rights are not lost through non-use.

The Winters Doctrine will apply to any Indian water rights in Montana or along the Missouri River.

### *Surface Water*

The Corps is the federal agency responsible for operations of the Missouri River. The Corps has recognized that certain Missouri River Basin tribes are entitled to water rights in streams running through and along their reservations under the Winters Doctrine. Several Missouri River Basin tribes have quantified or are in the process of quantifying their water rights. Currently, the only tribal reserved water rights that have been legally quantified are:

- State of Wyoming settlement with tribes of the Wind River Reservation (adjudicated under the McCarran Amendment)
- Compact between the state of Montana and the tribes of the Fort Peck Reservation (awaiting congressional approval)
- Compact between the state of Montana and the tribes of the Fort Belknap Reservation (ratified by the state legislature)
- Compact between the state of Montana and the Crow Tribe (Crow Tribe Water Rights Settlement Act of 2010 [PL 111-291])
- Compact between the state of Montana and the tribes of the Rocky Boys Reservation (Chippewa Cree Tribe of the Rocky Boy's Reservation Indian Reserved Water Rights Settlement and Water Supply Enhancement Act of 1999 [PL 106-163])
- Compact between the State of Montana and the Northern Cheyenne Tribe (The Northern Cheyenne Indian Reserved Water Rights Settlement Act of 1992 [P.L. 102-374])

The Lower Yellowstone Intake is a "run of the river" diversion structure and will continue to function in this capacity upon completion of the project. There will be no change in the amount of water diverted, the time of diversion, the priority date, or the purpose. The only change may be the point of diversion. None of the alternatives currently under consideration are anticipated to have an adverse impact on Indian Treaty rights.

The diversion is operated and maintained by the Board of Control under contract with Reclamation. It is anticipated that this arrangement would continue upon completion of the project.

### *Groundwater*

Groundwater also can constitute an ITA as a water right. Montana regulates and permits groundwater withdrawals. It is not anticipated that this project will affect groundwater resources.

## Impacts to Indian Trust Assets

The following discussion addresses the potential impacts of the proposed alternatives on ITAs. The alternatives potentially could affect three different categories of ITAs, if any are identified: 1) trust lands, 2) hunting, fishing, and gathering rights, and 3) Indian water rights. The potential impacts are summarized in Table H.3.

**Table H.3 – Summary of the Consequences of No Action and Potential Impacts to ITAs by Action Alternatives**

| Indian Trust Assets | No Action Alternative | Action Alternatives |
|---|---|---|
| Trust Lands – none identified | No consequences | No effect |
| Hunting, Fishing & Gathering Rights – none identified | The existing Intake Diversion Dam is a partial barrier to some fish species and a total barrier to others, like the pallid sturgeon. | No effect; all action alternatives would improve pallid sturgeon fisheries in the Yellowstone River to varying degrees. |
| Indian Water Rights – surface water | No consequences | Undetermined<br><br>Most tribes within the Missouri River Basin have not quantified these rights; those that have will not receive any water directly from the Lower Yellowstone. |
| Indian Water Rights - groundwater | No consequences | No effect |

### *Trust Lands*

Trust lands are lands set aside for Indians to which the United States holds legal title and the Indians receive the beneficial interest. A review of the Bureau of Indian Affairs land database for the tribes listed in Table H.1 indicates that no trust lands are within the area of potential effects for the proposed alternatives.

**No Action Alternative** There are no trust lands in the area of potential effects.

**Bypass Channel and Rock Ramp Alternatives** Neither of the action alternatives would affect trust lands.

### *Hunting, Fishing, and Gathering Rights*

Many of the treaties with the tribes in the Missouri River basin provided for continued hunting, fishing, and gathering on ceded lands. If future federal court decisions affirm the hunting, fishing, and gathering rights of the tribes, those rights may need to be given consideration.

**No Action Alternative** The existing Intake Diversion Dam is a partial barrier to some fish species and a total barrier to others, like the pallid sturgeon. Because no fishing rights have been identified in the area of potential effects, there would be no consequences to ITAs.

**Bypass Channel and Rock Ramp Alternatives** Both of the proposed action alternatives would improve pallid sturgeon fisheries in the lower Yellowstone River to varying degrees. These improvements are discussed in the aquatic resources impacts section of chapter four.

### *Indian Water Rights*

The basis for Indian water rights in the western United States stems from the U. S. Supreme Court decision in *Winters v. United States* (1908), commonly known as the Winters Doctrine. According to the Winters Doctrine, the establishment of an Indian reservation implied that sufficient water was reserved to fulfill purposes for which the reservation was created, with the priority date being the date the reservation was established. As such, Indian water rights to both surface water and groundwater constitute an ITA.

**No Action Alternative** The No Action Alternative would not have consequences for surface water or groundwater rights.

**Bypass Channel and Rock Ramp Alternatives** Surface water rights have been quantified for the two tribes upstream of Intake, Montana. The Northern Cheyenne Water Rights Compact with the State of Montana was ratified by Congress in September 1992. The Crow Water Rights Compact with the state of Montana was ratified by the state in June 1999. The Crow Settlement Act was introduced into Congress and signed into law in 2010. All of these water rights have an earlier priority date than the water rights diverted by the Lower Yellowstone Project. The proposed Intake Project would not affect Indian water rights.

# Appendix I – Actions to Minimize Effects

## Introduction

A key factor in successful construction and operation of this Intake Project would be the implementation of actions to minimize effects and monitoring. If a Finding of No Significant Impact (FONSI) is signed, to ensure that Intake Project activities are completed concurrently and in full compliance with all environmental commitments, Reclamation and the Corps will establish the Environmental Review Team (ERT) to implement management practices to avoid, minimize or mitigate adverse impacts to Intake Project area resources. This team will be comprised of federal, state, and local entities, which will develop the specific actions and monitoring programs and provide input to Reclamation and the Corps. This team could include technical representatives of the following agencies:

- Bureau of Reclamation
- U.S. Army Corps of Engineers
- Lower Yellowstone Irrigation Project Board of Control
- Montana Department of Environmental Quality
- Montana Department of Natural Resources and Conservation
- Montana Fish, Wildlife & Parks
- U.S. Fish and Wildlife Service
- The Nature Conservancy
- Montana State Historic Preservation Officer
- Other technical entities as deemed important to the process

When construction affects private lands or lands administered by agencies other than those listed above, landowners or specialists representing other agencies will be invited to participate on the team for the components that potentially affect their lands.

The ERT will use adaptive management principles and other methods to monitor the effectiveness of actions to minimize effects. The purpose of this team is to ensure that Intake Project activities are completed concurrently and in compliance with all environmental commitments in NEPA documents, such as the Final EA and FONSI decision. This team will also address other relevant state and federal environmental rules and regulations, such as the Clean Water Act and the National Historic Preservation Act.

ERT Responsibilities, Goals, and Objectives may include:

- Review and evaluate project construction plans and specifications to assist in identifying, avoiding, minimizing, or mitigating potential impacts to resources. Annually or as needed, the team will review modifications to the construction plans.

- Conduct field reviews (annually or as needed) prior to construction to identify environmentally sensitive areas where site-specific mitigation may be required.
- Review construction plans to determine if all required field surveys within the appropriate survey periods have been completed prior to Intake Project disturbance.
- Review previous construction activities to determine if required mitigation measures are sufficient and have been accomplished and prepare an annual environmental mitigation/progress report for the Intake Project.

Recognizing that the details of Intake Project impacts cannot be fully identified until the final engineering stage, many of the environmental commitments (identified below) are general in nature. Depending upon the alternative selected in the FONSI, the following commitments will be implemented to avoid adverse impacts to resources. Some of these commitments are not applicable to every alternative. The FONSI will list the environmental commitments applicable to the selected alternative.

### Adaptive Management

- Reclamation and the Corps recognize that there is uncertainty in addressing natural resource issues. To manage this uncertainty Reclamation and the Corps will develop an adaptive management plan. The plan will be developed in accordance with the Department of the Interior Policy guidance (Order 3270) and the report *Adaptive Management, The U.S. Department of Interior Technical Guide* (Williams et al., 2007).
- Reclamation and the Corps will follow the Adaptive Management Strategy outlined in Appendix J. Prior to completing construction, a specific Adaptive Management Plan for the selected alternative will be completed.
- All constructed features will be monitored for at least 8 years in accordance with an adaptive management plan to ensure that these are operating as designed to improve fish passage and reduce entrainment.

### Air Quality

- Dust suppression techniques, such as sprinkling problem sites with water, will be used during construction activities.

### Geomorphology

- River morphology will be monitored to assess changes to the stream channel resulting from construction of the selected alternative. The ERT will be consulted regarding specific measures to mitigate impacts if substantive changes are determined to have been caused by the Intake Project.

### Surface Water Quality

- A water quality monitoring program will be established for ensuring that water quality standards are not violated during construction activities.
- Equipment for handling and conveying materials during construction shall be operated to prevent dumping or spilling the materials into wetlands and waterways.
- Discharges of dredge or fill material into waters of the U.S. will be carried out in compliance with provisions of Section 404 of the Clean Water Act, the permit

requirements of the Corps, and requirements contained in the Section 401 water quality certification issued by the Montana Department of Environmental Quality.

- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness, particularly after storm events, and the most effective techniques will be used.
- Silt barriers, fabric mats, or other effective means will be placed on slopes or other eroding areas where necessary to reduce sediment runoff into stream channels and wetlands until vegetation is re-established. This will be accomplished either before or as soon as practical after disturbance activities.
- Contamination of water at construction sites from spills of fuel, lubricants, and chemicals would be prevented by following safe storage and handling procedures in accordance with state laws and regulations.
- Hazardous materials will be handled and disposed of in accordance with a hazardous waste plan.
- Contractor will be required to have an approved construction storm water management plan to control runoff.

## Aquatic Communities

### *General*

- All work in the river will be performed in a manner to minimize increased suspended solids and turbidity, which may degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed by construction will be seeded with native vegetation to minimize erosion.
- All contractors will be required to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread on Aquatic Nuisance Species.

### *Fish*

- To avoid potential impacts, cofferdam construction and in-stream heavy equipment activity will be coordinated with fishery experts from the Service, Montana Fish, Wildlife & Parks (MFWP), Reclamation and the Corps to avoid and or minimize potential impacts.
- All pumps will have intakes screened with no greater than ¼-inch mesh when dewatering cofferdam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of juvenile or adult fish occupying these areas. Fish will be removed by methods approved by the Service and MFWP prior to final dewatering.
- Reclamation will consult with MFWP to ensure that flows comparable to environmental baseline are maintained during construction to support the fishery during low-flow periods (late summer/early autumn).

## Federally-Listed Species and State Species of Special Concern

### *Whooping Crane*

- Reclamation will monitor the Service's whooping crane sighting reports to ensure that whooping cranes are not in the Intake Project area during construction. If any are sighted within the Intake Project area, Reclamation will consult with the Service regarding appropriate actions.

### *Interior Least Tern*

- Visual surveys will be conducted weekly from May 15 to August 15 at all potential least tern nesting areas (sparsely vegetated sandbars) within line of site of the construction area.
- All surface-disturbing and construction activities will be restricted from May 15 to August 15 within 0.25 miles or the line of site of any active interior least tern nest.

### *Pallid Sturgeon*

- A physical model will be constructed to provide additional velocity and turbulence data needed for final design.
- Reclamation and the Corps will consult with the BRT during the design of the selected alternative, including but not limited to reviewing results and making recommendations on the physical model, hydraulic modeling, and final alternative design.
- The construction activities will be monitored by a qualified fisheries biologist to avoid direct impacts to adult or juvenile pallid sturgeon. In-stream construction activities will cease if the fisheries monitor determines there is potential for direct harm or harassment of pallid sturgeon, until the potential for direct harm or harassment has passed. This will mainly be accomplished by coordination with MFWP regarding its observation of movements of radio-tagged pallid sturgeon and other monitored native fish during the construction season.
- Any in-stream construction activity will be conducted during periods most likely to minimize the potential impact to the pallid sturgeon. The months to avoid and/or minimize impacts to pallid sturgeon are June and July.

### *Species of Special Concern*

- Before every construction season, the ERT will meet with MFWP to determine procedures to minimize impacts to species of special concern. Surveys for species likely to occur in the Intake Project area may be required as some of these species could be potentially harmed by construction activities. Survey requirements will be coordinated with Montana Natural Heritage Program and MFWP prior to any construction activities. These species could require surveys: bald eagle, grasshopper sparrow, red-headed woodpecker, greater sage grouse, Sprague's pipit, Townsend's big-eared bat, nine-anther clover, pale-spiked lobelia, and silky-prairie clover.

## Lower Yellowstone Irrigation Project

Modification of the original engineering design to incorporate an additional screen and phasing construction would avoid interruptions in water deliveries to the irrigation districts during the irrigation season.

- If the Rock Ramp Alternative is selected, construction of the north half of the concrete weir and rock ramp will start after completing the headworks and canal extension to continue diversion of flows for uninterrupted operation of the irrigation districts.

## Recreation

- In order to minimize impacts to recreationists, the construction contractor will implement dust abatement activities on all dirt or gravel roads within or leading to the construction zone, on both sides of the river.
- To allow access to recreation areas, the construction contractor will grade, on an as needed basis, all dirt or gravel roads within or leading to the construction zone, on both sides of the river, except in areas with historic properties.
- The construction contractor will use “flaggers” during periods of time when large volumes of vehicles cross the entrance road to the campground and picnic/day use area.
- The construction contractor, Reclamation, and the MFWP will meet to evaluate and coordinate closures at the fishing access site (FAS) and Joe’s Island to recreational use, including closure of construction zones to swimming, fishing, boating, hiking, camping, hunting, etc. within or on both sides of the river.
- The construction contractor, Reclamation, and the MFWP will identify a “portage” route around or through the construction zone to allow boaters to hand-carry or drag their boats past the construction zone.
- The construction contractor will clearly post and sign any areas within any designated construction zones. Signs will include warnings limiting or prohibiting certain recreational uses within the zone, such as swimming, fishing, boating, hiking, camping, etc. Signs will be posted upstream and downstream of the Intake Diversion Dam to warn boaters of construction activity.
- The MFWP will designate access corridors through the existing Intake FAS campground and picnic/day use area that could be used to access the river by foot or to launch boats under “primitive” conditions.
- To the extent possible, construction activities will cease during the paddlefish season or until the paddlefish season is closed at Intake FAS.

For the Rock Ramp Alternative, Reclamation and the MFWP will evaluate and the Corps will construct either:

- a new boat ramp at the existing Intake FAS, or
- a new boat ramp immediately adjacent to the existing Intake FAS, or
- a new boat ramp at a site near the existing Intake FAS on the west side of the Yellowstone River and accessible by Highway 16.

Reclamation and the MFWP will develop a public notification plan to include:

- Signs on the road leading to the FAS or Joe’s Island advising the public of closures or restrictions

- Signs indicating the location of other recreation sites including campgrounds, picnic/day use areas and boat ramps

## Lands and Vegetation

### *General*

- The ERT will play a role in oversight of actions to minimize effects for land and vegetation.
- Before every construction season, Reclamation and Corps will meet with the Service and the appropriate state wildlife agencies to determine a procedure to minimize impacts to lands and vegetation. A reconnaissance survey of construction easements will be conducted to identify and verify wetlands, grasslands, woodlands, and riparian areas subject to disturbance and/or destruction in the Intake Project area during construction activities. The ERT will be consulted, as necessary, to determine appropriate avoidance and/or protection measures. If adverse impacts cannot be avoided, appropriate procedures and requirements for minimizing or mitigating effects will be discussed with the ERT.
- Disturbance of vegetation will be minimized through construction site management (e.g., using previously disturbed areas and existing easements when feasible and designating limited equipment/materials storage yards and staging areas). It will be limited to that which is absolutely necessary for construction of the Intake Project.
- All contractors will be required to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread on Aquatic Nuisance Species.
- All areas disturbed or newly created by the construction activity will be seeded with vegetation indigenous to the area for protection against subsequent erosion and noxious weed establishment.
- All equipment tracks and tires working on Joe's Island or other noxious weed infested areas will be cleaned daily to reduce potential transportation to an uninfested site.
- An integrated weed plan will be developed and approved by the ERT. It will identify best management practices to control the spread or introduction of any noxious weeds or plants. The weed plan will be implemented during and subsequent to construction.
- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness and only effective techniques will be used.
- No permanent or temporary structures will be located in any floodplain, riparian area, wetland or stream that would interfere with floodwater movement, except for those described in chapter two of the Intake Final EA.

### Wetlands

- Prior to beginning construction through Conservation Reserve Program lands or program wetlands, the Natural Resources Conservation Service, Consolidated Farm Services Agency, and respective landowners will be consulted to ensure that landowner eligibility in farm subsidy programs (if applicable) will not be jeopardized and that Sodbuster or Swampbuster requirements will not be violated by construction.
- Waste material, topsoil, equipment, debris, excavated material, or other construction related materials will not be disposed of within 50 feet of any wetland, drainage channel, irrigation ditch, stream or other aquatic systems.

- Topsoil from the existing high water side channel should be stockpiled and placed along the banks of the new bypass channel in areas that would be temporarily to seasonally inundated.
- Discharges of fill material associated with unavoidable crossings of wetlands or intermittent streams will be carried out in compliance with provisions of Sections 401 and 404 of the Clean Water Act and the nationwide and/or Intake Project-specific permit requirements of the Corps.
- Rock quarry materials will come from sites with no potential to impact wetlands or other protected resources.
- The ERT will play a role in oversight of actions to ensure compliance with Sections 401 and 404 of the Clean Water Act and will recommend actions to minimize effects to wetlands.

**Grasslands**

- Grasslands temporarily affected during construction will be restored with similar native species. Where existing native grasslands cannot be re-seeded in their current location, procedures for appropriate restoration will be reviewed by the ERT.Disturbed native grassland will be reseeded with native species with the seed mix being determined by the ERT. Planted grassland will be reseeded with a seed mixture appropriate for the site and watered, if necessary, until establishment. Reseeding may require mulching in order to be successful.
- Seed would be certified as cheatgrass and weed free and “blue tag;” this is especially important in areas where weedy or invasive species are already present. There are no seed lots that are s free of all weeds; however, requests can be made to specify the type of weed that you would like excluded. The seed company will provide a letter of certification for the seed that would list any noxious weeds or other weed seeds in the lot of seed being provided. This information comes directly from the seed test analysis provided by certified seed testing labs. The seed used on the site can be guaranteed to be cheatgrass free. It is recommended that the seed be tested independently, if necessary, to verify that there are no cheatgrass or noxious weed seeds present.
- Two methods of seeding should be utilized for reclamation areas. Seeds will either be drilled or broadcast based on the species being planted. Drill seeding is recommended for most grasses and large-seeded shrubs and forbs that need to be planted at least ¼ inch deep. Drill seeding is preferred for soil to seed contact, positive depth control, proper seeding rate (once calibrated), and minimum amount of seed usage. Broadcast seeding is recommended for very small and fluffy seeds that need to be planted 1/16 to 1/8 inches deep. Modern range drills may be capable of drill and broadcast seeding.
- Areas requiring re-vegetation will be seeded and mulched during the first appropriate season after redistribution of topsoil. If reseeding cannot be accomplished within 10 days of topsoil replacement, erosion control measures will be implemented to limit soil loss. Local native grass species would be used (mixture to be reviewed by the ERT).
- Seeding should take place the first appropriate season following topsoil replacement. Seeding between October 15 and April 15 is the most effective throughout Montana because late winter/early spring is the most reliable period for moist soil conditions. In general, fall seeding (between October 15 and when the frost line is deeper than four to

six inches) in eastern Montana has been more successful than spring seeding. Some seed may require cold stratification to germinate. However, spring seeding may be considered if timing of construction warrants.

