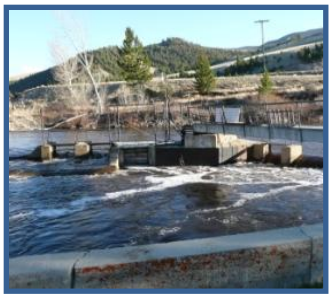

PUBLIC AND AGENCY REVIEW DRAFT

ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

December 2009

DOWL HKM

ENVIRONMENTAL ASSESSMENT
for
Big Hole River Diversion Dam
in
Silver Bow and Beaverhead Counties, Montana

Reviewed & Approved for Distribution:

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Abstract: The proposed project is a diversion dam replacement initiated by the City and County of Butte-Silver Bow. The Proposed Action is to replace the existing Big Hole River diversion dam and intake structure in order to provide a reliable source of potable water for the Butte service area. The Preferred Alternative provides a reliable diversion system, improves safety at the site for maintenance personnel and recreational users, and improves boat and fish passage.

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Supporting Technical Report

Water Master Plan, Robert Peccia & Associates (RPA), July 2008.

Copies of this report are available for review at the following locations:

BSB Public Works Office
126 W. Granite
Butte, MT 59701
(406) 497-6515

DOWL HKM
130 N. Main Street
Butte, MT 59701
(406) 723-8213

ABBREVIATIONS AND ACRONYMS

BLM.....United States Bureau of Land Management
BRR.....Biological Resources Report
BSB.....City and County of Butte-Silver Bow
CFR.....Code of Federal Regulations
cfs.....cubic feet per second
CWA.....Clean Water Act
DEQ.....Montana Department of Environmental Quality
DNRC.....Montana Department of Natural Resources and Conservation
EA.....Environmental Assessment
EPA.....United States Environmental Protection Agency
FEMA.....Federal Emergency Management Agency
FWP.....Montana Fish, Wildlife & Parks
FWS.....United States Fish and Wildlife Service
HPC.....Historic Preservation Commission
HUC.....Hydrologic Unit Code
MCA.....Montana Code Annotated
MDT.....Montana Department of Transportation
MEPA.....Montana Environmental Policy Act
MFISH.....Montana Fisheries Information System
mgd.....million gallons per day
MNHP.....Montana Natural Heritage Program
MPDES.....Montana Pollution Discharge Elimination System
NEPA.....National Environmental Policy Act
NRCS.....Natural Resources Conservation Service
NRDP.....Natural Resource Damage Program
NRHP.....National Register of Historic Places
NRIS.....Natural Resource Information System
SHPO.....State Historic Preservation Office
SPA.....Stream Protection Act
SSURGO.....Soil Survey Geographic
USACE.....United States Army Corps of Engineers
U.S.C.....United States Code
WMA.....Wildlife Management Act

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1.0 Purpose and Need for the Proposed Action