- To reduce erosion, water bars will be installed at specified intervals, depending upon soil type, grade, and terrain on disturbed slopes with grades of 6% or greater.
- Vegetation and soil removal will be accomplished in a manner that will prevent erosion and sedimentation.
- Noxious weeds will be controlled, as specified under state law, within the construction footprint during and following construction. Herbicides will be applied in accordance with labeled instructions and state, federal, and local regulations.
- Grass seeding will be monitored for at least three years. Where grasses do not become adequately established, areas will be reseeded with appropriate species.

### Woodlands and Riparian Areas

- No disposal of waste material, topsoil, equipment, debris, excavated material, or other construction related materials will be done within 50 feet of any riparian area.
- Woodland and riparian areas will be avoided where practical when constructing permanent facilities.
- Woodland and riparian areas impacted by the Intake Project will be restored 2:1 with native species. Where existing woodland and riparian areas cannot be restored in original locations, then off-site mitigation will be considered by the ERT.
- Native trees and shrubs will be replaced with similar native species at a ratio of two trees or shrubs planted for each tree or shrub removed. Long-term success of plantings will be reviewed and approved by the Environmental Review Team.
- Weed growth in tree plantings will be controlled, and tree plantings will be monitored for at least three years. Where plantings are not successful, they will be replanted with appropriate species.
- Where practicable, replanted riparian areas will be watered to ensure survival of planted vegetation. Long-term success of plantings will be reviewed and approved by the ERT.

## Wildlife

### Mammals and Migratory Birds

- Before each construction season, the ERT will meet with FWP to determine procedures for avoiding and minimizing impacts to nesting or migrating birds.
- Areas potentially hazardous to wildlife will be adequately protected (e.g., fenced, netted) to prevent access to wildlife.
- To protect wildlife and their habitats, Intake Project-related travel will be restricted to existing roads and Intake Project easements. No off-road travel will be allowed, except when approved through the ERT.
- Wildlife-proof fencing will be used on reclaimed areas, if it is determined that wildlife species and/or livestock are impeding successful vegetation establishment.
- A migratory bird management plan will be developed in cooperation with the Service and MFWP to minimize potential impacts to breeding birds during construction activities.

### Amphibian and Reptiles

- All riverbank disturbance areas will be inventoried for potential turtle nesting habitat. If turtle nesting habitat or evidence of turtle nesting is found in construction areas, construction in these areas will be restricted during June and July, or mitigation measures approved by the ERT will be implemented.

## Historic Properties

Reclamation proposes to implement the following actions to offset any adverse effects to historic properties:

- Engineering drawings and photographs of affected buildings and structures, if available, will be filed with the State Historic Preservation Office (SHPO) and the National Archives.
- If engineering drawings and photographs are not available, the buildings and structures will be recorded in accordance with the Historic American Buildings Survey and the Historic American Engineering Record, as appropriate.
- If practicable, historic buildings or structures that must be moved for construction will be returned to their original locations after construction of the Intake Project is completed. If that is not feasible, Reclamation will seek a party willing and able to adopt the historic structure or building with appropriate preservation covenants.
- Reclamation will develop and implement a data recovery plan in consultation with the Montana SHPO, Advisory Council on Historic Preservation, and other interested parties, as appropriate, for mitigation of the Headworks Camp (24DW447).
- One or more signs will be installed at or near the Intake FAS to summarize the history of the Lower Yellowstone Irrigation Project.
- A fence will be installed around the Old Cameron and Brailey Sub-Camp (24DW298) to protect it from disturbance by unloading and storage of rock or other construction activities.
- All construction activities will avoid using the road through the late plains archaic campsite (24DW430).
- All gravel, fill, and rock materials will be obtained from a source approved by Reclamation to ensure compliance with Section 106 of the NHPA.
- Reclamation will continue consultation with the Montana State Historic Preservation Office on the preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan.

## Indian Trust Assets

- Reclamation will continue to consult with the Bureau of Indian Affairs and tribes to identify potential Indian trust assets and any adverse effects to them.

# Draft Lower Yellowstone Project Monitoring and Adaptive Management Plan

Intake Diversion Dam Modification, Lower Yellowstone Project

U.S. Bureau of Reclamation
and
U.S. Army Corps of Engineers

December, 2013

# Introduction

The proposed Intake Dam modifications described in the action alternatives in the supplemental EA are based on the best available scientific information. Nonetheless, uncertainty exists regarding assumptions about biological response to the alternatives and the relative effectiveness of the alternatives for improving fish passage and minimizing entrainment.

The purpose of this draft monitoring and adaptive management plan (Plan) is to validate assumptions and address project uncertainties through monitoring of physical and biological responses to management actions, assessment of progress towards project objectives, and implementation of potential adjustments to achieve and maintain project performance.

To maximize project success, this draft Plan is intended to evolve as designs are refined, additional information is gathered, and the project is implemented. Information in this draft Plan is preliminary and subject to considerable change as the process moves forward. A final Plan would likely not be developed until after construction is completed.

Adaptive management is a decision-making process that provides for implementing management actions in the face of uncertainty. The purpose of this Plan is to define objectives, metrics, and targets for proposed management actions and potential adjustments that may be warranted based on monitoring. This Plan 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 Project and Intake Dam modifications. The Plan is focused on improving passage at Intake and minimizing canal entrainment to avoid jeopardizing the continued existence of pallid sturgeon.

## *Background*

Construction of the Lower Yellowstone Project began in 1905 under the Reclamation Act of 1902. The Intake Diversion Dam is a 12-foot high wood and stone structure that spans the Yellowstone River and raises the water level for diversion of water into the main canal. Intake Diversion Dam has impeded upstream migration of pallid sturgeon and other native fish for more than 100 years.

The Bureau of Reclamation (Reclamation) and the Corps of Engineers (Corps) need to comply with the Endangered Species Act (ESA) for different regulatory reasons. Reclamation must complete consultation under Section 7(a)(2) for operation of the Lower Yellowstone Project. If Reclamation does not successfully complete consultation, then the ability to operate the diversion and headworks to deliver water could be severely constrained or limited in the future. Reclamation has contractual obligations to deliver water needed to continue effective operation of the Lower Yellowstone Project.

The Corps needs to comply with the 2003 Missouri River Amended Biological Opinion, as amended by letters on October 23, 2009, April 7, 2010, and February 6, 2013. Fish passage and minimization of entrainment at Intake are now requirements under the amended biological opinion. Section 3109 of the 2007 Water Resources Development Act authorizes the Corps to use funding from the Missouri River Recovery and Mitigation Program to assist Reclamation with compliance with federal laws, design, and construction of modifications to the Lower Yellowstone Project for the purpose of ecosystem restoration.

# *Project Features*

The supplemental EA describes two action alternatives – the Bypass Channel and Rock Ramp alternatives – in addition to the No Action Alternative.

**Bypass Channel**

The Bypass Channel Alternative is intended to improve fish passage with a long, low-gradient channel around the diversion dam. A new headworks structure with rotating drum screens has been constructed to control diversion of water into the canal and minimize fish entrainment. The effectiveness of these features will be monitored, and if needed, modifications will be in an effort to achieve project objectives. Figure 1, provided below, depicts the locations of major project features. The following is a summary of the major project features.

1. Bypass channel – the bypass channel would be excavated from the inlet of the existing high flow channel to just downstream of the existing diversion dam. The proposed bypass channel alignment is approximately 15,500 feet long at a slope of 0.0006 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 15% of the total flow of the Yellowstone River.
2. Upstream control structure – a riprap/concrete sill control structure designed to control discharge into, and stabilize the entrance to, the bypass channel would be situated on the upstream end of the channel.
3. High flow channel diversion – a channel diversion would be constructed in the existing high flow channel to keep most flows in the proposed bypass channel. The channel diversion would have multiple discharge elevations and would be designed to overtop during larger events.
4. Riprap at bends for lateral stability – bank riprap is proposed at two outside bends to minimize the risk of losing the bypass channel planform.
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. Downstream lateral stability structure – riprap bank stabilization would be constructed on the right bank of the bypass channel to prevent downstream migration of the downstream end of the bypass channel.

8. New diversion weir – to maintain irrigation and by-pass channel diversion capabilities. The new weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities.
9. 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.

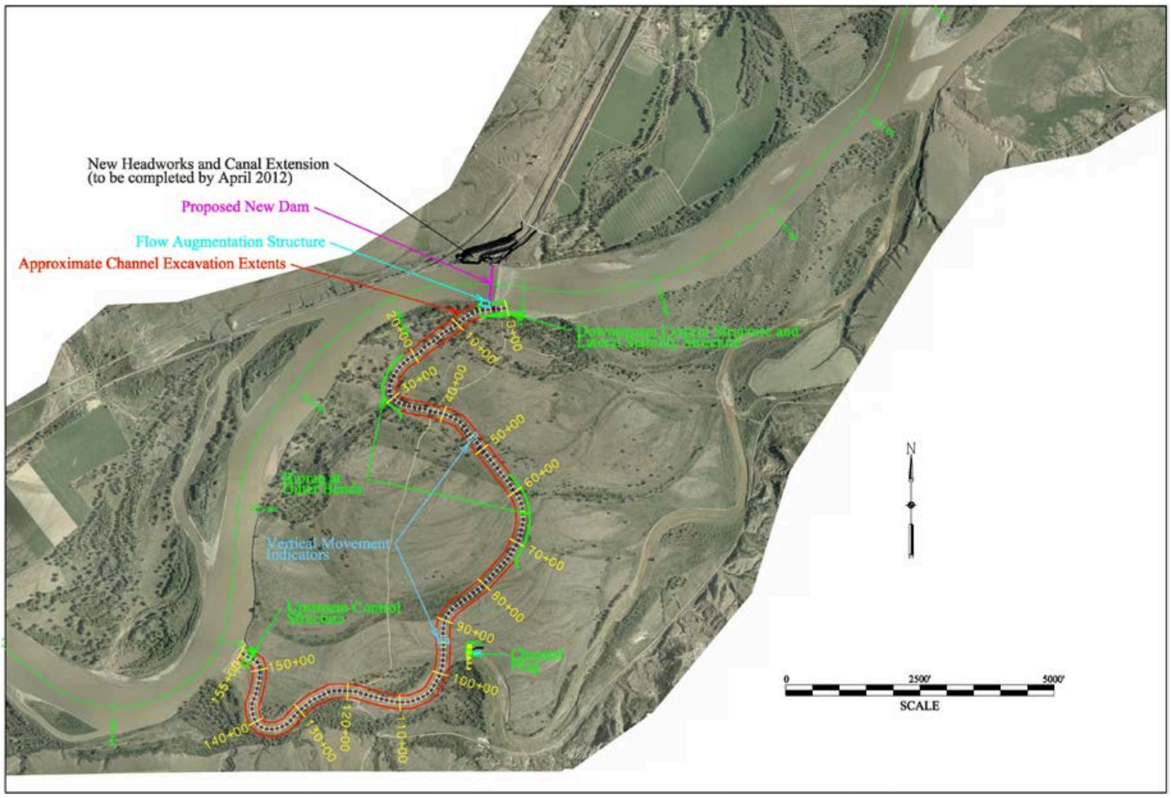



**Figure 1: Location of Proposed Project Features**

## Rock Ramp

The Rock Ramp Alternative is intended to improve fish passage with a shallow-sloped, un-grouted boulder and cobble rock ramp. The rock ramp would be designed to mimic natural river function and would provide lower velocities and turbulence so migrating fish could pass over the dam improving fish passage and contributing to ecosystem restoration. A new headworks structure with rotating drum screens has been constructed to control diversion of water into the canal and minimize fish entrainment. The effectiveness of these features will be monitored, and if needed, modifications will be made in an effort to achieve project objectives. The following is a summary of the major project features.

1. New diversion weir – to maintain irrigation and provide structural stability of the rock ramp a new diversion weir is proposed. The replacement concrete weir would be located downstream of the new headworks to create sufficient water surface elevations to divert 1,374 cfs into the main canal. The concrete weir

would be constructed as a cast-in-place reinforced concrete wedge spanning the Yellowstone River. The upstream, sloping face of the concrete weir would be designed to withstand damage from ice moving up and over the ramp. The historic headworks has been preserved in place and would serve as a weir abutment on the north bank of the river. A new concrete weir abutment would be constructed on the south bank. It would anchor into adjacent ground.

2. Weir Crest – The weir crest would vary in elevation and include at least one low-flow channel for fish passage. The variable crest would offer depth-velocity habitat zones for fish migration under the wide range of flows typical on the lower Yellowstone River. The channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1 - 2 feet deep. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded passage as fish migrate upstream.

# Project Uncertainties

There are uncertainties related to the design and performance of the proposed action alternatives that could affect their ability to meet stated goals and objectives. Uncertainties associated with each alternative are presented below.

**Bypass Channel**

1. How will native fish react to complex flow patterns and turbulence associated with the bypass channel?
2. Will the bypass channel produce the desired velocity, depth, and width?
3. Can the bypass channel be maintained to produce the expected velocity, depth and width?
4. Will the screened headworks minimize entrainment of pallid sturgeon greater than 40 mm in total length?

**Rock Ramp**

1. Will native fish successfully navigate the rock ramp to migrate upstream?
2. Will the ramp design, including crest depth, velocity, and degree of turbulencepermit the passage of native species?
3. How will the ramp hold up to ice conditions?
4. How will boulders that are scoured out be replaced?
5. Will the screened headworks prevent entrainment of pallid sturgeon greater than 40 mm in total length?

# Goals and Objectives

The goals of this plan are to ensure that modifications to Intake Dam and canal headworks improve passage for native species and minimize entrainment into the main canal, and contribute to lower Yellowstone River ecosystem restoration.

In 2013, the Fish and Wildlife Service (Service) amended the Corps' 2003 Amended Fort Peck Dam – Intake Montana River Restoration Biological Opinion Reasonable and Prudent Alternative (RPA) element. The amended RPA requires fish passage construction that meets "hydraulic and physical conditions for fish passage…established collaboratively by the projects interagency Biological Review Team." The amended RPA states that meeting the "hydraulic and physical conditions for fish passage" constitutes successful performance. Reclamation presumes that ESA consultation on operation and maintenance of the Lower Yellowstone Irrigation Project with the Service would result in comparable criteria requirements for successful operation and maintenance of the fish passage structure.

Fish passage and entrainment will be monitored, and project features will be modified through adaptive management as needed to meet the following compulsory (Objective 1 and 2 based on existing and anticipated ESA consultation) and validation (Objective 3) objectives:

**Objective 1**: Achieve the desired hydraulic and physical parameters believed to improve fish passage based on the best available scientific information (i.e., BRT Criteria).

*Performance Metric:* Bypass channel velocity and depth

*Measurement:* Achieve and maintain designed hydraulic and physical parameters of the bypass channel/rock ramp:

- ☐ Depth – Depth would be measured using Acoustic Doppler Current Profiler (ADCP) data
- ☐ Width – ADCP data and physical measurements
- ☐ Channel Velocity – ADCP data
- ☐ Entrance Velocity – ADCP data
- ☐ Discharge – ADCP data

*Target:*

- ☐ Depth – Minimum cross-sectional depth at 95% exceedance flow (7,000 cfs) at any sampled cross-section: 3.28 ft (1.0 meter)
- ☐ Width – Target top-widths vary from 130-250 feet depending on location
- ☐ Channel Velocity – Bypass channel cross-sectional mean column velocity at any sampled cross-section: Minimum 2.4 fps (.73 m/s); maximum 6.0 fps (1.8 m/s)
- ☐ Entrance Velocity – Attraction flows at fish entrance: 3 fps (0.91 m/s)
- ☐ Discharge – Target numbers vary and correspond to design percent diversion. Design percent diversion varies from 15% to 23% depending on total flow and inclusion of flow augmentation structure flows.

**Objective 2**: Minimize entrainment of pallid sturgeon > 40 mm through the intake structure.

*Performance Metric:* Entrainment rates of pallid sturgeon > 40 mm

*Measurement:* Annual sampling would quantify entrainment of pallid sturgeon > 40 mm. Entrainment nets will be placed directly behind the headworks to monitor fish being entrained through the screens. Some larval work will also be conducted from the bridge just downstream from the headworks.

*Target:* Document entrainment of pallid sturgeon > 40 mm has been minimized over a five-year period following construction.

**Objective 3**: Maintain or improve the ability of native fish migration upstream and downstream of Intake Diversion Dam; improve ability of pallid sturgeon to migrate upstream and downstream of Intake Diversion Dam.

*Performance Metrics:* Document movement of native fish upstream and downstream of Intake Diversion Dam.

*Measurement:* Tracking radio-telemetered native fish tagged below Intake. Monitoring will involve tracking fish moving both upstream and downstream past Intake.

Once fish have moved into the area of Intake, DIDSON (Dual-frequency IDentification SONar) cameras will be used to determine behavior once they encounter the passage alternative, particularly species' ability to overcome complex flow patterns and, in the case of the Bypass Channel Alternative, enter the downstream entrance of the bypass channel.

*Target:* Document movement of native fish from below Intake Diversion Dam to upstream of the dam over a period of five years following construction at rates equivalent to pre-construction passage; improve pallid sturgeon movement from below Intake Diversion Dam to upstream of Intake Diversion Dam.

# Adaptive Management Strategy

Based upon hydraulic and physical modeling, expected velocities and depths should improve upstream and downstream passage of pallid sturgeon and other native fish over a wide range of flows and screening should minimize entrainment. However, actual performance will not be known until construction is complete. Because of these uncertainties, an adaptive management approach will be used to monitor and, as necessary, adjust operation or physical configuration of the bypass channel or rock ramp and screens to achieve project objectives.

## Monitoring

The bypass channel, rock ramp, and fish screens were designed to meet pallid sturgeon hydraulic and physical requirements. For example, the design criterion for water velocity was based in part on laboratory studies of pallid sturgeon swimming ability, and the screen design was based on NOAA-Fisheries criteria that appear appropriate for pallid sturgeon based on laboratory studies. Nonetheless, uncertainty remains whether the bypass channel, rock ramp, and/or fish screen will meet their design criteria and whether pallid sturgeon and other native fish will react as predicted. Therefore, a monitoring program would be established to assess whether pallid sturgeon and other native fish passage and entrainment objectives are being met.

### Hydraulic and Physical Characteristics Objectives

#### *Methods*

Monitoring equipment will be installed at various locations for hydraulic and physical criteria monitoring. Hydraulic properties, including water depth, channel velocity, entrance velocity, discharge and turbulence will be measured over a range of discharges using ADCP data to ensure the constructed project is achieving design criteria.

- Depth, width, velocity, and discharge would be measured using ADCP at a cost of approximately $30,000/year for five years.

#### *Success Criteria*

Within five years after completion of the fish passage and entrainment projects at Intake Dam:

- Document whether depths, widths, channel velocities, entrance velocities, discharge, and turbulence improve passage of pallid sturgeon.