1.1 Proposed Action

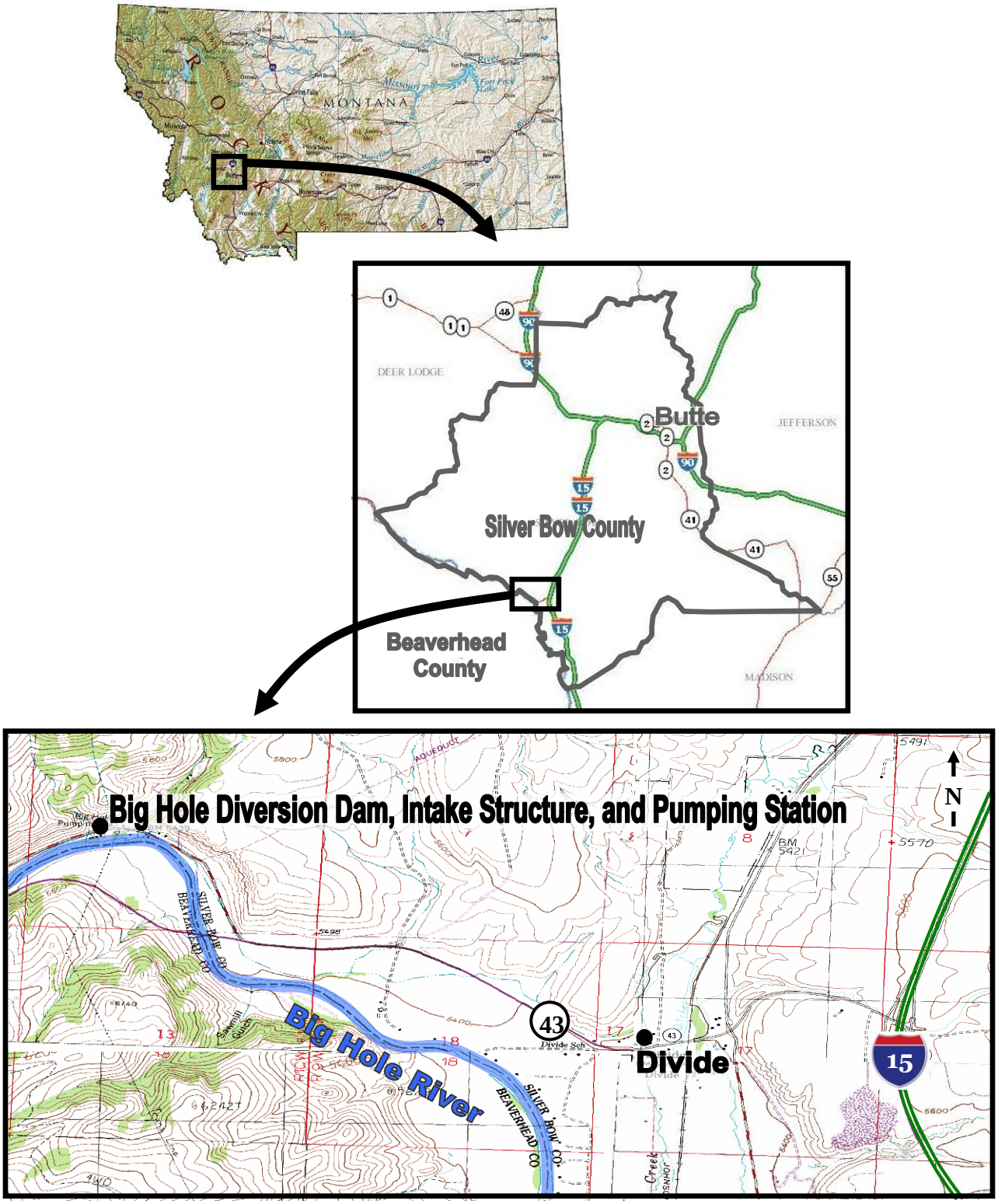
The proposed project is to replace the existing Big Hole River diversion dam and intake structure in order to provide a reliable source of potable water for the Butte service area. The facility is owned and managed by the City and County of Butte-Silver Bow (BSB) and is used to divert water from the Big Hole River to an adjacent pump station located on the river's north bank. The pump station lifts the water to a treatment plant located outside the project area approximately 10 miles to the northeast. Treated water is then piped another 11 miles northeast to storage and distribution systems in Butte, Montana. This system provides approximately 65 percent of the city's potable water.

Primary funding for this project is provided through a grant from the Natural Resource Damage Program (NRDP), with matching funds provided by BSB. Additionally, the U.S. Army Corps of Engineers (USACE) has committed to provide secondary funding for the environmental and design phases of the project.

1.2 Project Area Description

As illustrated in Figure 1-1, the proposed project is located in the Big Hole River on the border of Silver Bow and Beaverhead Counties near the community of Divide, Montana within Township 1S, Range 10W, Section 12.