### Pallid Sturgeon Entrainment Objective

#### *Methods*

Instrumentation will be installed on the screens to measure approach velocity. Larval sampling would be used to quantify entrainment of larval fish > 40 mm either directly behind the new headworks screen structures or just down-canal. Baseline monitoring has been conducted to determine larval entrainment prior to screening, and post-construction monitoring would be compared to this baseline to indicate the reduction of larval entrainment afforded by the screens as well as assuring that the success criterion for larval sturgeon is met. Larval sturgeon (*Scaphirynchus* spp.) > 40 mm sampled in the canal would need to be genetically analyzed to determine species.

- Cost Estimate: $150,000 per year (includes genetic testing if needed), for five years.

***Success Criteria***
Within five years after completion of the fish passage and entrainment projects at Intake Dam:

- Document whether adult and stocked juvenile pallid sturgeon > 40 mm can pass downstream of Intake Dam without being entrained into the irrigation canal.

**<u>Native Fish Passage Objective</u>**

***Methods***
The ability of native fish, including pallid sturgeon, to migrate upstream and downstream will be assessed by tracking radio-telemetered by land based radio telemetry stations along the selected passage alternative.

- Montana FWP Cost Estimate: $250,000 per year, for five years

The physical mechanisms and behaviors by which pallid sturgeon (and other native fish) move up and down through the selected passage alternative would be observed visually using DIDSON cameras. The DIDSON cameras would be deployed over a two- to four-week period during upstream migration indicated by the radio-telemetry study. Once radio-telemetered fish were located near Intake, these fish would be targeted with the DIDSON. This technique would also help provide insight to the construction success of the fish passage structure and could be used to diagnose and improve areas of ineffective passage.

- TSC Cost Estimate: $100,000 per year, for five years

***Success Criteria***
Within five years after completion of the fish passage and entrainment projects at Intake Dam:

- Document whether pre-construction levels of native fish passage are occurring at Intake Diversion Dam.
- Document improvement in pallid sturgeon passage at Intake Diversion Dam.

## Potential Adaptive Management (AM) Measures

Data from hydraulic monitors would be evaluated and compared with monitoring of fish movement and modifications would be proposed to reduce hydraulic constraints. Potential AM measures for each alternative include but are not limited to the following (Table J-1):

**<u>Bypass Channel</u>**

1. Flow Augmentation Structure – Construct and use the flow augmentation structure to increase attractive flow. Flow could be increased to as much as 23% of the main channel flow (during peak spring runoff season). Investigations into this structure are still ongoing. It has not been determined if this structure will be needed in the initial design or if it will be an AM measure.

2. Physical Changes – Modification as needed to the upstream control structures, vertical control structures, lateral stability structures, and downstream structure to address potential depth, velocity, and width issues.
3. Existing High Flow Channel Diversion – Modifications as needed to the channel diversion blocking flows from the existing high flow channel. At this time it is not known how much passage the existing high flow channel provides. If pallid sturgeon are found to use the existing high flow channel, the channel diversion will have to be changed to allow for fish passage. This could include lowering the diversion elevation or turning the diversion into a rock ramp design.
4. Bypass Channel Entrance – Modifications as needed to the channel entrance to allow for adequate attraction flows, alleviate sheer flows and minimize eddy formation near the channel entrance.
5. Intake Diversion Weir Revisions – Modification to the diversion weir as needed to improve passage for other native fish species that may be impacted by the proposed project.

**Rock Ramp**

1. Physical Changes – If native fish do not pass the rock ramp, physical and hydraulic parameters may need to be addressed.
2. Physical Changes to the Yellowstone River Channel – Modification as needed to main channel training structures and debris field adjustments.
3. Intake Diversion Weir Revisions – Modification to the diversion weir as needed to improve passage for other native fish species that may be impacted by the proposed project.

Implementation of the above measures would be based on results of hydraulic and physical monitoring including: depth, velocity, and width; and observation of native fish migration upstream and downstream of Intake Diversion Dam.

### Entrainment

If fish > 40 mm continue to be entrained after the screens are installed, modifications or O&M repairs would be made as needed. Currently, there are no proposed AM measures related to the entrainment objective. O&M activities would ensure that the screens continue to function as designed.

## Adaptive Management/Long-term Operations and Maintenance

Reclamation believes adaptive management and long-term O&M are two intricate pieces to the long-term success of the project. Items that are not outlined in the adaptive management measures are assumed to be long-term O&M.

**Table J-1. Potential AM measures**

| | Proposed Funding Agency | Proposed Agency Conducting Work | Estimated Annual Cost (if applicable) | Estimated Cost |
|---|---|---|---|---|
| **Monitoring** | | | | |
| Depth, width, velocity, and discharge measured using ADCP | Corps (1st year) and Reclamation | TSC | $30,000 per year for five years | $150,000 |
| Tracking radio-telemetered fish to validate passage | To Be Determined[1] | MFWP & TSC & MSU | $250,000 per year for five years | $1,250,000 |
| Dual Frequency Identification Sonar (DIDSON) to observe physical mechanisms and behaviors by which native fish and pallid sturgeon migrate through the channel or over ramp | To Be Determined[1] | TSC | $100,000 per year for five years | $500,000 |
| Monitoring pallid sturgeon entrainment | Reclamation | TSC | $150,000 per year for five years | $750,000 |
| *Total Estimated Monitoring Costs* | | | | *$2,650,000* |
| **Potential Adaptive Management Measures** | | | | |
| Bypass Channel - Construction of flow augmentation structure to increase attractive flows in the bypass channel | To Be Determined[1] | Reclamation | NA | $4,012,147 |
| Bypass Channel - Bypass channel structure modifications for hydraulic and physical success – Modification as needed to the channel diversion, lateral stability structures, vertical control structures, upstream and downstream control structures (assumed rearranging of 1,000 cubic yards of material over 5 years) | Corps During One Year Warranty; To Be Determined in Subsequent Years[1] | Corps (1st year) and Reclamation | $25,560 per year for five years | $127,800 |
| Bypass Channel - Physical Changes to Yellowstone River channel for hydraulic and physical success – Modification as needed to the main channel training structure and debris field adjustments (assumed rearranging of 10,000 cubic yards of material over 5 years) | Corps During One Year Warranty; To Be Determined in Subsequent Years[1] | Reclamation | $67,963 per year for five years | $339,815 |
| Bypass Channel/Rock Ramp - Intake Diversion Weir Revisions to improve passage for native fish species | To Be Determined[1] | Reclamation | NA | $256,075 |
| Rock Ramp – Physical modifications to the rock ramp as needed to achieve hydraulic and physical success criteria | Corps During One Year Warranty; To Be Determined in Subsequent Years[1] | Corps (1st year) and Reclamation | NA | $2,000,000 |

[1]Reclamation, the State of Montana, and the Lower Yellowstone Irrigation Project intend to work cooperatively to identify funding sources for this measure.

## *Assessment and Implementation of Adaptive Management*

Assessment of the selected passage alternative will be conducted by Reclamation. Reclamation will review data from monitoring physical parameters. It will be Reclamation's responsibility to determine whether or not the passage alternative is meeting the physical parameters established in this document and provide recommendations to remedy potential problems.

## 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.

## Decision-making

The Montana Area Office Area Manager will be the decision maker for the Lower Yellowstone Project Adaptive Management Program.

## Data Management and Project Closeout Plan

The monitoring and assessment activities identified in the Adaptive Management Plan will continue for five years following completion of construction of the bypass channel or rock ramp. The program or elements of the program may be terminated early through a decision by Reclamation if success has been clearly demonstrated. Likewise, the program, or elements of the program may also be extended if it is determined that the project has not yet been successful.

All monitoring data will be stored electronically on a secured server maintained by MTAO and will comply with Reclamation's proposed data stewardship guidelines. All data collected by contractors will be provided to MTAO 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.

# Intake Diversion Dam Modification

# Lower Yellowstone Project

# Waters of the U.S. Delineation Report

**U.S. Army Corps of Engineers – Omaha District**

Planning, Programs and Project Management Division
Regulatory Field Support Section
Montana Regulatory Field Office

**September 2012**

## Introduction

A bypass channel to accommodate fish passage around an irrigation intake dam on the Yellowstone River is proposed to be constructed as a part of the preferred alternative outlined in the *Intake Diversion Dam Modification, Lower Yellowstone Project, Supplemental Environmental Assessment* (EA). To assess potential impacts to regulated wetlands and waterways (waters of the U.S. or WUS) a determination and delineation was completed on August 16 and 17, 2012. Three areas were evaluated for potential WUS: a waste pile site (Area 1), construction limits of the proposed bypass channel (Area 2) and a nearby quarry (Area 3). A general description of the investigation area and anticipated impacts along with a more detailed description of findings are provided below.

## Methods

Soil survey maps, topographic maps, National Wetland Inventory (NWI) maps, aerial photos and the Montana Natural Heritage maps were used to conduct a preliminary desktop investigation to locate highly probably locations of wetlands and waterways. ArcMap shapefiles of these features were loaded into a Trimble Global Positioning System (GPS). Hard copies of these maps were also taken into the field to cross-reference GPS shots to ensure the accurate recording of observations.

All three areas listed in the introduction were investigated during the site visit. Sample points were placed within areas that were identified during the desktop investigation to determine if features were WUS. Photographic stations were placed to document overall site conditions. Wetland and waterway boundaries were determined using routine methodologies and categorized according to the Cowardin Classification System (Cowardin et al., 1979). All project features were surveyed using a GPS unit and post-processed for sub-meter accuracy. A small scale delineation map is presented in Attachment 1 and a list of recorded vegetation and wetland indicator status are provided in Attachment 2.

## Area 1: Waste Pile Site

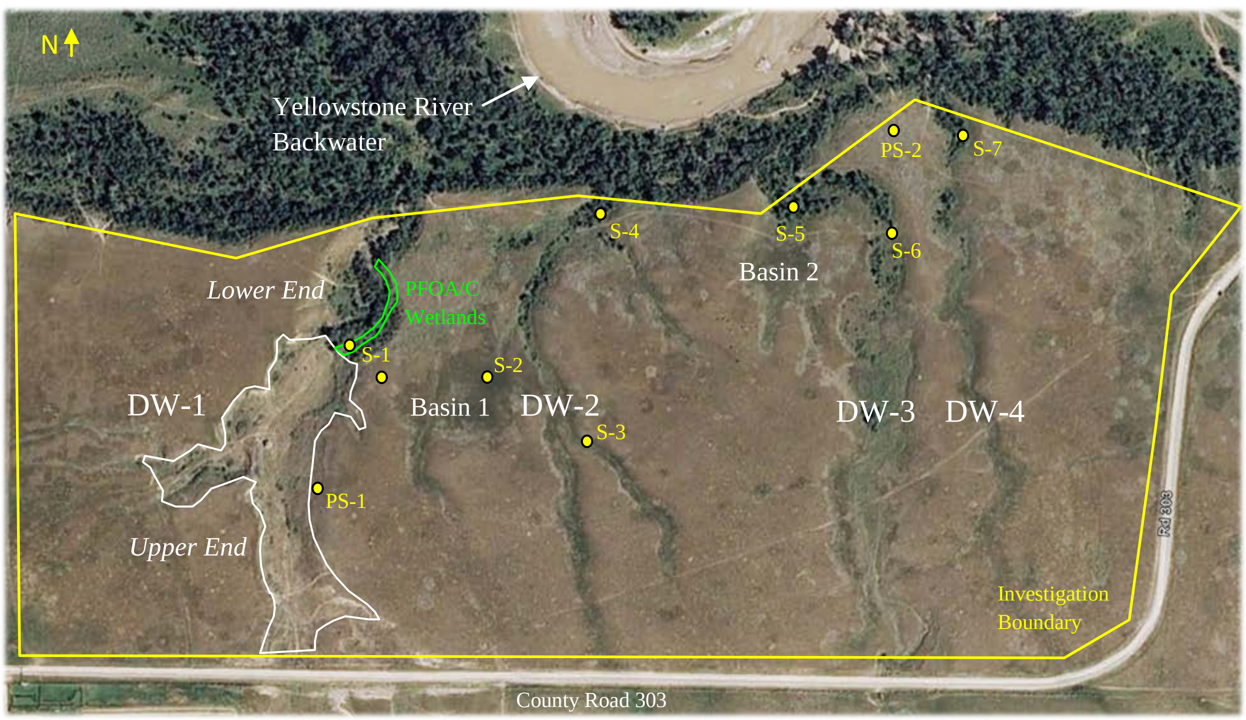



**Figure 1. Waste pile site**

Excess material from the excavation of the bypass channel would be displaced at this location. Up to 1.2 million cubic yards of material would cover 22 acres and create a 40-foot high artificial hill that would be shaped to blend in with the surrounding topography. Currently, the area is generally flat and dissected by four drainageways that convey water northerly during precipitation events until reaching a backwater of the Yellowstone River. See Figure 1 for a map identifying the investigation boundary, drainageways, photo stations, sample points and approximate wetland boundaries. See Map in Attachment 1 for the relationship of the waste pile site with other project areas.

Drainageway 1 (DW-1)

DW-1 was an incised drainageway with moderately steep banks located near the western boundary of the Waste Pile Site. A majority of DW-1 was dry at the time of investigation. DW-1 appears to drain areas south of County Road 303, collect overland flow and convey direct precipitation into the backwater of the Yellowstone River. DW-1 is described below in two sections, the upper end and the lower end. The upper end did not contain any wetlands and no evidence of an ordinary high water mark (OHWM) was present. See Photographs 1 and 2 for views of this area. Recorded upland species are listed in Table 1 below.

**Table 1. Species identified in the upper end of DW-1**

| | |
|---|---|
| *Symphoricarpos albus** (common snowberry) | *Elymus virginicus* (Virginia wildrye) |
| *Grindelia squarrosa* (curlycup gumweed) | *Euphorbia esula* (leafy spurge) |
| *Artemisia cana** (silver sagebrush) | *Bromus japonicus* (Japanese brome) |
| *Artemisia tridentata** (big sagebrush) | |

*Woody species

**Photograph 1 – View from Photo Station 1 (PS-1) facing west showing upper end of DW- (south)**


**Photograph 2 – View from west of PS-1 from within DW-1 facing upstream**

The lower end of DW-1 begins at the southern edge of a forested canopy where a seepage spring emerges from the hillside. See Photograph 3 for view of Sample point 1 (S-1), spring and wetlands (green line). The spring creates a narrow stream with gravel substrate that is approximately one- to four-inches deep and six-inches to five-feet wide. The stream flows in a northerly direction for approximately 325 feet until it dissipates and could no longer be observed. An OHWM was present near the current flow elevation.

Emergent wetlands formed a band from two inches to six feet wide around the stream. The wetlands transition to uplands where the stream dissipates. Hydrophytic trees dominate the overstory above the stream and herbaceous wetlands. Approximately 0.12 acres of Palustrine Forested Temporarily to Seasonally Flooded (PFOA/C) wetlands were surveyed at this location and are shown in green in Figure 1. See Photographs 3, 4 and 5 for views of this area. Recorded vegetation species are listed in Table 2 below.


**Photograph 3 – View of S-1 and spring within lower end of DW-1 facing southwest**

**Table 2. Species identified in the lower end of DW-1**

| | | |
|---|---|---|
| *Eleocharis* spp. (spikerush) | *Scirpus pungens* (sharp bulrush) | *Polypogon monspeliensis* (rabbitfoot polypogon) |
| *Elymus* spp. (wildrye) | *Calamagrostis canadensis* (blue-joint reedgrass) | *Ranunculus* spp. (buttercup) |
| *Juncus dudleyi* (Dudley's rush) | *Lycopus americanus* (American bugleweed) | *Eriogonum* spp. (buckwheat) |
| *Polygonum* spp. (smartweed) | *Conyza canadensis* (horseweed) | *Mentha arvensis* (wild mint) |
| *Artemisia ludoviciana* (prairie sagewort or white sagebrush) | *Trifolium* spp. (clover) | *Salix amygdaloides** (peach-leaf willow) |
| *Fraxinus pennsylvanica* (green ash) | *Ulmus Americana** (American elm) | *Populus deltoides** (Great Plains cottonwood) |
| *Juniperus* spp. (juniper) | | |

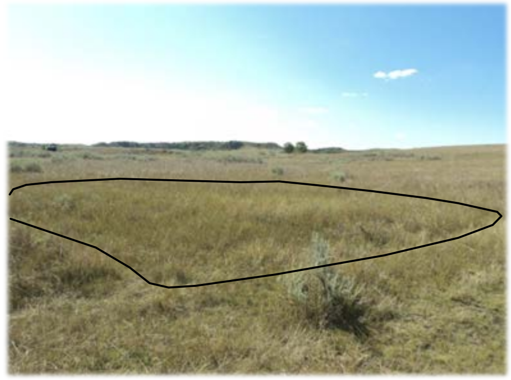
*Woody Species


**Photograph 4 – View of area where stream and wetlands transition to upland area facing southwest**

**Photograph 5 – View of upland area where stream and wetlands end facing north**

Basin 1 (B-1)

A lower flat area (B-1) between the upper ends of the banks of DW-1 and DW-2 appeared dark in a 2012 aerial photograph. Dark features on aerials may indicate wetness; therefore, a Sample point (S-2) was placed in the area to document observations. Conditions were very dry and only upland plants were identified. See Figure 1 for S-2 location and Table 3 for recorded vegetation. See Photograph 6 for a depiction of B-1 (black line).



**Photograph 6 – View from S-2 of B-1 facing north**

**Table 3. Species identified in B-1**

| | |
|---|---|
| *Agropyron cristatum* (crested wheatgrass – grazed) | *Bromus* spp. (brome) |
| *Artemisia tridentata** (big sagebrush) | *Artemisia cana** (silver sagebrush) |

*Woody species

Drainageway 2 (DW-2)

North of County Road 303 DW-2 is a grassed drainageway with gently sloping banks located near the center of the waste pile site. Near the northern boundary of the investigation area it transitions into a forested drainageway until reaching the Yellowstone River backwater. All of DW-2 was dry at the time of investigation. Similar to DW-1, DW-2 appears to drain areas south of County Road 303, collect overland flow and convey direct precipitation into the backwater of the Yellowstone River. Two Sample points (S-3 and S-4) were placed to document observations within DW-2. No hydrophytic vegetation or OHWM was present in this area. See Figure 1 for S-3 and S-4 locations and Table 4 for recorded vegetation. See Photograph 7 and 8 for depiction of DW-2.

**Table 4. Species identified in DW-2**

| | | |
|---|---|---|
| *Populus deltoides** (Great Plains cottonwood) | *Symphoricarpos albus** (common snowberry) | *Agropyron cristatum* (crested wheatgrass – grazed) |
| *Juniperus spp.* (juniper) | *Achillea spp.* (yarrow) | |

*Woody species

**Photograph 7 – View from S-3 facing northwest showing DW-2**

**Photograph 8 – View near S-4 showing DW-2 facing northwest**

Basin 2 (B-2)

A slightly lower flat area was located west of DW-3 and appeared dark in a 2012 aerial photograph. Dark features on aerials may indicate wetness; therefore, a Sample point (S-5) was placed in the area to document observations. Conditions were very dry and only upland plants were identified. See Figure 1 for S-5 location and Table 5 for recorded vegetation. See Photograph 9 for a depiction of B-2 (foreground from black line).