Figure 1-1 Project Location Map



Note: Figure not to scale.

1.3 Purpose of the Proposed Action

The purpose of the proposed project is to provide a reliable source of drinking water for the Butte service area and to improve safety at the diversion dam site for maintenance personnel and public recreational use.

1.4 Need for the Proposed Action

The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction. Loss of the diversion dam would deprive the citizens of Butte of potable water. Additionally, there are safety issues associated with maintenance and recreation at the site. These concerns are discussed in more detail below.

Existing Big Hole River Diversion Dam. DOWL HKM, 2009.

In 2008, BSB developed a Water Master Plan that evaluated the condition of various existing facilities in the Butte Water System. The Master Plan identified major deficiencies associated with the existing Big Hole diversion dam. Drawing from the Master Plan, the following sections describe in more detail the need for replacement of the existing facility.

Threat of Failure or Malfunction

The dam's downstream timber apron is failing, which has resulted in undercutting at the base of the dam. In recent years, emergency repairs have been required to abate this undercutting and prevent dam failure, and have included placement of large rocks below the dam to fill voids and to prevent further erosion of materials from under the dam. These repairs are considered temporary in nature and cannot be relied upon as a long-term strategy to prevent dam failure. A new scour hole was recently discovered under the dam that will require repair in the immediate future to prevent dam failure.

Deterioration of the Concrete Cap and Wall of the Settling Basin, facing southwest. HRA, 2009.

In addition to the timber apron, the concrete structure itself has severely deteriorated, including the abutment walls, settling basin, and intake structure. While these elements have been repaired several times, their strength has been compromised and they are in need of replacement.

The existing dam height and resulting water elevation is marginally sufficient to meet the suction head requirements of the vertical turbine pumps. A settlement or failure of the dam due to undercutting or further deterioration of the concrete structure would lead to a drop in water level, thereby preventing operation of the pumps and resulting in the loss of Butte's main source of potable water.

Apart from total failure of the diversion dam facility, winter conditions also threaten the flow of potable water to the Butte service area. Icing problems can obstruct the intake gates and intake structure. Ice must be removed by hand to prevent blockage that would result in interruption of flow to the Big Hole Water Treatment Plant and treated water consumers.

Safety Concerns

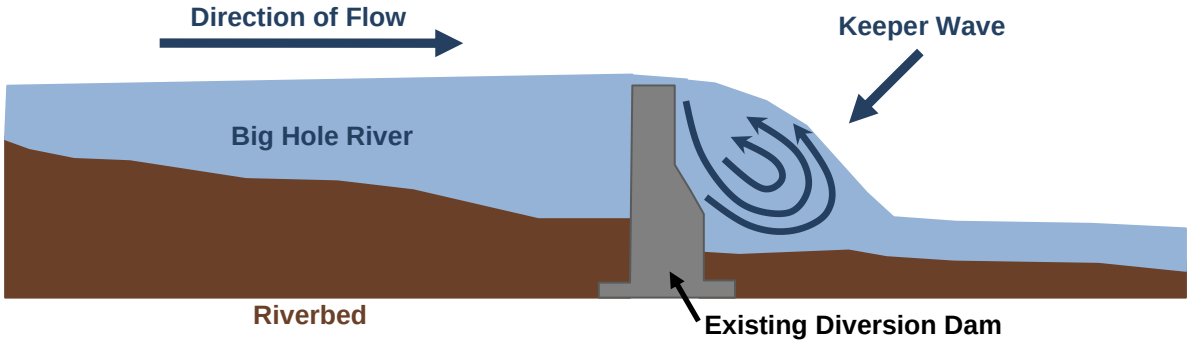
There are two main safety hazards associated with the operation and design of the existing dam structure. First, as noted above, the facility experiences icing problems in winter months. In order to remove blockages, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning.

BSB Personnel Risk Injury at the Diversion Dam Site. DOWL HKM, 2009.