**Photograph 9- View from S-5 of B-2 facing south**

**Table 5. Species identified in B-2**

| | |
|---|---|
| *Agropyron cristatum* (crested wheatgrass) | *Bromus* spp. (brome) |
| *Stipa spartea* (porcupine needlegrass) | *Artemisia tridentata** (big sagebrush) |

*Woody Species

Drainageway 3 (DW-3)

DW-3 resembles DW-2. North of County Road 303 DW-3 is a grassed drainageway with gently sloping banks located in the eastern half of the waste pile site. Near the northern boundary of the investigation area it transitions into a forested drainageway until reaching the Yellowstone River Backwater. All of DW-3 was dry at the time of investigation. It appears that DW-3 would collect overland flow and convey direct precipitation into the backwater of the Yellowstone River. Sample point 6 (S-6) was placed to document observations within DW-3. No hydrophytic vegetation or OHWM was present in this area. See Figure 1 for the location of S-6 and Table 6 for recorded vegetation. See Photograph 10 and 11 for a depiction of DW-3.

**Table 6. Species observed in DW-3**

| | | |
|---|---|---|
| *Artemisia tridentata** (big sagebrush) | *Symphoricarpos albus** (common snowberry) | *Agropyron cristatum* (crested wheatgrass – grazed) |
| *Artemisia cana* (silver sagebrush) | *Achillea* spp. (yarrow) | *Acer negundo** (box-elder) |
| *Bouteloua gracilis* (blue gramma) | *Stipa spartea* (porcupine needlegrass) | |

*Woody species

**Photograph 10 - View where DW-3 transitions from grassed to forested drainageway facing north**

**Photograph 11 - View from south of S-5 facing north showing DW-3**

Drainageway 4 (DW-4)

Similar to the other drainageways, DW-4 transitions from a grassed drainageway with gently sloping banks into a forested drainageway with steeper banks that connects to a backwater of the Yellowstone River. All of DW-4 was dry at the time of investigation. It appears that DW-4 would collect overland flow and convey direct precipitation into the backwater of the Yellowstone River. Sample point 7 (S-7) was placed to document observations within DW-3. *Populus deltoides* (Great Plains cottonwood) is a facultative tree (50% likelihood of being in a wetland) but was not the dominant vegetation within DW-4. No other hydrophytic species or OHWM was present in this area. See Figure 1 for the location of S-7 and Table 7 for recorded vegetation. See Photograph 12 for a depiction of DW-3 and Photograph 13 for a view from Photo Station 2 (PS-2) showing the steep drop off east of S-7 outside of the investigation limits.

**Table 7. Species identified in DW-4**

| | | |
|---|---|---|
| *Populus deltoides** (Great Plains cottonwood) | *Symphoricarpos albus** (common snowberry) | *Juniperus spp.* (juniper) |
| *Agropyron cristatum* (crested wheatgrass – grazed) | *Achillea* spp. (yarrow) | |

*Woody species

**Photograph 12 - View showing S-7 facing northwest**

**Photograph 13 - View from PS-2 facing north showing steep drop off outside investigation area**

### Avoidance and minimization of impacts

One wetland and a spring with a waterway that did not have a continuous OHWM were identified at the Waste Pile Site. Although a continuous OHWM was not observed, these features are likely regulated WUS as they connect directly to the Yellowstone River and should be avoided as a place to dump fill material. Additionally, areas within the banks of all drainageways should be avoided to the maximum extent possible. If fill must be placed in the drainageways, it should be placed in the headwaters as these areas are the flattest and fill here would most blend in with the surrounding topography. Culvert extensions would be needed if fill were placed in drainageway headwaters near the south boundary of the waste pile site so as to not hinder drainage from areas south of County Road 330.

### Area 2 – Construction limits of the bypass channel and improved access roads on Joe's Island

Joe's Island is essentially flat with some low areas and historical meander scars dissecting the landscape. The excavation of a bypass channel would begin just east of the existing Intake Dam on the right descending bank of the Yellowstone River and would traverse southerly along a historic meander scar until reaching an existing backwater. The excavation of 1.2 million cubic yards of earthen material would be disposed of at the waste pile site (Area 1). A new access road would be constructed directly east of the proposed bypass alignment. This new road would tie into existing access roads that may need to be improved to accommodate heavy machinery traffic. More details related to construction can be found in Chapter 2 of the EA. See Figure 2 for a map identifying the investigation boundary, drainageways, photo stations, sample points and wetland approximate wetland boundaries. See Map 1 in Attachment A for the relationship of the waste pile site with other project areas.

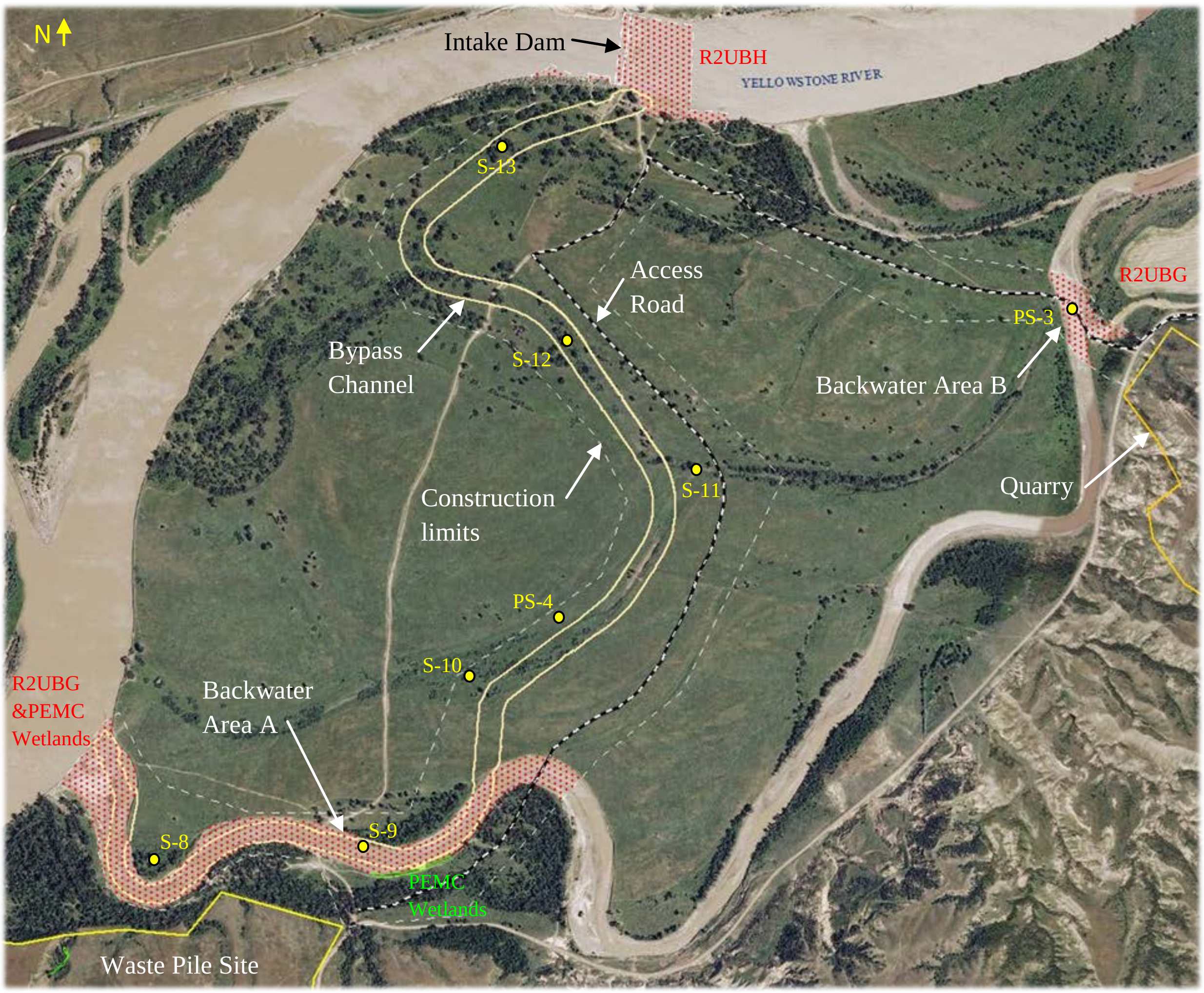



**Figure 2. Joe's Island**

Backwater areas, meander scars, NWI polygons, Montana Heritage Program habitat polygons and other areas that may have indicated wetness on aerial photographs were investigated on Joe's Island for potential wetlands or waterways.   Four major communities were observed: backwater channels containing fringe wetlands on sand and gravel bars, cottonwood gallery forests, sagebrush and crested wheatgrass shrubland community and the Yellowstone River.

<u>Backwater channels</u>

**Backwater Area A** – The NWI map classifies this area as Riverine Lower Perennial Unconsolidated Bottom Intermittently exposed (R2UBG) channel backwater.  See Figure 2 for backwater location.  The OHWM appeared to be along the banks as indicated by the yellow line in Photograph 14.  Flow was imperceptible and the backwater appeared to be stagnant at the time of the investigation.  Rock and gravel bars were present throughout the banks of the channel.  Bands of fringe wetlands lie adjacent to the channel and are represented by seasonal to semi-permanent herbaceous vegetation.  Observations recorded at Sample point 9 (S-9) are presented in Table 8.  See Photos 14 and 15 for depictions of Backwater Area A.  A narrow two- to four-foot side channel was dominated by wetland vegetation and likely conveys water during high flows and functions as a wetland swale when flows are low.  See green boundary line in Photo 16 for a view of this wetland swale.

**Photograph 14 – View of Backwater Area A from north of S-9 facing south**

The palustrine emergent seasonally flooded (PEMC) wetlands likely fluctuate in size every year based on flow through the backwater channel.  All areas have a direct connection to the Yellowstone River.  Areas within the investigation area in Backwater Area A that are R2UBG and/or PEMC wetlands measure approximately 45 acres in size and are pixilated red on Figure 2.  The side channel contained approximately 0.40 acres of PEMC wetlands and is shown in green on Figure 2.

**Table 8.  Species observed in Backwater A**

| | | |
|---|---|---|
| *Scirpus pungens* (sharp bulrush) | *Salix exigua** (sandbar willow) | *Carex* spp. (sedge) |
| *Echinochloa crusgalli* (barnyard grass) | *Equisetum* spp. (horsetail) | *Potentilla anserina* (silverweed cinquefoil) |

**Photograph 15 - View from S-9 showing Backwater Area A facing west**

**Photograph 16 – View of wetland swale from south of S-9 facing east**

**Backwater Area B –** The NWI map classifies this area as Riverine Lower Perennial Unconsolidated Bottom Intermittently Exposed (R2UBG) channel backwater. See Figure 2 for backwater location. At the time of investigation there was very little vegetation within the area where an existing road would be improved to accommodate heavy machinery traffic. No vegetative species were recorded at Sample point 14 (S-14). Flow in the backwater was imperceptible and appeared to be stagnant. Sand and gravel were present adjacent to the open water areas. Backwater Area B connects directly to the Yellowstone River and contained approximately six acres of R2UBG habitat. See Photographs 17 and 18 below for depictions of this area.

**Photograph 17 - View of Backwater Area B from Photo Station 3 (PS-3) facing southeast**

**Photograph 18- View of Backwater Area B from PS-3 facing northwest**

### Avoidance and minimization of impacts

Backwater Area A contains wetlands and a waterway while Backwater Area B consisted of a waterway without wetlands. Both areas would be considered jurisdictional waters of the U.S. Fill should be avoided from being placed in these locations to the maximum extent practicable. If temporary fill is placed into either backwater, then the site should be restored to pre-disturbance conditions when the activity is completed. If either area is excavated, it is likely similar wetlands would develop along the banks following construction.

<u>Cottonwood gallery forests</u>

Sporadic cottonwood cover was present in patches across Joe's Island. *Populus deltoides* (Great Plains cottonwood) is a facultative tree (50% likelihood of being in a wetland) but was not the dominant vegetation within this community. Cottonwoods are approximately 75 feet tall with root systems likely as deep. These root systems probably penetrate through shallow groundwater systems which allow the cottonwoods to survive in an otherwise dry area. The understory of these areas contained upland shrubs, forbs and grasses. Leaf litter from previous growing seasons was present. See Table 9 for species identified in this area. Conditions were dry at the time of investigation. Several sample plots were placed throughout Joe's Island to document this community. Sample points S-8, S-11, S-12 and S-13 are depicted in Figure 2. No wetlands or waterways with an OHWM were identified in these areas. See Photographs 19 and 20 for typical views of the cottonwood gallery forested areas.

**Table 9. Species identified in cottonwood gallery forests**

| | | |
|---|---|---|
| *Populus deltoides** (Great Plains cottonwood) | *Symphoricarpos albus** (common snowberry) | *Elaeagnus angustifolia** (Russian olive) |
| *Juniperus* spp.* (juniper) | *Shepherdia argentea** (silver buffaloberry) | *Acer negundo** (box-elder) |
| *Agropyron cristatum* (crested wheatgrass) | *Euphorbia esula* (leafy spurge) | *Ambrosia spp.* (ragweed) |
| *Grindelia squarrosa* (curlycup gumweed) | | |

*Woody species

**Photograph 19 – View of cottonwood gallery forests near S-9 facing north**

**Photograph 20 – View of cottonwood gallery forests near S-13 facing north**

## Avoidance and minimization of impacts

The removal of mature cottonwood trees along the proposed bypass channel should be avoided to the maximum extent practicable. Modifying the alignment slightly and/or incorporating the trees into the bypass channel would preserve a scarce habitat in Montana and should be given consideration during the final design.

**Photograph 21 - Typical view of sagebrush and crested wheatgrass community from PS-4 facing north**

<u>Sagebrush and crested wheatgrass shrubland</u>

A majority of Joe's Island is dominated by a sagebrush and crested wheatgrass shrubland community. Multiple species of sagebrush and buffaloberry dominate the shrub stratum while crested wheatgrass and leafy spurge dominate the herbaceous understory. Old meander scars and areas that looked dark on aerials were investigated for wetlands or waterways. See Table 10 for species recorded at Sample point 10 (S-10) for typical vegetation in this community.   Conditions were dry and no wetlands or waterways with an OHWM exist.  See Photo 21 for a typical view from Photo Station 4 (PS-4) of this community type.

**Table 10.  Species identified in sagebrush and crested wheatgrass community**

| | | |
|---|---|---|
| *Agropyron cristatum* (crested wheatgrass) | *Euphorbia esula* (leafy spurge) | *Grindelia squarrosa* (curlycup gumweed) |
| *Ambrosia spp.* (ragweed) | *Bromus japonicus* (Japanese brome) | *Pseudoroegneria spicata* (bluebunch wheatgrass) |
| *Symphoricarpos albus** (common snowberry) | *Shepherdia argentea** (silver buffaloberry) | *Artemisia tridentata** (big sagebrush) |
| *Artemisia cana** (silver sagebrush) | *Artemisia ludoviciana** (white sagebrush) | |

*Woody species

## Avoidance and minimization of impacts

The bypass channel would impact this community the most.  Due to the availability of similar habitat on Joe’s Island, the cumulative impacts to the environment would be minor.  Construction of the project would increase floodplain connectivity and increase the habitat diversity as compared to the existing monotypic habitat community.

<u>Yellowstone River</u>

The NWI map classifies this area as a Riverine Lower Perennial Unconsolidated Bottom Permanently Flooded (R2UBH) channel.  See Figure 2 for the location of the Yellowstone River.  The banks ranged from steep to gradual and contained small patches of palustrine emergent seasonally flooded (PEMC) wetlands.  The PEMC wetland acreage was estimated to be less than 0.05 acres and the area of potential disturbance to R2UBH river habitat is approximately one acre.  See Table 11 for species identified along banks of the Yellowstone River and Photograph 22 for a panoramic view of this area.

**Table 11.  Species observed along banks of the Yellowstone River**

| | | |
|---|---|---|
| *Juncus dudleyi* (Dudley’s rush) | *Equisetum* spp. (horsetail) | *Elymus* spp. (wildrye) |
| *Polygonum* spp. (smartweed) | *Grindelia squarrosa* (curly-cup gumweed | |

**Photograph 22 - View of Intake Dam from right descending bank of the Yellowstone River facing north**

## Avoidance and minimization of impacts

The Yellowstone River is a waterway with small patches of emergent wetlands along the shoreline. Both habitats would be considered jurisdictional waters of the U.S. Fill should be avoided from being placed in these locations to the maximum extent practicable. If temporary or permanent fill is placed into the river, than environmental conditions should be restored to a pre-disturbed state when the activity is completed.

**Area 3 – Quarry**

The desktop investigation indicated that this area likely did not contain wetlands or waterways. The quarry is on private land and permission was not obtained prior to the investigation, so investigators could not verify desktop findings in the field. Excavating material from here for construction on Joe's Island and the Waste Pile Site should not impact any waters of the U.S. at this site. No avoidance or minimization techniques are recommended regarding sensitive habitats for Area 3. See Figure 3 for an aerial view of this location.

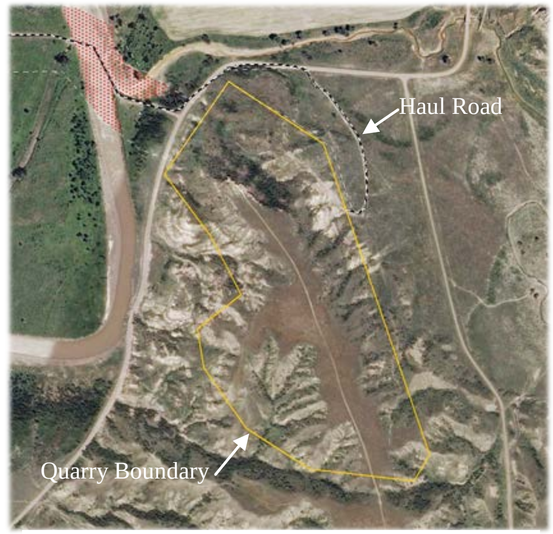


**Figure 3. Quarry site**

**Conclusion**

Waters of the U.S. were identified within Area 1 (waste pile site) and Area 2 (proposed bypass channel alignment and the Yellowstone River). No WUS were identified within Area 3 (Quarry). See Table 12 below for a list of type and quantity of wetlands or river/channel habitat identified during the investigation.

Fill disposed of at the waste pile site should be placed in the areas above the banks of the drainageways. If fill is placed near the southern boundary to construct a temporary construction haul road, culvert extensions should be used to keep areas south of County Road 303 draining north. All fill at the Waste Pile Site should be graded to match surrounding topography and to ensure that drainage resembles, as much as possible, pre-disturbance conditions. Topsoil from the excavated bypass channel should be stockpiled, placed at the top of the disbursed fill and seeded with a mix resembling pre-disturbance conditions. A recommended seed list is provided in Attachment 3.

**Table 12. Total wetlands and river/channel habitat acreages**

| Cowardin classification | Approximate Acres |
|---|---|
| PFOA/C | 0.12 |
| PEMC | 0.45 |
| R2UBG | 6.00 |
| R2UBH | 1.00 |
| R2UBG/PEMC | 45.00 acres |

Coordination of Clean Water Act authorizations and their processes should be in consultation with the Corps' Omaha District Billings Regulatory Office. A review of the project features and channel alignment during the final design phase is recommended for a verification of authorizations required.