Secondly, the current configuration of the dam results in a turbulent area immediately downstream of the dam crest that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam. This turbulent area is generally referred to as a "keeper wave," and is illustrated conceptually in Figure 1-2. Based on anecdotal evidence, there have been a number of incidents at the diversion dam site in recent years involving boaters becoming trapped in this keeper wave and requiring external retrieval and rescue. This results in danger to both boaters and rescue personnel.

Warning Sign for Boaters. WHPacific, 2009.

Figure 1-2 Conceptual Illustration of Keeper Wave Downstream of Existing Diversion Dam



1.5 Project Goals, Screening Criteria, and Design Criteria

Project goals were developed to aid in the development and evaluation of proposed project alternatives. Through the Environmental Assessment (EA) scoping process, BSB gathered input from BSB operation and maintenance personnel, regulatory agencies, stakeholders, and members of the public to aid in establishing project goals. As noted in previous sections, the reliability of the water source and the potential for dam failure or malfunction are of primary concern. The Big Hole River must continue to serve as a source of potable water for Butte. BSB personnel have expressed concern regarding icing, debris and sediment loading, maintenance requirements, and safety issues. BSB, regulatory agencies, and members of the public are also concerned that the existing diversion dam serves as a check point for larger aquatic organisms; due to the facility's design, fish have difficulty passing the existing structure. Similarly, the existing structure presents challenges for safe boater passage. Regulatory agencies also voiced concern about environmental impacts that might result from the proposed project.

These concerns were considered in the development of the following Project Goals, which are not listed in order of importance.

- Goal 1: Provide a reliable source of potable water for the BSB service area
- Goal 2: Reduce maintenance requirements
- Goal 3: Reduce icing problems
- Goal 4: Improve fish passage
- Goal 5: Improve boat passage safety
- Goal 6: Minimize impacts to environmental resources
- Goal 7: Improve safety for maintenance personnel
- Goal 8: Minimize project costs

These project goals are used in Chapter 5 as Screening Criteria to aid in the evaluation of alternatives and selection of the Preferred Alternative.

2.0 Alternatives Development

2.1 No Action Alternative

Alternative 1: No Action

The Big Hole Diversion Dam was constructed in approximately 1927. The diversion dam consists of a concrete dam wall with a vertical upstream face, which is approximately five feet high and 10 feet wide at the bottom. The dam wall was constructed on top of an 18-inch-thick base slab with a 4-foot-deep cut-off wall on the upstream side. The downstream apron of the dam is approximately 12 feet wide and constructed of 12-foot-long by 6x6-inch timbers. The total length of the dam is approximately 190 feet. Depending upon water levels and river flow conditions, water can be diverted from the river at a multitude of locations, including the center channel raceway, the upstream weir, and a concrete pier located mid-river. As water is diverted from the river, it enters a concrete settling basin to allow for settlement and removal of debris and sediment before entering the concrete pier. From the concrete pier, water is conveyed via a 4-foot by 5-foot concrete pipe to a 20-foot-diameter concrete cistern located on the north bank of the river. Discharge piping from the cistern feeds a common suction header pipe with individual pipe branches to each of the vertical turbine pumps in the pump station building.