**List of Preparers**

Field work completed by Michael Gilbert (CENWO-OD-RF), Cathy Juhas (CENWO-OD-RMT) and John Shelman (CENWO-PM-AC)

Report completed by John Shelman

Reviewed and approved by Michael Gilbert and Cathy Juhas

**References**

Cowardin, L.M., V. Carter V., F.C. Golet, E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service Report No. FWS/OBS/-79/31.Washington, D.C.

U.S. Army Corps of Engineers – Omaha District. 2012. Intake Diversion Dam Modification, Lower Yellowstone Project, Supplemental Environmental Assessment. Omaha, Nebraska

Intake Diversion Dam Modification Preliminary Draft Supplement to the 2010 Final Environmental Assessment
Comment Disposition
December 13, 2013

| # | Comment | Disposition |
|---|---|---|
| | Biological Review Team Comments on the Preliminary Draft Supplemental EA, June 2012 | |
| 1 | There is little to no justification in the Supplemental EA for the proposed 0.9 foot increase of dam crest height. | The EA was revised and states the need for the raised weir crest is to provide sufficient water surface elevations to divert the appropriate flows through the bypass channel and for irrigation diversions.<br><br>The weir height was determined through hydraulic analysis of the varying flow split scenarios. |
| 2 | The document acknowledged concerns that raising the dam may further aggravate passage, but it appears as this concern has been dismissed in the following sentence in the document "Hydraulics analysis indicates that flows will not significantly change across the weir compared to the current dam configuration." However, what is a significant change? A slight increase in hydraulics can be significant and to say no significant change would occur is likely inaccurate. | This section of the EA (p. 4-16) has been revised to address these comments. |
| 3 | Also, to offset crest height increase and to keep hydraulics "similar", the new dam would add length to the rock ramp. This additional length needs to be addressed in the document. The additional length at "similar" (yet greater) hydraulics has the potential to further aggravate existing in-river passage opportunities currently used by several species of fish. | The text has been revised to address this comment. |
| 4 | With no increase in dam height, at what discharge will irrigation be affected? | The lead agencies hope that the collaborative stakeholder meetings held the summer of 2013, and the alternatives explored and information shared at those meetings, have addressed these BRT comments. |

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| 5 | How frequently is this condition expected to occur? | See response to Comment #4. |
| 6 | Is it feasible to mitigate these low-flow conditions with pumps or some other mechanism? | See response to Comment #4. |
| 7 | A cost analysis should be performed comparing supplementing low base-flow periods, when irrigation might be affected with no dam modifications, with pumps to better evaluate if the increased dam height and/or new dam is a cost-effective alternative. | See response to Comment #4. |
| 8 | Selection of a 15% flow split does not seem well justified as described in the draft EA. This decision appears to have been solely based on the possibility of sediment deposition occurring in front of the head gates. | The lead agencies recognize that a 15% flow capture design for the bypass channel is not the most favorable bypass option from a biological standpoint according to the BRT, but does aid in managing sedimentation issues and minimizing the height of the new weir. Thus, it is a compromise between providing higher bypass channel flows and the other issues. Please be aware that 15% is an average with bypass flows dependent on runoff and river stage. |
| 9 | Because 1) models are approximations of reality, 2) uncertainty was described to unusual lengths, 3) the model that predicted effective sediment transport at flow splits up to 30% was apparently disregarded, 4) the most conservative model (that we know was not accurately predicting the present condition and was based from conditions occurring about 40 miles downstream where the river goes through perhaps its largest geomorphological change) was used as the sole determinant of suitable flow splits, we request that additional criteria and considerations are taken into account when determining designed flow split. | The lead agencies took additional criteria and considerations into account in the revised design of the Bypass Channel Alternative. |
| 10 | Providing passage for pallid sturgeon (and all other fish species) is the purpose of this action. However, the decision appears to have been based primarily on irrigation efficiency by choosing a very conservative flow split at the expense of being generous about whether that flow split could effectively pass fish. We request that fish passage be given at least equal consideration. | The lead agencies re-evaluated the flow split, conducted additional analyses and determined that providing increased flows into the bypass channel would require increasing the height of the weir and increase the risk of sediment deposition in front of the new headworks. |
| 11 | More work should be done to determine how a larger flow split design can be achieved without causing sediment aggradation. | See response to Comment #10. |
| 12 | A sloped dam crest, i.e. higher on the east abutment and lower on the west abutment, if designed, could facilitate sediment transport. The channel will remain entrained on the west side of the river even at low flows, possibly minimizing sediment deposition in front of | Various notch configurations are being evaluated as the design progresses. A sloped crest can be considered if desired. |

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| | the head gates (most deposition would occur on the inside east bend). | |
| 13 | Installation of a sluice gate on the west side of the dam to convey sediment could further minimize the possibility of deposition. The sluice gate could be run at all times irrigation is not occurring (~6 months of the year) which would eliminate built-up sediment and chronic channel instability. It could also be run during periods of high flow (~1-2 months of the year) when sediment transport is also highest because there would be enough water to achieve adequate head without fully impounding the river. | The lead agencies hope that the collaborative stakeholder meetings held the summer of 2013, and the alternatives explored and information shared at those meetings, have addressed these BRT comments. |
| 14 | Examination of additional alternatives such as these [above], in combination with consideration of both of the aforementioned models and their uncertainty, should occur. This additional analysis, collectively, could lead to development of reasonable alternatives that could support a greater flow split more conducive to fish passage. | See response to Comment #13. |
| 15 | The cost benefit analysis (appendix D) and FPCI model (appendix E) do not assess the direct or cost-adjusted benefits of providing larger flow splits. This affects the perceived benefits to both pallid sturgeon and other species in the fish assemblage. This model should be run at higher flow splits up to 30% and appendices D and E should be updated accordingly to allow for full analysis of the benefits of increased flow splits. We also made this request during review of this model several months ago and it did not occur. | See response to Comment #13. |
| 16 | The first is related to parameter Fl, which quantifies the ability of a fish to locate the passage alternative. The bypass is located on an outside bend with a fairly substantial velocity shear zone, which will negatively affect the ability of sturgeon to locate the entrance. This was not quantified, which makes the bypass appear better than it is. | Reclamation TSC is constructing a physical model to evaluate these concerns. |
| 17 | Also larger flow splits, which would increase Fs for the bypass channel and substantially improve its performance, were not modeled as noted above. | See response to Comment #13. |
| 18 | Interpretation of acres of habitat and cost effectiveness provided by passage alternatives should occur on two levels in appendix D and E: 1) pallid sturgeon and 2) all fishes. The difference between alternatives (ramp and bypass) when all species are considered is small; mostly because of values for non-sturgeon species. This small | See response to Comment #13. |

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| | difference or similar performance between alternatives is primarily what is discussed. However, the ramp provides a larger relative benefit than the bypass for pallid sturgeon. Because pallid sturgeon are the primary reason this project is occurring, that should be given independent scrutiny. Analysis of larger flow splits should occur to determine when equal passage benefits between alternatives occur for pallid sturgeon. | |
| 19 | Table 3 of the adaptive management appendix implies that 12 years can go by while flows are incrementally adjusted from 15 to 23%. We question why 23% is not the starting point? | See response to Comment #13. |
| 20 | We also recommend that actual increases in bypass channel size up to 30% flow split be integrated into the adaptive management plan if not a component of the initial design. | See response to Comment #13. |
| 21 | In several places the term recruitment is misused, (i.e., p 3-3 "The 2011 runoff event in the Missouri River resulted in the first documented natural recruitment of wild, naturally spawned pallid sturgeon above Gavins Point Dam."; p 3-5 "This atypical run up the Missouri River resulted in the first documented natural recruitment of wild, naturally spawned pallid sturgeon above Gavins Point Dam. A naturally spawned pallid sturgeon was confirmed when a day old larvae was found upstream of Wolf Point Montana in the Missouri River (Fuller 2012).") The documentation of a larval pallid sturgeon confirms the first successful **spawning/reproduction;** not recruitment. | The text has been revised to reflect the accurate use of these terms. |
| 22 | P3-3, it states "Braaten et al. (2012) recently showed via a recapture study that pallid sturgeon originally released as free embryos and larvae can survive beyond the first year of life, indicating the importance and ability of the Yellowstone River and Missouri River to providing conditions that support survival, feeding, and growth of pallid sturgeon early life stages." As written this is misleading. Braaten and others did document survival of larval pallids that were released in the Missouri River. These fish would have been at or near the age when drifting slows or ceases (i.e. 11-17 days post-hatch). These fish were not released in the Yellowstone River so one should not suggest this. Perhaps rewording is in order. | The text has been revised to address these comments. |
| 23 | P3-5 Last paragraph, first few sentences Bramblett did not confirm but only speculated about spawning based on fish aggregations in | The text has been revised to address these comments. |

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| | the lower 6-9 miles of the Yellowstone River. The author should cite more recent data from Fuller, or Jaeger, or others to articulate that known gravid (reproductive condition) fish were documented moving to Intake Dam. | |
| 24 | The figures for the adaptive management and monitoring may be low (i.e. 2-6 and 2-9). It may not be reasonable to assume that more than a hundred years of restricted passage and lack of recruitment due to impoundment can be "fixed" by simply "providing" a passage alternative. For a long-lived species such as a sturgeon, adaptive management may include a number of creative strategies for establishing or encouraging spawning aggregations above Intake. This may reasonably take decades. This potential for "delayed success" should be articulated to managers, stakeholders and the public. The recovery of sturgeon populations requires long-term investment and commitment to a comprehensive set of management actions directed at recovery. That expectation is needed at the outset. | The lead agencies appreciate this information. The Adaptive Management Plan focuses on uncertainties associated with alternatives proposed in the draft supplemental EA. Uncertainties related to spawning and ultimately species recovery are outside the scope of the Adaptive Management Plan for this specific project. |
| 25 | The monitoring plan for passage in Appendix J is minimal and provides mostly a positive or negative response of tagged fish to the structure without any causative or mechanistic explanation to why fish did or did not pass the structure. There is no discussion of reproductive evaluation or assessment of motivation of the fish to pass. Other than sturgeon, no native fish are included in monitoring. There is no comprehensive evaluation of native fish use of the proposed constructed side channel. Thus, native fish passage should be integrated into the 1) success criteria, 2) adaptive management plan, and 3) monitoring program. If current in-river passage of other species is compromised by reconfiguring the dam, then that should be addressed and formalized within this document to make sure that adaptations are provided to ensure native species passage. | The draft Adaptive Management Plan has been revised in response to this comment, and we welcome additional comments on the plan. |
| Environmental Protection Agency Comments on the Preliminary Draft Supplemental EA, June 2012 | | |
| 1 | New information regarding pallid sturgeon behavior that resulted in reevaluation of the Bypass Channel Alternative is not identified or discussed. We recommend that this new information be explained and described in greater detail, so the public can better understand | The text has been revised to address this comment. |

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| | why the Bypass Channel Alternative is being reconsidered. | |
| 2 | We recommend that the draft EA explain why the bypass channel is proposed at its current location, and why the connection with the main river channel should not be moved further downstream (i.e., away from Intake Dam's turbulence). | The EA was revised to provide the following information:<br>• "By locating the exit point at the downstream end of the dam, fish are thought to be more likely to find the bypass channel, and utilize it in their movement upstream." (p. 2-3)<br>• "The critical point in upstream fish passage design is the location of the fish pass entrance and the attraction flow (Larinier 2001). The optimal location of a fish bypass entrance is near enough to the dam that the fish are guided into it as they look for a barrier-free pathway." (p. 4-7) |
| 3 | We recommend that the "sediment balance" issue that apparently constrains use of higher river flows in the bypass channel be more fully described in the EA, including discussion of trade-offs regarding bypass channel flows vs. pallid sturgeon use and sediment balance. | The lead agencies hope that the collaborative stakeholder meetings held the summer of 2013, and the alternatives explored and information shared at those meetings, have addressed these EPA comments. |
| 4 | Would relocation of the channel inlet further downstream from the dam as suggested in our comment #2 reduce sediment balance effects, and thus, allow a higher river flow, more attractive to pallid sturgeon, to be used in the bypass channel? | See response to Comment #3. |
| 5 | We also note that if a higher percentage of river flow in the bypass channel is more likely to attract and promote use of the bypass channel by pallid sturgeon, it would appear appropriate to direct a higher percentage of river flow through the bypass channel (e.g., 30-35% of river flow). Perhaps this would only need to be done before and during the May-June pallid sturgeon spawning season to encourage greater use by pallid sturgeon just before and during the spawning period. Flows through the bypass channel could then be reduced to 15% after spawning season, and thus, allow more flow in the main river channel during most of the irrigation season. | See response to Comment #3. |
| 6 | The draft Supplemental EA states that the design of the headworks requires that the crest of the dam be raised by approximately 1 foot to create additional head in order to operate effectively (page 4-14). It also states that a new dam (or river wide concrete weir) is proposed to be constructed 40 feet upstream of the existing dam crest in the future (page 2-6). It is not clear if this increase in height of the dam by 1 foot refers to raising the crest of the existing dam by | The elevations of the top of the existing Intake Dam timber crib (i.e., without rock) (1988.0) and proposed weir (1990.5) have been provided in the DSEA. Rock placement on the top of the existing timber crib is used to raise the elevation of the water surface. Given the variability of the large rock placed on the timber crib and its periodic displacement, it is difficult to provide a precise difference in operational elevations between the existing conditions and the |

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| | 1 foot or raising the crest of the new dam (or river wide concrete weir) by 1 foot, or both. This should be clarified. | weir proposed under the Bypass Channel Alternative. |
| 7 | In addition there is concern that raising the elevation of the existing dam and/or constructing an additional dam (or river wide concrete weir) 40 feet upstream of the existing dam with a slightly higher crest both may create new or additional impediments to fish passage in the main river channel for other Yellowstone River fish species. | The Bypass Channel Alternative weir design has been further refined to reduce potential impacts to fish passage. |
| 8 | We recommend that the potential for reducing wetland and riparian impacts continue to be evaluated and minimized while providing the best available option for sustaining pallid sturgeon. | It is our goal to minimize impacts to wetlands and riparian areas wherever practical. BMPs have been identified to address these concerns. |
| Fish and Wildlife Service Comments on the Preliminary Draft Supplemental EA, June 2012 | | |
| 1 | For consistency between sections, and for reasons identified specifically in several of the comments below, we recommend that the No Action be included under all resource categories in Chapter 4. In some cases, it may be appropriate to simply reference the analysis in the 2010 EA. | The No Action Alternative is contained in the 2010 EA, which will be provided electronically with the DSEA. |
| 2 | We noted several typographical errors (spelling, missing words, extra words, capitalization, etc.) throughout the document, but for the most part did not specifically identify these as part of our review and comment. | The document has been revised. |
| 3 | Chapter 1, Background Information, P 1-4: Recommend revisions as follows: "*Reclamation and the Corps remain committed to providing effective fish passage. Reclamation, the Corps, and the Service believe it is prudent to revisit both the rock ramp design and other fish passage alternatives,…*" | The lead agencies hope that the collaborative stakeholder meetings held the summer of 2013, and the alternatives explored and information shared at those meetings, have addressed these Service comments. |
| 4 | Chapter 1, Scoping, Issues, and Public Involvement, P 1-5: Since hydrology is a relevant fish passage issue, additional rationale/discussion should be provided in this section as to why hydrology is not addressed separately (i.e., under its own heading) in chapters 3 and 4, as it was in the 2010 EA. | The existing conditions of the hydrology has not changed since the 2010 EA nor have the impacts related to hydrology, therefore it is not necessary to include a specific hydrology section in the supplement. A hydraulics/geomorphology analysis is in included in the document. All hydraulics discussions are incorporated into the relevant sections of impacted resources as well as the Engineering Appendix (A2). |
| 5 | Chapter 2, No Action (Continue Present Operation), P 2-2: The statement, "This would include the annual placement of 1-2 feet of rock on the crest of the dam, using the existing cableway, to replace rock moved by ice and high flow events" is inconsistent | New information indicates that following some high flow years more rock placement may be necessary than originally anticipated. Rock placement is not necessary annually – only as needed. |

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| | with the statement, "The design of the headworks requires that the crest of the dam be raised by approximately 1 foot to create additional head in order to operate effectively" on p 4-14 and the proposed 11-inch crest raising via rock placement described/ analyzed in the February 2012 Reclamation BA. This text should be made consistent with the Chapter 4 text and 2012 BA or further explained. | |
| 6 | Chapter 2, No Action (Continue Present Operation), P 2-2 (bottom): The difference between the annual O&M activities "rock placement on the diversion dam" and "diversion dam rehabilitation" should be briefly explained. | The text has been clarified in response to this comment. |
| 7 | Chapter 2, Bypass Channel Alternative, figure on P 2-4: We recommend that the two mid-channel vertical control structures (riprap sills) discussed on P 2-5 be included on this figure. | Figure 2.6 has been added to the document which shows the vertical control structures. |
| 8 | Chapter 3, Fish, P 3-1 and 3-2: Citation should be provided for statement, "*Currently Reinhold is looking into whether this trend is also true during base flows when runoff is not a factor*." | Statement has been removed from the DSEA. |
| 9 | Chapter 3, Fish, P 3-2: The statement that pallid sturgeon are not strong swimmers may not be completely factual. They have evolved in large rivers with strong currents and migrate long distances. We recommend the author articulate that the high turbulence, unnatural velocities at the dam, and downstream boulder field are conditions with which the species did not evolve and thus biologically is not equipped to readily negotiate. Also, this section should reference White and Mefford's 2002 research that further confirms shovelnose sturgeon, and thus likely pallid sturgeon, have a difficult time with high velocities and turbulent flows. | The text has been revised in response to this comment. |
| 10 | Chapter 3, Fish, P 3-2: The statement, "*Radio telemetry studies have documented pallid sturgeon moving up to the Intake Diversion Dam, turning around, and moving downstream (Bramblett 1996, Bramblett and White 2001; Fuller et al. 2008)*" should also cite the 2011 FWP / USGS telemetry study on the lower Yellowstone River. | The lead agencies have requested the appropriate citations for this telemetry data. |
| 11 | Chapter 3, Fish, P 3-3: First paragraph last sentence states, "*The 2011 runoff event …resulted in the first documented natural recruitment of wild…*" This is inaccurate. The documentation of a larval pallid sturgeon confirms the first successful **spawning/** | The text has been changed to reflect this comment. |

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| | **reproduction.** However, reproduction means nothing if young do not survive to adulthood to reproduce again; this is **recruitment**. | |
| 12 | Chapter 3, Fish, P 3-3: The second paragraph states, "*On the lower Yellowstone River, bluff pools and terrace pools, which have relatively coarse substrates, are presumed to be a preferred spawning habitat for pallid sturgeon.*" We disagree with this statement. Pallid sturgeon spawning has been documented in these habitats in the lower Missouri and Yellowstone rivers, but we are not certain that these habitats within the lower Yellowstone River are preferred spawning habitats. Also, bluff pools and terrace pools should be briefly defined for non-technical readers. | The text was revised in response to this comment. |
| 13 | Chapter 3, Fish, P 3-3: Recommend revisions as follows: "*Hiebert et al. (2000) estimated that about 500,000 fish of 36 species were annually entrained into the main canal at Intake Diversion, of which as many as 8% were sturgeon*." | The text was revised in response to this comment. |
| 14 | Chapter 3, Fish, P 3-4: Recommend revisions as follows: "*Because the canal headworks at Intake has recently been rebuilt, and has incorporated removable rotating drum screens that meet screening criteria standards for minimizing entrainment, it is anticipated that entrainment is no longer a substantive issue*." | The text was revised in response to this comment. |
| 15 | Chapter 3, Fish, P 3-5, first few sentences of last paragraph: Bramblett did not confirm pallid sturgeon spawning in the lower 6-9 miles; this was speculated based on fish aggregations. We highly recommend the Supplement author look at more recent data from Fuller and others to articulate that known gravid (reproductive condition) fish were documented moving to Intake Dam. Then begin making the argument that the fish would likely have continued upstream had the barrier not been there. | The text was revised in response to this comment. |
| 16 | Also, remove "natural recruitment of" from the penultimate sentence (see comment above). | The text was revised in response to this comment. |
| 17 | This section also should mention the independent reviews related to larval drift in the Yellowstone River concluding that passage at the dam should increase drift distances. | The text was revised in response to this comment. |
| 18 | Chapter 3, Aquatic Invasive Species, P 3-4: Revise "confluents" to "confluence". | This correction was made to the text. |
| 19 | Chapter 3, Federally Listed Species and State Species of Special | The text was revised in response to this comment. |

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| | Concern, P 3-5 (top): States, "*The Service, as required by the ESA, confirmed a list of federally-listed endangered, threatened and proposed species that are or may be present in the Intake Project area. The same species that were looked at in the 2010 EA were also considered under the new alternatives. Species status and biology can all be located in the 2010 EA. All species biology and status has stayed the same but new information has been obtained on pallid sturgeon since the release of the 2010 EA.*" It should be clarified that the Intake ESA species list was updated by Reclamation in their February 2012 BA. The 2012 BA list included pallid sturgeon, interior least tern, whooping crane, black footed ferret, and the candidate greater sage-grouse and Sprague's pipit. It should be clarified that the greater sage-grouse and Sprague's pipit were designated as candidates in 2010 (March and September, respectively). Neither species was assessed in the 2010 EA or 2010 BA as candidate species, although the Sprague's pipit was discussed as a species of special concern in the 2010 EA. Clarifying discussion should be added to this section. | |
| 20 | Chapter 4, Geomorphology, P 4-4, Figure 4.1: Recommend replacing "on" with "within" in figure title. | Change was made to title. |
| 21 | Chapter 4, Geomorphology, P 4-6, Figure 4.2: Recommend replacing "on" with "within" in figure title and eliminating "proposed" from the "New Headworks" and "Main Canal Extension" labels in the legend as these features have been constructed. | Change was made to title and legend was revised to remove "proposed". |
| 22 | Chapter 4, Geomorphology, P 4-7, 2nd paragraph under Bypass Channel Alternative: Recommend also including discussion of the proposed riprap sill at the downstream end of the channel. | The text was revised in response to this comment. |
| 23 | Chapter 4, Geomorphology, Rock Ramp Alternative, Cumulative Effects and Summary, P 4-8: States, "*The Bypass Channel Alternative would increase the length of stabilization features on the Lower Yellowstone River by about 20% in the reach from Cartersville Dam to the confluence of the Missouri River. The Rock Ramp would provide a minor increase of 1.6% in the length of stabilization on the Lower Yellowstone River from Cartersville Dam to the confluence of the Missouri River.*" | The text was revised in response to this comment. |

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| | However, the Summary states that the Bypass Alternative would add 1,400 feet of bank stabilization, while the rock ramp alternative would add 2,899 feet of bank stabilization – double that of the Bypass Channel Alternative. This discrepancy should be clarified or corrected. | |
| 24 | Chapter 4, Surface Water Quality, Bypass Channel Alternative, P 4-9: States, "*Because the Bypass Channel Alternative would not affect river flows, point source discharges, or non-point source discharges after construction, all water quality effects would be temporary*." The bypass channel would affect river flows post-construction, in that it is designed to carry and reduce the mainstem flow by approximately 15% (over the affected segment). This should be discussed / addressed. | Sentence has been changed to say "Because the Bypass Channel Alternative would not affect cumulative river flow quantity, point source discharges, or non-point source discharges after construction, all water quality effects would be temporary". |
| 25 | Chapter 4, Aquatic Communities, Fish, Bypass Channel Alternative, P 4-14: Recommend revision as follows: "*At a 15% flow capture design, the bypass channel is not optimal*." Also, this statement should be further explained and discussed since the BRT is seeking higher (30%) flows; indicate from an engineering standpoint why the 15% recommendation might not work. The ongoing design process should strive to incorporate BRT flow split recommendations to the maximum extent possible. Additional analysis should be performed as necessary to determine how a larger flow split design can be achieved without causing sediment aggradation at the headworks. | The text was revised in response to this comment. |
| 26 | Chapter 4, Aquatic Communities, Fish, Bypass Channel Alternative, P 4-14: The statement, "*Hydraulics analysis indicates that flows will not significantly change across the weir compared to the current dam configuration*" should be further explained / quantified. How much are flows predicted to change? | The text was revised in response to this comment. |
| 27 | Chapter 4, Aquatic Communities, Fish, Bypass Channel Alternative, P 4-14: States, "*In addition, the removal of any metal components utilized in the construction of the new weir will take place*." It is unclear whether this means that metal components will be removed from the new design, or that metal components in the existing weir would be removed. Further, the sentence, "*Therefore, there will not be significantly more metal after* | The text was revised in response to this comment. |

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| | *construction of the weir than currently exists within the existing dam that could be considered problematic for fish that are electroreceptive…*" implies that there will be more metal post-construction than currently exists. This discussion should be clarified. | |
| 28 | Chapter 4, Aquatic Communities, Fish, p 4-11 through 4-16: For the action alternatives, temporal impacts of not providing fish passage for the 2-3 year period between summer 2012 and anticipated passage alternative completion dates should be discussed. For the No Action alternative, the short and long-term impacts of not providing fish passage, and potentially further impeding or eliminating fish passage, should be discussed. The additional 11 inches of rock placed on the dam in 2012 in order to achieve sufficient hydraulic head at the new headworks incrementally decreased potential fish passage for several species. The No Action alternative would seemingly have the greatest impact to fish in this regard (in that passage potential was further decreased, with no proposed remedy incorporated into the alternative), but is not currently analyzed in the EA. | The lead agencies believe this is adequately addressed in the 2010 EA. |
| 29 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Introduction, P 4-16: "BiOp" should be replaced with "2003 amended Missouri River Biological Opinion" | The text was revised in response to this comment. |
| 30 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Introduction, P 4-16: Recommend revision as follows: "*Provided an action alternative is selected, this project constitutes implementation of an RPA, and Endangered Species Act section 7 consultation on its construction is therefore concluded. However, the operations of the Intake Project by Bureau of Reclamation, including operation of the new headworks in conjunction with the implemented (selected) fish passage design, requires a separate but parallel section 7 consultation. This parallel effort will likely require formal section 7 consultation with the Service. This future BA on operations will be completed prior to the actual operation of the selected fish passage alternative.*" | The EA was revised to provide the following information: "While Section 7 consultation for a fish passage project has been concluded, the operations of the Intake Project by Bureau of Reclamation, including operation of the new headworks in conjunction with the implemented (selected) fish passage design, requires a separate but parallel Section 7 consultation. This parallel effort will likely require formal Section 7 consultation with the Service. This future BA on operations will be completed prior to the actual operation of the selected fish passage alternative." (p. 4-18) |
| 31 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Methods, P 4-16/4-17: Again, it should be clarified that the Intake ESA species list was updated by Reclamation in | The text was revised in response to this comment. |

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| | their February 2012 BA. | |
| 32 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Short Term and Long Term Effects of the Alternatives, P 4-17: The No Action alternative should be addressed. The short and long-term impacts of not providing fish passage for pallids, and potentially further impeding or eliminating fish passage for other species of concern, should be discussed (see comment above). | The lead agencies believe this is adequately addressed in the 2010 EA. |
| 33 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Short Term and Long Term Effects of the Alternatives, Federally-Listed Species (both action alternatives) P 4-17/4-18: Brief rationale for the effect determinations for the whooping crane and least tern should be provided. For consistency with the February 2012 BA, the black-footed ferret, greater sage-grouse, and Sprague's pipit should also be addressed in the discussion. Also, determinations should be consistent with those made for the Rock Ramp alternative (on P 4-18). | The text was revised in response to this comment. |
| 34 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Short Term and Long Term Effects of the Alternatives, Federally-Listed Species, Bypass Channel, P 4-17: States, "*Incidental take of pallid sturgeons during construction are considered in the original Missouri River BiOp, with reasonable and prudent measures to avoid take being associated with each RPA element.*" This is true for the RPAs considered in the original 2003 amended Missouri River Biological Opinion. However, anticipated incidental take associated with the Intake project construction was not specifically addressed in the 2003 amended Missouri River Biological Opinion nor the 2009 Service letter that substituted the RPA element at Intake Dam and its irrigation headworks for that originally identified to be taken at Fort Peck Dam. Based on the analysis and environmental commitments identified in the 2010 Intake project construction BA, EA, and FONSI, such take was not anticipated. Provided new information does not emerge during the amended EA analysis indicating that take may occur, and conservation measures and environmental commitments identified in the 2010 BA, EA, and FONSI will remain in place or undergo revision with Service approval, the | The text was revised in response to this comment. |

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| | Service does not currently anticipate incidental take in conjunction with fish passage project construction. The explanation in the EA should be clarified accordingly. | |
| 35 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Short Term and Long Term Effects of the Alternatives, Federally-Listed Species, Rock Ramp, P 4-18: Brief rationale for the effect determinations for the whooping crane and least tern should be provided. The pallid sturgeon discussion should be to a similar depth of discussion as it was under the Bypass Channel, or specifically referenced from the 2010 BA, EA, etc. For consistency with the February 2012 BA, the black-footed ferret, greater sage-grouse, and Sprague's pipit should also be addressed in the discussion. Also, determinations should be consistent with those made for the Bypass Channel alternative (on P 4-17). | The text was revised in response to this comment. |
| 36 | Chapter 4, Federally-Listed Species and State Species of Special Concern, Short Term and Long Term Effects of the Alternatives, Federally-Listed Species, Actions to Minimize Effects, P 4-19: Due to its larger footprint and potential for affecting a variety of habitat types, the Bypass Channel alternative may warrant additional commitments beyond those originally proposed for the Rock Ramp. These may include channel excavation sequencing to minimize sedimentation and fish entrainment potential, nesting bird construction timing considerations, and replacement / restoration of wetlands, riparian areas, and other habitats etc. Such measures specific to the Bypass Channel alternative should be considered as necessary in the EA. | Best Management Practices and other measures specifically addressing the effects of the Bypass Channel Alternative are included in the DSEA and Appendix I. |
| 37 | Chapter 4, Recreation, Short Term and Long Term Effects of the Alternatives, Fishing, P 4-21: The No Action alternative should be addressed. The short and long-term impacts of potentially further impeding or eliminating fish passage for game fish should be discussed (see comments above). | The No Action Alternative is contained in the 2010 EA, which will be provided electronically with the DSEA. |
| 38 | Chapter 4, Recreation, Short Term and Long Term Effects of the Alternatives, Fishing, last paragraph, P 4-22: Recommend revision as follows: "*Permanently closing the boat launch ramp under the Rock Ramp Alternative would result…*" | This change was made to the text. |
| 39 | Chapter 4, Social and Economic Conditions, Results, Short Term and Long Term Effects of the Alternatives, P 4-26: The No Action | The No Action Alternative as it relates to socioeconomic conditions is contained in the 2010 EA, which will be provided electronically |

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| | alternative should be addressed. The short and long-term economic impacts of not implementing the RPA and resulting potential regulatory implications, costs, water delivery issues, etc. should be discussed at least in general terms. | with the DSEA. Chapter 4 of the DSEA contains supplemental No Action Alternative socioeconomic information for comparative purposes. |
| 40 | Chapter 4, Social and Economic Conditions, Results, Short Term and Long Term Effects of the Alternatives, Cumulative Effects, P 4-32/33: States, "*Based on Reclamation's experience with Section 7 consultation and ESA compliance on other projects and facilities, the Service would likely require that improved fish passage and entrainment minimization be in place by a certain date*." Entrainment minimization is already in place and therefore should be removed from this sentence. | This correction was made. |
| 41 | Chapter 4, Lands and Vegetation, Results, Short Term and Long Term Effects of the Alternatives, Wetlands, P 4-34/35: It appears that deepwater (rock bottom or unconsolidated bottom) riverine habitat is lumped together with wetlands for purposes of this analysis as "riverine wetland" in portions of the discussion under both action alternatives, which leads to unclear and likely exaggerated projected wetland impact discussion, and may confuse any wetland mitigation aspects of this project. Projected impact acres of wetland verses non-wetland deepwater riverine habitats should be clearly discussed and provided for each alternative for comparison purposes. To avoid confusion, non-wetland riparian area impacts should be discussed exclusively under Riparian Areas. | The text has been revised in response to this comment. |
| 42 | Chapter 4, Lands and Vegetation, Results, Short Term and Long Term Effects of the Alternatives, Riparian Areas and Woodlands, P 4-35: It is unclear from the discussions under these headings whether woodlands are inclusive of riparian areas – this should be clarified in the discussion. | The text has been revised in response to this comment. |
| 43 | Chapter 4, Lands and Vegetation, Results, Short Term and Long Term Effects of the Alternatives, Noxious Weeds, No Action Alternative, P 4-36: This section references "what already occurs", but should provide a description of what this means. For example, is there ongoing weed treatment? No treatment? Are weeds an ongoing issue? | The text has been revised in response to this comment. |
| 44 | Chapter 4, Lands and Vegetation, Results, Actions to Minimize | The text has been revised in response to this comment. |

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| | Effects, Wetlands, P 4-38, 2nd bullet, Suggested revision as follows: "*Discharges of fill material associated with unavoidable impacts to wetlands or intermittent streams…*" | |
| 45 | Chapter 4, Lands and Vegetation, Results, Actions to Minimize Effects, Wetlands, P 4-38, 4th bullet, Suggested revision as follows: "*…and will suggest actions to minimize and mitigate effects to wetlands*. | The text has been revised in response to this comment. |
| 46 | Chapter 4, Wildlife, Results, Short Term and Long Term Effects of the Alternatives, Bypass Channel Alternative, P 4-40, Mammals & Birds sections: States, "*The excavated bypass channel would impact approximately 73 acres of mixed habitats, including wetlands, riparian areas, woodlands and grasslands*." However, previous discussion under these headings implies permanent and temporary impacts 1 ac of emergent wetland, 13 ac of riparian, 32 ac woodlands (channel), 51 ac woodlands (borrow), 20 ac grasslands (channel), and 153 ac grasslands (waste pile). We are not able to discern where the 73 ac originates. This should be clarified/ corrected. This is also very inconsistent with the Summary, which concludes, "*Based upon the total construction footprint, the Bypass Channel Alternative would have the most impacts (over 626 acres)*." | In writing the EA, acres of impacts were calculated for "affected area", or the area in which the overall project is taking place and impacts are likely to be within. In addition, we track temporary direct impacts associated with temporary construction features (staging areas, haul roads, etc) as well as permanent direct impacts, which are impacts from features that will permanently change the area in which they occur were tracked separately for each resource category. That being said, it appears the reader has tried to add up specific permanent and temporary impact acreages to get the "affected area" acreage. This calculation would be in error, as the affected area is only the area in which impacts may potentially occur, and not the total area of direct impact.<br><br>Also, the analysis for each of the resource categories may be confusing to the reader, as resources types sometimes overlap. For example, "Forested Wetlands" impacts in the wetlands analysis may overlap with impacts to "riparian forest" in the vegetation analysis. These are separate analyses, and are not additive. They simply help to provide perspective to how this activity may impact categories of resources within the overarching resource type. |
| 47 | Chapter 4, Wildlife, Results, Short Term and Long Term Effects of the Alternatives, Bypass Channel Alternative, Birds, P 4-40: Should include a discussion of potential impacts to nesting birds in affected habitats during construction. | The text has been revised in response to this comment. |
| 48 | Chapter 4, Wildlife, Results, Short Term and Long Term Effects of the Alternatives, Rock Ramp Alternative, P 4-41: States, "*…a limited amount*" of vegetation would be impacted. An estimate of impacted acreage should be provided to facilitate comparison | The text has been revised in response to this comment. |

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| | between alternatives. | |
| 49 | Chapter 4, Wildlife, Results, Short Term and Long Term Effects of the Alternatives, Rock Ramp Alternative, Amphibians and Reptiles, P 4-41: States, "*Rock Ramp construction activities would have a temporary effect on amphibians and reptile species located in the immediate vicinity of the construction area, similar to the impacts described for the other action alternative*." However, no discussion of amphibians and reptiles was provided for the Bypass Channel Alternative. | A section on Amphibians and Reptiles has been added for the Bypass Channel Alternative. (p. 4-46) |
| 50 | Chapter 4, Wildlife, Results, Summary, P 4-41: States, "*Based upon the total construction footprint, the Bypass Channel Alternative would have the most impacts (over 626 acres)*." Previous discussion indicated 70 total ac riparian, 184 total ac woodlands, and 321 total ac grasslands within the construction footprint (total of 575 ac). Also, the previous discussion on p 4-40 indicated only 73 ac of impacts to these habitats (see previous comment). Further, this Summary section states that the Rock Ramp would result in 28 ac of impacts, while previous section discussions total 5 ac riparian, 12 ac woodlands, and 21 ac grasslands (total 38 ac). All of these vegetation community / wildlife habitat discussions need to be examined for consistency and accuracy and corrected as necessary. | See response to Comment #46. |
| 51 | Chapter 5, Endangered Species Act Consultation, P 5-3: Suggested revision as follows: "*…in the Service's 2003 amended Missouri River Biological Opinion to the Corps*." | The text has been revised in response to this comment. |
| 52 | Chapter 5, Migratory Bird Treaty Act and Executive Order 13186, P 5-6: MBTA is described, but EO 13186 is not. A description of EO 13186 should be included in this section. | The text has been revised in response to this comment. |
| 53 | Chapter 5, Biological Review Team, P 5-2: We recommend listing both Matt Jaeger and Jason Rhoten and indicating that Jason Replaced Matt with the effective date. | The list has been updated. |
| 54 | Chapter 5, Distribution List, U.S. Fish and Wildlife Service, P 5-12: Please substitute Jeff Berglund for Lou Hanebury in this list. | This change was made to the list. |
| 55 | Chapter 5, Distribution List, State Agencies, P 5-12: The Director of Montana Fish, Wildlife and Parks is Joe Maurier. | The text was updated to indicate that Jeff Hagener is the current Director of Montana Fish, Wildlife and Parks. |
| Montana Fish, Wildlife and Parks Comments on the Preliminary Draft Supplemental EA, April 2013 | | |