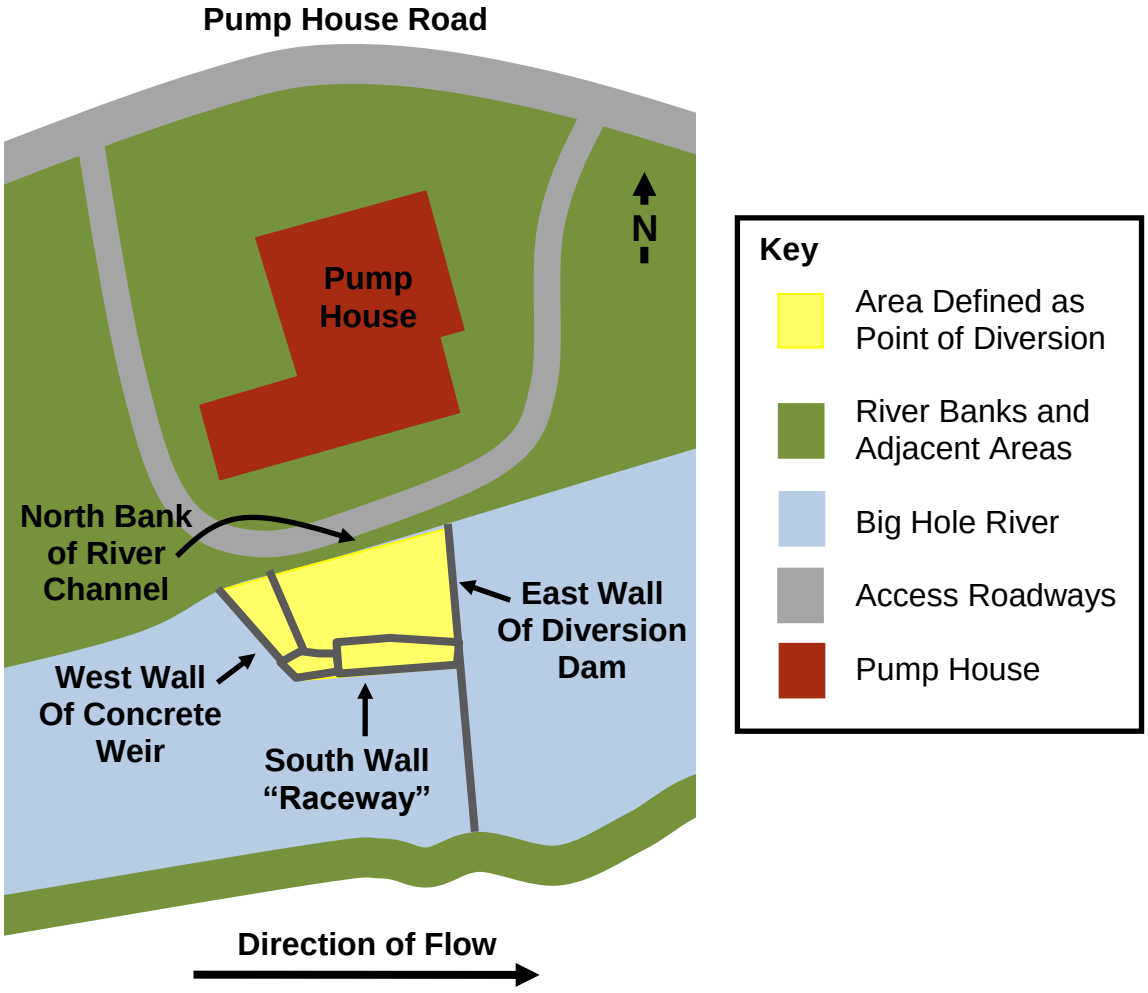
Alternative 1 would consist of leaving the facility in its current configuration and state of operation. Although routine maintenance would be provided, critical elements of the structure would continue to deteriorate over time. The high risk of failure or malfunction would remain, with the associated threat of interruption of potable water service to Butte. Further, there would be no improvement in safety for BSB personnel or for boaters at the site. Additionally, fish passage would continue to be impeded by the existing diversion dam.