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| 1 | Corps unilateral decision that a bypass channel is the only option moving forward. Revisiting or at least discussing and rescoring other alternatives were minimized. | Reclamation and the Corps recognized the State and other stakeholders had significant concerns about the alternative identification process. In response, Reclamation hosted a series of meetings during the summer of 2013 to re-engage stakeholders in exploring alternatives for fish passage. This process is documented in Appendix A.1. |
| 2 | Biop changes that obviate the Corps from further pallid recovery efforts on the Yellowstone River or Missouri River at Ft Peck after a bypass channel is built is objectionable. | The lead agencies acknowledge the State's concern; this comment is outside the scope of the NEPA process. |
| 3 | Addressing all the uncertainties associated with the bypass channel on "adaptive management" is unacceptable when no agency is currently held responsible for adaptive management in writing. Funding realities for any of these adaptive management practices are not certain. | Reclamation has agreed to be responsible for implementation of adaptive management measures necessary to achieve fish passage, and intends to sign a Memorandum of Agreement that commemorates this responsibility. Funding sources for adaptive management measures hinges on a number of factors including applicable laws, regulations, and policies; total costs; the nature of the adaptive management measure; and likely other circumstances unknown until the specific measure is identified. |
| 4 | Language needs to be provided throughout the EA that describes who will be responsible for all the adaptive management actions. In multiple meetings the State has been assured that the BOR has verbally committed to taking on the responsibility for adaptive management and O&M. If this is true the EA needs to provide the statutory requirements that all expenses incurred by the BOR at Intake, even for the adaptive management of the bypass channel, have to be passed on to the irrigation district. The irrigation district should be provided an accurate estimate of annual O&M including realistic projections of adaptive management costs they will be responsible for reimbursing the BOR for upon completion of the bypass channel.<br><br>Include statutory requirement in response and add where it is located in the document. | Text responding to this comment has been provided in Chapter 2 of the draft supplemental EA. |
| 5 | Basis for moving forward with the project is primarily driven by a business decision, not biologic criteria. This is supported by language in the EA that states the Rock Ramp outscores the Bypass Alternative in providing fish passage for pallid sturgeon and other fish communities, but the bypass alternative is superior because it is | Additional information has been included in the Chapter 2 – Preferred Alternative section describing the factors the lead agencies have considered in selecting the preferred alternative, including: the fish passage connectivity index results, constructability, ice forces, cost effectiveness, pallid side channel use, risk, and uncertainty. |

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| | cheaper to construct (pg 4-19, 4-20 and A.1 -33). | |
| 6 | In meetings with the Corps FWP has been told that the rock ramp alternative is not a reality because of engineering limitations and more specifically costs. We have also been told that entertaining other alternatives is not an option. These realities need to be clearly articulated in the supplemental EA. As currently wrote, the reasons for picking the Bypass Channel distract readers from these two primary realities. FWP still prefers the Rock Ramp alternative and potentially other options over the bypass alternative. | Please see response to Comment #5 above. |
| 7 | Fish monitoring for the eight year period following construction and the associated annual cost is confusing. The states proposed monitoring and associated costs do not correlate to the cost provided in the EA? | Cost estimates were developed by the interagency team including MFWP, FWS, Reclamation, and the Corps. These are preliminary numbers that will need to be updated once monitoring requirements are finalized. |
| 8 | Add an index at the front of the EA that covers the entire document. | An index has been added to the document. |
| 9 | Pg iii fourth paragraph, add <u>reasons</u> why the reevaluation is necessary, including the <u>new information</u> that has become available regarding the rock ramp since the 2010 EA and FONSI. Pg i similar statements. | Specific information on the need to reevaluate fish passage alternatives has been provided in the Chapter 1 – Background Information section, and touched on in several other places in the DSEA. |
| 10 | Pg iii directs readers to Appendix A. Pg A.1-11. The bypass was never considered a Priority 1 alternative not even a Priority 2 alternative. How have we got here and why? | The lead agencies used past information and consultation with cooperating agencies to initially identify the bypass channel as a suitable alternative for consideration. Reclamation undertook additional collaborative alternative identification efforts during the summer of 2013, which concluded, when all factors were considered, the bypass channel and rock ramp were the best alternatives for detailed analysis. |
| 11 | Pg iv: The actual dam height increase (in feet) needs to be presented for the reader– we have been told in meetings that the dam will be 2 feet higher than the old dam. | The elevations of the top of the existing Intake Dam timber crib (i.e., without rock) (1988.0) and proposed weir (1990.5) have been provided in the DSEA. Rock placement on the top of the existing timber crib is used to raise the elevation of the water surface. Given the variability of the large rock placed on the timber crib and its periodic displacement, it is difficult to provide a precise difference in operational elevations between the existing conditions and the weir proposed under the Bypass Channel Alternative. |
| 12 | Pg 2-1 states "Because entrainment protection has been achieved through the ……". This has to be confirmed with sampling, simply building it does equate to entrainment protection. | Language in the DSEA has been changed to reflect this concern. |
| 13 | Pg 2-3: Second to last sentence in first paragraph reads "A concrete | This change was made throughout the document. |

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| | weir would be ……to provide adequate water surface elevations for water diversion into the new bypass channel." The words "and irrigation canal" must be added. | |
| 14 | Pg 2-6, the last paragraph before the Rock Ramp Alternative title has multiple issues: 1) all the cost figures do not match those provided in Table 2 Appendix E (Bypass Channel 15% Diversion, Weir 2 Alternative). For example the O&M provided on pg 2-6 is $138,000, Table 2 shows $220,216; 2) another sentence should identify that all costs will be covered by Corps except the O&M which will be the BOR responsibilities. Could reference this fact by citing Table 1 Appendix J. | The O&M costs for each of the alternatives have been updated with the most current information. Additional language is provided indicating the contract between LYIP and Reclamation for reimbursement of O&M costs would likely need to be amended if an action alternative is implemented. |
| 15 | Pg 2-6, the Rock Ramp Alternative should be removed from the Supplemental EA since it is not an option. | The Rock Ramp Alternative has been retained to provide the public and decision-makers with comparative information on a range of reasonable alternatives, which was also the approach agreed to by participants in the summer 2013 collaborative meetings. |
| 16 | Pg 2-7 remove "be" from the following "This concrete weir would be replace an existing….". | Correction was made. |
| 17 | Pg 2-9 define(s) the numbers for "….characteristics that meets the swimming abilities of pallid….". | The text has been changed to identify the BRT criteria as the standard for design. |
| 18 | Pg 2-10 , the third full paragraph has multiple issues: 1) all the cost figures do not match those provided in Table 2 Appendix E (Original Rock Ramp with Crest 2 Alternative). For example the O&M provided on pg 2-10 is $199,000, Table 2 shows $282,028; 2) another sentence should identify that all costs will be covered by Corps except the O&M which will be the BOR responsibilities. Could reference this fact by citing Table 1 Appendix J; 3) the last sentence says bypass channel, this should say rock ramp. | Please see response to Comment #14. |
| 19 | Pg 2-11: last paragraph states "…..the bypass channel is more efficient at providing fish passage benefits", this is contradictory to what is said in the first paragraph on 4-19 "Although the scores are close (both alternatives), the benefits for the bypass channel are slightly less favorable than the Rock Ramp Alternative." This last sentence needs to be included on pg 2-10 under Identification of the Preferred Alternative section. | Efficiency refers to the cost and benefit information for providing fish passage, whereas the second sentence cited refers to fish passage connectivity scoring. Information about both is discussed in the Chapter 2 – Preferred Alternative section. |
| 20 | Pg3-2 states 52 species in Yellowstone River then next sentence begins with say 54 species in the Yellowstone. | The information has been corrected. |
| 21 | Pg 3-2, "Garvey, personal communication, 2012" appears to be | This information has been added. |

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| | missing from literature cited list. | |
| 22 | Pg 3-3 referenced "Deloney et al 2009" should be Delonay | This information has been corrected. |
| 23 | Pg 3-3 states "Of the current population of pallids within RPMA2, a large majority of fish tend to utilize the Yellowstone River during June/July with the exception of 2011" Statement should be further clarified. Missouri has altered hydrograph but experienced flows (similar to Yellowstone) in 2011 and approximately 40% of pallid sturgeon utilized the Missouri River above the confluence. | This section has been heavily revised and captures these suggestions. |
| 24 | Pg 3-3 It has been documented multiple years that pallid sturgeon have migrated up to and did not pass Intake. It has only 2008 as a reference year however this behavior has been documented multiple years | This information has been added. |
| 25 | Pg3-3 Fuller et al 2012 is referenced multiple times on the document but is not provided in Literature cited. | This has been corrected. |
| 26 | Pg 3-4 add sentence to end of first paragraph that explains that the BOR will sample the Intake Canal in 2013 & 2014 to demonstrate the assumed level of reduced entrainment. | This information has been added. |
| 27 | Pg 3-4 Whirling disease has not been verified at the Miles City hatchery. One sample was suspect of whirling diseases but repeated test did not detect its presence. The first test was determined to be a false positive. | This information has been corrected, and information on iridovirus has also been added. |
| 28 | Pg 3-6 states "While spawning is suspected to have occurred in the Yellowstone River, there is no evidence that any resulting young were hatched, …." Braaten Rhoten 2012 captured genetically confirmed pallid sturgeon embryo in Yellowstone River. Pg A.1-4 similar statement, | This information has been corrected. |
| 29 | Pg 3-6 and A.1-4 states "While in most years it appears that sturgeon migrate up the Yellowstone, during the 2011 spawning season, the opposite was true,….." This is a **false and inaccurate** statement. The opposite did not occur. In 2011, 60% of transmitted pallid sturgeon migrated into the Yellowstone River, less than the typical year but not opposite. | This information has been corrected. |
| 30 | Pg 4-2 states "Reclamation and the Corps would use adaptive management to determine the effectiveness of the selected alternative to allow passage of adult pallid sturgeon." The Corps needs to be removed from this sentence because recent Biop changes have eliminated the Corps responsibility for adaptive management! | This information has been corrected. |

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| 31 | Pg 4-7 states "A new, raised concrete dam is proposed….flows through the bypass channel." Include the actual height increase to the first part of sentence and add "and irrigation canal" to the last part of the sentence. | This information has been added. |
| 32 | 4-11 add bullet that requires contactors to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread on Aquatic Nuisance Species. | This information has been added to the Chapter 4 and Appendix I. |
| 33 | Pg 4-13 the last paragraph demonstrates that other passage structures in the Missouri system have failed for pallid sturgeon. This supports our concerns regarding attraction flows and the large eddy that forms in the location of the proposed bypass fish entrance. The last few sentences specific to these failures should be included on pg 2-3 and 2-11. | This text has been deleted, however the section did refer to conditions in constructed side channels (shallow water habitat) that are not conducive to or specifically designed for pallid sturgeon passage. The bypass channel design is taking those conditions into consideration, and using the best available information to create suitable passage for pallid sturgeon. |
| 34 | Pg 4-15 the first paragraph discusses adaptive management and potential adjustments that could be made. A sentence needs to be added that demonstrates that this effort and expense would be the BOR responsibility and then passed onto irrigators. The second paragraph presents an increased weir height of 1 foot. If this is the case one foot needs to be present everywhere the EA talks about increased weir height. | Language has been added throughout the document addressing implementation and funding responsibility. The design height of the weir has been added where appropriate in the document. |
| 35 | Pg 4-19, 4-20, 4-21 & A.1-33 have a common theme regarding the rock ramp scoring higher than the bypass channel in three different quotes: pg 4-19 "Although the scores are close, the benefits for the bypass channel are slightly less favorable than the Rock Ramp Alternative.", pg 4-20 "Again, while the benefits are much higher for either action alternative over the no action, benefits associated with the rock ramp appear to be somewhat greater than benefits of the bypass channel.", pg 4-20 "The hydraulic analysis and FPCI evaluation found that the Rock Ramp Alternative scores slightly higher and more favorably for pallid sturgeon than the Bypass Channel Alternative…", pg 4-21 "Because large, stable substrates such as boulders and cobbles support larger, more productive invertebrate populations than do unstable gravel and sand substrates, creating a rock ramp could result in minor improvements in the diversity of the aquatic invertebrate community." and pg A.1-33 "Fish passage benefits modeling, while not all inclusive of all parameters that may affect fish passage, does indicate that the Rock | A section on the rationale used to select the preferred alternative has been added to Chapter 2. |

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| | Ramp option may be slightly better at providing passage to sturgeon and other fish communities…..". All of these support the rock ramp over the bypass alternative but they are dismissed because of cost alone! In other words we get a less beneficial alternative for fish passage because it cost less. All three of these quotes should be added to pg iv and 2-11. | |
| 36 | Pg 5-3 add assignment of adaptive management responsibilities to BOR under the Endangered Species Act Consultation. | Language has been added throughout the document acknowledging Reclamation's responsibility for implementing adaptive management measures. |
| 37 | Pg 5-5 change "The proposed by-pass channel will improve fish passage…" to "The proposed by-pass channel is intended to improve fish passage…". | This information has been changed. |
| 38 | Pg 3 & 4 (Table 2) Appendix E: Where did the cost figures for fish monitoring the first 8 years after project completion come from? In Table 2 identify the two alternatives that are relative to the EA (Bypass Channel 15% Diversion Weir 2 and Original Rock Ramp with Crest 2). I believe that Table 2 does not reflect additional costs of the most recently discussed concerns about rip rap at bypass sill and modifying bypass outlet structure and river bank to reduce or eliminate large eddy. | Cost estimates were developed by an interagency team including MFWP, FWS, Reclamation, and the Corps. These are preliminary numbers that will need to be updated once monitoring requirements are finalized. Construction costs are not continually updated. A 38% contingency was included in the original cost estimate to account for uncertainties that may come up as designs progress. |
| 39 | Pg 6 Appendix J adds three paragraphs, without KEA successes, to pg v and 2-11.??? | Not clear as to what this comment refers to. |
| 40 | Pg 10 Appendix J add language about failed side channel usage of Missouri side channels from pg 4-13 and second paragraph from 4-17 to the 4.0 Adaptive Management Strategy section. | Change has been made |
| 41 | Pg 12 Appendix J states "…the bypass channel will be modified accordingly." Add language that describes that the BOR will be responsible for funding these alterations. | The Adaptive Management Plan has been revised and incorporates the lead agencies' positions on funding AM. |
| 42 | Pg iv last paragraph. The first paragraph needs to be changed to "Both actions alternatives would attempt to meet the purpose and need for the proposed action, attempt to reconnect the lower Yellowstone River and possibly allow passage of the …..". Building the structure does not equate to meeting the three points: purpose, reconnect and passage. Monitoring is the only way to know if the three points are successful. See previous comments regarding the | The text has been changed. |

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| | use of “ecosystem restoration”. | |
| 43 | Ch 1 pg iii states “Originally, because of uncertainties in pallid sturgeon movement, one of the requirements of the BRT’s passage criteria was full river width passage. Since the bypass channel would not meet this criteria it was not carried forward in earlier analysis.” The original scoring of alternatives occurred in 2002, the BRT was not formed until 2005. It is inaccurate and inappropriate to use the BRT as the reason for dismissing the bypass alternative. The bypass channel was not one of the original 110 ideas proposed for addressing the goals of the project in 2002. How did the bypass channel become a reality considering it was not part of the original discussions, compared with other alternatives or presented in the original EA? | The text has been changed in response to this comment. |
| 44 | Pg 2-3 states “This alternative would provide passage for pallid…..” the word “would” should be changed to “is expected to” or “intended to”. Building it does not equate to successful passage. | This language has been changed. |
| 45 | Pg 4-17 the second paragraph demonstrates our reservations about accepting a fish passage alternative that does not incorporate a full width of the river passage opportunity which also includes the integrity of the existing side channel. This paragraph or content needs to be added to pg 2-3, 2-11 & 4-13. | The Preferred Alternative section describes the factors the lead agencies considered in selecting the preferred alternative, including: the fish passage connectivity index results, constructability, ice forces, cost effectiveness, pallid side channel use, risk, and uncertainty. |
| 46 | Pg A.1-15 the ranking and comparison of alternatives looks completely different if you add the bypass channel and add the cost estimates from pg 2-6, 2-10 and Table 2 Appendix E. This simple step should be completed to compare current data and cost estimates with other alternatives of 2005 screening matrix. | The bypass channel was compared against the other alternatives in the table (referred to as the long low gradient channel) at a comparative level of detail and design. |
| 47 | Pg A.1-20 states in reference to elimination of a single pumping plant alternative “4) continued effective operation of the Lower Yellowstone Project could not continue because the irrigation districts probably could not afford to pay the O&M costs.” The O&M and power for the single pumping plant alternative projected at $138,000 annually (pg A.1-15) of that $108,000 for power. O&M for bypass is estimated at $138,000 annually (pg 2-6). Identical cost to irrigators whereas elimination of the pumping plant was based upon this O&M cost to the irrigators. Or is this not affordable | There were multiple reasons the pumping plant alternative was eliminated, not just O&M costs. The O&M costs that are displayed in Table A.1 were reflective of 2005 costs and were for comparative purposes. They do not reflect current costs. |

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| | statement in reference to PgA.1-21 where it states power will cost $315,000? | |
| 48 | Pg A.1-31 All alternatives were not reviewed and reconsidered by all cooperating agencies. The state was not part of this process because we were not asked or consulted. | Reclamation and the Corps recognized the State and other stakeholders had significant concerns about the alternative identification process. In response, Reclamation hosted a series of meetings during the summer of 2013 to re-engage stakeholders in exploring alternatives for fish passage. |
| 49 | Table 3, 6 & 7 Appendix E identifies the two alternatives that are relative to the EA (Bypass Channel 15% Diversion Weir 2 and Original Rock Ramp with Crest 2). | Added a notation at the bottom of the tables to indentify which alternatives are carried forward into the EA. |
| 50 | Building a new weir that will be the largest concrete structure ever constructed on the Yellowstone River (threatening the notion that it is the longest undammed river in the lower 48 states). All five diversion dams on the Yellowstone River have substantial impacts on upstream fish migrations. The fundamental reason for the Intake Project is improving fish passage at the Intake dam. Building a new weir that is taller and increases the length of the current dam and rock structure will certainly reduce fish passage by all species and not improve passage for pallid sturgeon. | The Bypass Channel Alternative weir design has been further refined to reduce potential impacts to fish passage. |
| 51 | Building a concrete plug in the existing side channel that is a known fish passage route is undesirable. This action will also reduce recreational boating in the side channel. | The Corp and Reclamation will consider design options to improve fish passage at the junction of the bypass channel and existing side channel. The lead agencies along with FWP considered alternatives to separate the bypass channel from the existing side channel; however modeling indicated that the performance of both channels was reduced under these alternatives. Given this information, the parties agree that separating the channels is not preferable and energy should be focused on improving the fish passage design at the junction. |
| 52 | Pg ii second paragraph reads "Intake Diversion Dam likely has impeded….", the word likely should be removed. | This language has been changed. |
| 53 | Pg iv: Add "Another feature of the bypass channel is a concrete plug in the existing side channel". | This description is intended to brief because it is in the Executive Summary, but the description of the structure used at the junction of the bypass channel and existing channel has been expanded in the alternative description section of Chapter 2. |

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| 54 | Pg iv: Increased dam height is also needed to improve water delivery to the Canal – this needs to be included in this paragraph. This is supported by item number 8, page 2 of appendix J. | Language has been added to address this. |
| 55 | Pg iv: The last sentence for the Bypass alternative reads "the bypass channel would improve fish passage and contribute to ecosystem restoration", fish passage is the goal of the bypass but there is no guarantee that it will improve fish passage. Ecosystem restoration is also a strong claim to make considering the uncertainties associated with the bypass channel. The only way to accomplish ecosystem restoration is removal of the dam. Even if fish passage is provided natural stream function is prohibited and the impact has increased as a result of the higher weir in the river and concrete plug in the side channel. Also applies to last sentence of the first full paragraph on pg 2-3. | The goal is for the project to *contribute* to ecosystem restoration. The lead agencies have developed both action alternatives with the intent to achieve this goal. A definition of ecosystem restoration has been added to the document on page iii. |
| 56 | Pg v states "…..(rock ramp) has fewer constructability issues than Rock Ramp alternative." The bypass has maintenance issues that must not by dismissed. | The Preferred Alternative section in Chapter 2 describes the factors the lead agencies considered in selecting the preferred alternative, including: the fish passage connectivity index results, constructability, ice forces, cost effectiveness, pallid side channel use, risk, and uncertainty. |
| 57 | Ch 1 page iii states "Based on new technical information documenting pallid sturgeon use of side channels" cited McElroy et. al 2012. McElroy et. al investigated migration pathways of least energy expenditure. Does this sentence suggest the bypass will create a lower energy expenditure pathway upstream of Intake? | The sentence was not intended to suggest that the bypass channel would result in less energy expenditure by migrating fish. Energy expenditure is not a BRT criterion. |
| 58 | Pg 2-5 fifth paragraph states "It was assumed that the portion of the historic high flow chute used for 1-2 months. With the new bypass constructed the channel should flow 12 months a year, this will certainly change the stability of the existing portion of the channel. | The invert of the proposed bypass channel is 4-5 ft lower than the existing high flow chute and would be designed to maintain stability. |
| 59 | Pg 3-1 the last paragraph demonstrates the importance of the existing side channels as a vital habitat for young fish while rearing and during winter. The side channels value as a passage for non-pallid fishes and its importance as rearing and winter habitat demonstrates why FWP is reluctant to eliminate this side channel as a cost of building the bypass channel alternative. | The lead agencies along with FWP considered alternatives to separate the bypass channel from the existing side channel; however modeling indicated that the performance of both channels was degraded under these alternatives. Given this information, the parties agree that separating the channels is not preferable and energy should be focused on improving the fish passage design at the junction of the two channels. |
| 60 | Pg 4-15: We do not agree with the following statement "……impacts to fish passage as it currently exists across the | A 2013 Value Engineering Study considered a range of options to address these concerns, including decreasing the width of the weir |

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| | structure is not anticipated to worsen." This may be true for water velocities only but adding an additional 60 feet (20 feet dam crest plus 40 feet additional feet of rock ramp) will require prolonged burst and swimming speeds at the dam. The combination of similar water velocities, increased swim distance and laminar flow over the concrete dam will likely reduce fish passage for all fish species known to be passing the existing structure. Furthermore, it will not increase passage potential over the dam, particularly for pallid sturgeon. Many of the species that pass over the existing dam are using the resting areas created by the boulders to navigate the margins of the river to pass over the dam. This potential would exist with the new weir but the laminar flow for 20 feet will likely reduce passage. Cartersville Dam is very similar to the proposed weir at Intake. Fish are observed passing over this structure at the margins of the river where boulders allow a pathway. They do not pass through the laminar flows over the concrete dam. Most fish passage likely takes place during high river flows. According to Appendix A2, Att 6-19 figure 7 flows during higher flows of 30,000-40,000 cfs are 10 and 11.5 feet/second over the new weir. Without boulders to create resting areas these velocities over the laminar 20 feet wide concrete weir will be problematic for most species. Fish will spend considerable energy prior to reaching the concrete weir and may not have the reserves to pass over the laminar flow especially with 10+ feet/second velocities. | crest from approximately 20 feet to 6 feet and varying the crest height to reduce laminar flows **(Corps 2013).** As the weir designs progress, these options will be incorporated into the design.<br><br>Also, modeling indicates that water velocities across the proposed weir are expected to decrease.<br><br>The text has been changed to address this comment. |
| 61 | The paragraph also states "……only positive affects to fish passage as a result of the dam modification are anticipated to occur." If attraction flows from turbulence of the dam or eddy formation at the bypass entrance prevent fish usage the overall net passage at Intake will be reduced because fish passage in the historical side channel will no longer occur and passage over the new weir will likely be reduced or at least will not improve. Secondly, if the bypass channel fails because of siltation or a blow-out occurs from high flows fish passage will certainly be reduced because passage over the weir and through the side channel have also been reduced. In this situation the only financially responsible parties to fix the bypass through adaptive management is the BOR or irrigators which in reality do not have the funding to execute such repairs or modifications. | The text has been changed to reflect that the bypass channel is expected to improve fish passage at Intake . |

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| 62 | Pg 4-16 last paragraph states "Strong swimming fish (e.g., adult sauger) can currently pass upstream of Intake Dam under most flows." This is partially true, sauger less than 3 years old have difficulty passing over the dam most years. However, the statement is false because the flows at which sauger pass over the structure have not been identified. One certainty is they cannot pass over the dam at "most flows", in fact it probably takes some very specific flow events to allow sauger passage. | The language has been changed to indicate that strong swimming fish currently pass under some flows. |
| 63 | Pg 4-23foot access to the portion of Joe's Island that would be bisected by the bypass channel" would be long-term but minimal impact" and only provides limited opportunities. Any access that is publicly accessible, especially by vehicle or by foot, is important and needs to be maintained. This impact would be permanent and should be considered a significant impact associated with constructing the bypass. | When all factors are considered, the lead agencies believe that reduced foot and vehicle access to a portion of Joe's Island does not result in significant environmental impacts. If MWFP has additional information pertaining to the magnitude of these impacts, the lead agencies would be interested in receiving this information. |
| 64 | Pg 4-24 last paragraph claims that there is only a "primitive" boat ramp at Elk Island. There are actually two concrete boat ramps at Elk Island. | This information has been corrected. |
| 65 | Pg 4-25 state "…boating waterway that provides easier access upstream than the current access of boating over the Rock Ramp". The new higher weir and side channel plug will drastically reduce upstream boat navigation. The new weir would become a significant boating hazard to floaters and/or jet boats. Jet boating over the old dam is fairly popular during higher flows, the higher weir may eliminate this opportunity. | The depth of water above the new weir will be very similar to the depth above the existing weir. Depending on the final selected weir configuration (i.e. inclusion of "notches"), certain locations on the new weir may have greater depth than the average depth over the existing weir. Jet boating opportunities are not expected to be adversely impacted. |
| 66 | Pg 4-24 and 4-25 Extensive detail was provided regarding potential impact to boat ramp. It states "……this alternative (bypass) could result in a boating waterway that provides easier access upstream….." Does this statement suggest no boating restrictions within the bypass? I would assume increased bank erosion would be a concern from wakes created by boat traffic. | MFWP has jurisdiction to regulate boating on State waterways. They have not indicated whether they would limit boating in the bypass channel.<br><br>If monitoring indicates boat wakes are impacting channel morphology, adaptive management measures would be considered. |
| 67 | Pg 4-26 upstream boating recreation will be reduced significantly because of reduce ability to navigate over higher weir and assuming upstream boat navigation through the bypass channel will not be tolerated. | See responses to comments #65 and #66. |
| 68 | Reducing fish passage from the entire river width (664 feet) plus the width of the side channel (40 feet) to a bypass channel that | The lead agencies are conducting extensive modeling efforts, including construction of a physical model, to identify potential |

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| | accommodates only 15% of river and is only 40 feet wide at the bottom. This is particularly unsettling if the bypass fails to provide fish passage or if the structure silts shut (like the Huntley bypass channel did the first year in operation) or blows out from a large flow event. This concern/uncertainty is demonstrated in the EA on pg 4-13 "it is uncertain exactly what kind of sheer flows or eddies may form near the downstream end of the bypass channel. Complex flows that become established at the fishway entrance could affect passage. Migrating telemetry-tagged pallid sturgeon in the Lower Missouri River have had difficulties and failed to pass exits in constructed side channels with high velocities, turbulent flow and deep scours." If fish passage does not occur through the bypass channel, management of all fish species and populations in the Yellowstone River will be compromised because existing passage options (over the dam or through the side channel) will be reduced or eliminated. | design issues and resolve them prior to construction. |
| 69 | Pg v: How can a bypass channel alternative be a "more natural fishway" than the rock ramp? The rock ramp alternative provides fish passage over the entire width of river which is 664 feet wide plus a side channel that is an additional 40 feet wide (pallid sturgeon migrations occur when river flows are high and corresponds when water is flowing through the side channel). Combined, both of these provide fish passage potential over a 704 feet wide area. The bypass alternative reduces passage down to a 40 foot wide area, passage over the new dam will be reduced or eliminated because of the increased height and length and fish passage through the old side channel will be eliminated by the concrete plug. The bypass channel alternative reduces the available width of river for passage from 704 feet to 40 feet, which is a 94% width reduction! Again, how is this considered a more natural fishway? | This characterization has been removed from the document. |
| 70 | Pg v: A new three mile long bypass channel, 664 foot wide concrete dam and concrete plug in the side channel are permanent impacts. How can any of these permanent impacts be "considered minor"? Both paragraphs on pg v are weak and need to be rewritten or additional explanation provided as to why the Bypass Channel was selected as the preferred alternative. | The text has been revised to provide a better summary of anticipated impacts.<br><br>The Preferred Alternative section in Chapter 2 has been expanded to describe the factors the lead agencies considered in selecting the preferred alternative, including: the fish passage connectivity index results, constructability, ice forces, cost effectiveness, pallid side |

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| | | channel use, risk, and uncertainty. |
| 71 | Ch 1 pg iv first sentence under Nature of Decisions to be Made states "provided no significant are identified….". I believe the work impacts are missing from this sentence. | This correction has been made. |
| 72 | Pg 2-11 add another paragraph that shares with readers some of the uncertainties of the bypass alternative. The paragraph should include: pg 4-13 "…it is uncertain exactly what kind of sheer flows or eddies may form near the downstream end of the bypass channel. Complex flows that become established at the fishway entrance could affect passage. Migrating telemetry-tagged pallid sturgeon in the Lower Missouri River have had difficulties and failed to pass exits in constructed side channels with high velocities, turbulent flow and deep scours."; pg 4-17 "….one of the main areas of uncertainty in designing fish passage projects is designing the fishway such that a fish will align with and utilize it. Because the rock ramp alternative is designed to provide passage across the full width of the main channel, and is designed to carry the whole flow of the main channel, there would be very little risk in a fish not being able to find the fish passage feature of the rock ramp."; 3) pg 6 appendix J – use the first three paragraphs under "2.0 Project Uncertainties". All of this information provides, to the reader, some of the inherent difficulty in providing successful fish passage alternatives. | Additional information has been included in the Chapter 2 – Preferred Alternative section describing the factors the lead agencies have considered in selecting the preferred alternative, including: the fish passage connectivity index results, constructability, ice forces, cost effectiveness, pallid side channel use, risk, and uncertainty. |
| 73 | Pg 3-1 states "the existing conditions of resources potentially affected by the Intake Project have, for the most part, not changed…."; They actually have changed substantially! Excavation of a 15,500 foot by 40 feet wide channel is a very significant change. Placing a concrete dam in the side channel is also a very significant change because the side channel will no longer pass fish or allow boat navigation. | This section states that conditions have not changed, for the most part, since issuance of the 2010 EA. |
| 74 | Design of the new weir must have modifications to accommodate improved fish passage. Suggestions would be reducing the top width from 24 feet, using a crowned surface like the historic dam design, and have lowered sections that would increase water depth and diversity of water velocities. | A 2013 Value Engineering Study considered a range of options to address these concerns, including decreasing the width of the weir crest and designs that eliminate laminar flows (Corps 2013). Several viable alternatives were identified. As the weir designs progress, these options will be incorporated into the design. |
| 75 | At the meeting in Billings on March 2$^{8th}$ we had a specific discussion | The lead agencies are conducting extensive modeling efforts, |

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| | about the need to engineer for the large back eddy that forms annually at the proposed location of the bypass channel fish entrance. The engineers did not seem to understand or model for this reality. This needs to be added to the EA including the cost estimates for dealing with the eddy. A similar issue is the migration of the river bank and side channel at the proposed water entrance. Recent review of aerial maps demonstrates that both the stream bank and side channel have changed by approximately 400 feet laterally in the last 60 years. Securing the longevity of the concrete invert sill, considering this lateral movement, will require substantially more rip rap on upstream and downstream shorelines. These two aspects would be a significant cost increase to the construction cost provided in the EA. These increased costs may be substantial enough to make other alternatives cheaper or more practical. | including construction of a physical model, to identify potential design issues and resolve them prior to construction. |
| 76 | Pg iv states "It would also replace Intake Diversion Dam with a concrete weir to raise the surface elevation of the river in front of the proposed bypass channel." Dam affect on surface water levels at the point of bypass water entry will be minimal. Modeling must indicate this? Additionally at what flows would this dam be "needed" to provide adequate water level in the bypass channel? The "need" is likely during extremely low flows, when fishes movement is far less than during other seasons/flows. The statement that the dam is needed for the bypass appears is likely inaccurate biologically. Pg 2-3 and pg 2-6 pg 4-7 pg 4-15 similar statements | The lead agencies hope that the collaborative stakeholder meetings conducted in 2013 provided stakeholders with information necessary to understand that the new weir is required to regulate flows into the bypass channel. |
| 77 | Pg v: How is the bypass channel "more efficient at providing fish passage benefits", this is an opinion with no factual basis. How can conceptual designs be evaluated on their efficiency at providing fish passage? This needs to be removed! The only bypass channel specifically designed to pass sturgeon in the Yellowstone drainage has yet to pass a sturgeon after 5 migration seasons (T & Y bypass on the Tongue River). | The text has been removed. |
| 78 | Ch 1 pg ii last paragraph states "…cost estimate for the rock ramp was approximately $18 million." The 2010 EA on pg 12 states "the estimated cost of construction is $38.8 million. This would include $18.2 million for the new headworks, canal extension, and fish screens, $13.5 million for the rock ramp and $7.1 million for non-contract costs." Why the difference in costs? | The direct costs of the rock ramp and indirect (non-contract) costs were estimated at approximately $18 million. |

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| 79 | Ch 1 pg iii states "…..rock ramp could approach $90 million." However, pg 2-10 presents a figure of $80 million. Inconsistency is very confusing. | The $90 million dollar reference in Chapter 1 describes the initial estimate that contributed to re-evaluation. The estimate in Chapter 2 reflects refinement of the costs as bypass channel designs have been refined. |
| 80 | Pg 2-5 first paragraph talks about four rock structures – what are these? | This section has been revised and expanded, and reference to these structures has been removed. |
| 81 | Pg 2-5 the fourth paragraph should mention that the "low-level discharge pipe" is 18 inches in diameter. | Language reflecting the ongoing design of this structure has been included. |
| 82 | Pg 2-5 the fifth paragraph needs to include a description of how engineering and construction will address the extremely large eddy that historically forms at the bypass channel fish entrance. This will increase cost of the bypass by a significant amount that is probably not reflected in the construction cost on pg 2-6 and Tables 2 & 3 Appendix E. | The description in this section has been revised and expanded. |
| 83 | Pg 2-5 fifth paragraph should include latest knowledge of reviewing aerial photography of stream bank erosion at concrete sill invert. This already demonstrates that the portion of the existing side channel is not stable. Since 1950 (60 years) the bank of the river has migrated approximately 400 feet laterally upstream and downstream of the proposed bypass channel water entrance. The side channels east bank has also migrated approximately 400 feet laterally over the same time period. This new reality will require substantially more rip rap armoring around the concrete sill to maintain its functionality. This will increase cost of the bypass by a significant amount that is probably not reflected in construction cost on pg 2-6 and Tables 2 & 3 Appendix E. | The design team is aware of these issues. The current designs and costs reflect these circumstances. |
| 84 | Pg 2-6 states "A new, raised concrete dam….", the amount raised, in feet, and the structural size (664 feet wide by 20 feet long) needs to be included in this paragraph. It should also describe the design which is a flat cap. We would actually like to see it much narrower and crowned like the design of the amount of additional head requirement needed. The weir for the Rock Ramp alternative provides the following language on pg 2-7 "The weir crest would vary in elevation, including at least one low-flow channel for fish passage. The variable crest would offer an array of depth-velocity habitat zones for fish migration under a wide range of flows, which are typical on the Lower Yellowstone River. The channels in the | The description in this section has been revised and expanded.<br><br>A 2013 Value Engineering Study considered a range of options to address these concerns, including decreasing the width of the weir crest and designs that eliminate laminar flows **(Corps 2013).** Several viable alternatives were identified. As the weir designs progress, these options will be incorporated into the design. |

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| | weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet deep."  These same designs need to be incorporated into the bypass channel weir for the same reasons. | |
| 85 | Pg 4-2 states "The Bypass Channel Alternative would not change the slope of the main channel of the Yellowstone River."  This is inaccurate; according to our understanding the new weir will be higher than the old concrete structure which will increase sedimentation and decrease slope upstream of the dam. | There is no old concrete structure; the historic structure is a rock filled timber crib with rock added above the wood crest.<br>The elevation of the proposed weir in 30% design is approximately 1990.5.  Current and future analyses are considering variation in the crest elevation between approximately 1988 and 1991. The current weir, with the rock on top of the crest, likely varies between 1988 and 1992, depending on time of year and whether or not rock has recently been added. |
| 86 | Pg 4-3 and pg 4-4 The channel migration zone is mentioned. Joe's Island, location of the bypass, is located in the migration zone. What happens if lateral migration occurs? The bypass water entrance is also located in the channel migration zone. The water entrance is located on an outside bend within the migration zone, thus it would appear there is potential for migration in this location. Would migration at this point be detrimental to the water entrance? If stabilization is required at this location the estimated impact and affect to channel migration zone acres was grossly underestimated. In addition, the bypass is equipped with concrete and rip rap stabilization to prevent avulsion as stated on pg 4-7 thus affecting impact to channel migration zone further supporting the assumption that the impact to channel migration zone acres was grossly underestimated. | There is stabilization to ensure the channel does not migrate at the entrance and exits. This stabilization has been accounted for in the EA. |
| 87 | Pg 4-14 states "the bypass channel is expected to function very much like a natural side channel, and as such, is likely to be utilized by many species of fish including sturgeon."  This is exaggerated, the current dam causes significant turbulence and water velocities that are not experienced at all the other side channels that pallid sturgeon utilized.  Limited attraction flows resulting from the large eddy at Intake Dam are also not experienced at any of the side channels encountered by pallid sturgeon. | The text has been changed from "expected" to "intended". |

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| 88 | Pg 4-16 an 18" culvert in the concrete plug will become plugged within the first year by siltation or woody debris or a combination of both. This will result in the side channel being dewatered and eliminate this historic fish habitat and passage route most of the year – it would only be recharged when a 60,000 cfs flow event occurs. This opinion comes from years of watching culverts twice this size fail repeatedly. Unless a success example of this size of culvert being used on the Yellowstone River is provided the deductions provided in the EA about the benefits of this culvert are inaccurate. | The Corp and Reclamation will consider design options to improve performance of the structure at the junction of the bypass channel and existing side channel. |
| 89 | Pg A.1-32 the BRT did provide input on the two action alternatives but they did prefer the rock ramp over the bypass alternative. This should be noted in the EA. | The Corps and Reclamation continue to work with the BRT and the Fish and Wildlife Service to improve and evaluate the alternatives. |