The existing point of diversion would remain unchanged under this alternative, which would eliminate the need for a lengthy permitting process potentially involving the readjudication of BSB's existing water right. As noted previously, water is diverted from the Big Hole River at various locations within the existing diversion dam and intake configuration depending on the flows during a particular time of year. Accordingly, in consultation with the Montana Department of Natural Resources and Conservation (DNRC) Water Resources, the existing point of diversion has been defined as the footprint or area approximately 750 square feet in size bound by the following system components:

- The south wall of the existing concrete channel known as the "raceway"
- The west wall of the existing concrete upstream weir
- The north bank of the river channel
- The east wall of the existing diversion dam back to the intersection of the south wall of the raceway

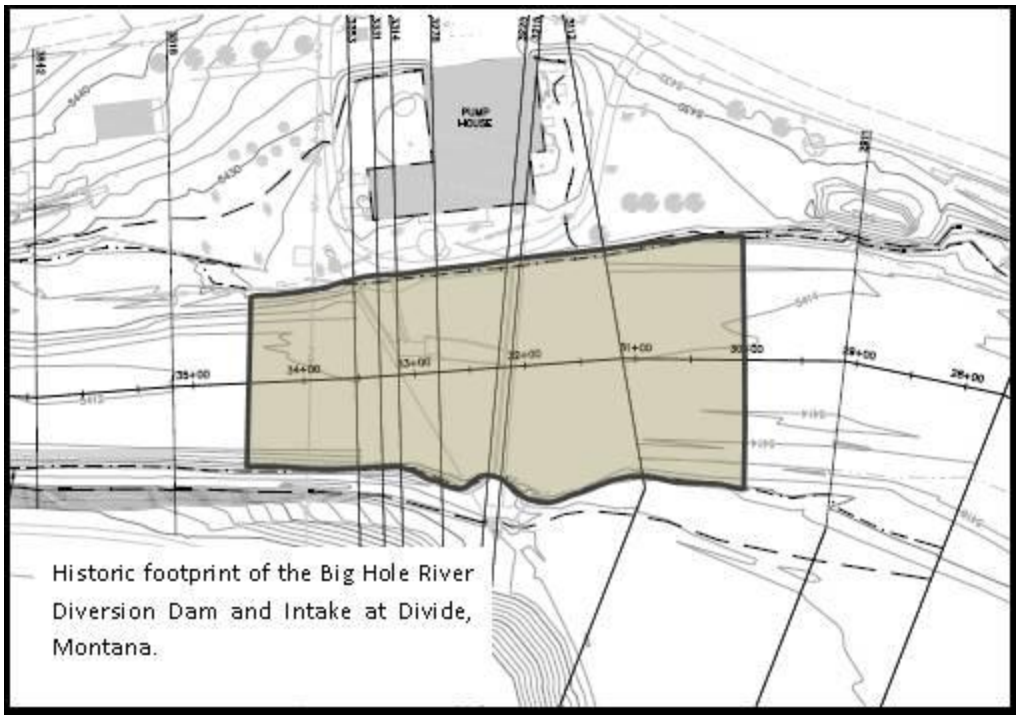
Figure 2-1 illustrates these system components and provides a reference figure for Alternative 1: No Action. A letter from DNRC Water Resources confirming this definition of the existing point of diversion is included in Appendix A.

Figure 2-1 Illustration of Alternative 1: No Action and Area Defined as Point of Diversion



For purposes of permitting through DNRC Trust Lands, the historic footprint has been defined more broadly to include the area of historic maintenance activities upstream and downstream of the diversion dam structure. This historic footprint is defined as an area approximately 400 feet in length by the width of the river comprising approximately 1.6 acres. More specifically, the area is defined as Station 30+50 downstream and 34+50 upstream and by the north and south banks of the river, as illustrated in Figure 2-2 (Appendix B contains a full description of the historic footprint).

Figure 2-2 Historic Footprint of Existing Diversion Dam Including Historic Maintenance



Source: DOWL HKM, 2009.

2.2 Proposed Action Alternatives

Through public involvement activities and interdisciplinary coordination with federal, state, and local officials and regulatory agencies, a number of alternatives were developed and analyzed for their operational benefits and impacts to the surrounding built and natural environment. A total of four Action Alternatives were considered for this project. These alternatives are described in more detail below. Preliminary design drawings illustrating these alternatives are included in Appendix C. A supporting Alternatives Analysis Report is included in Appendix D.

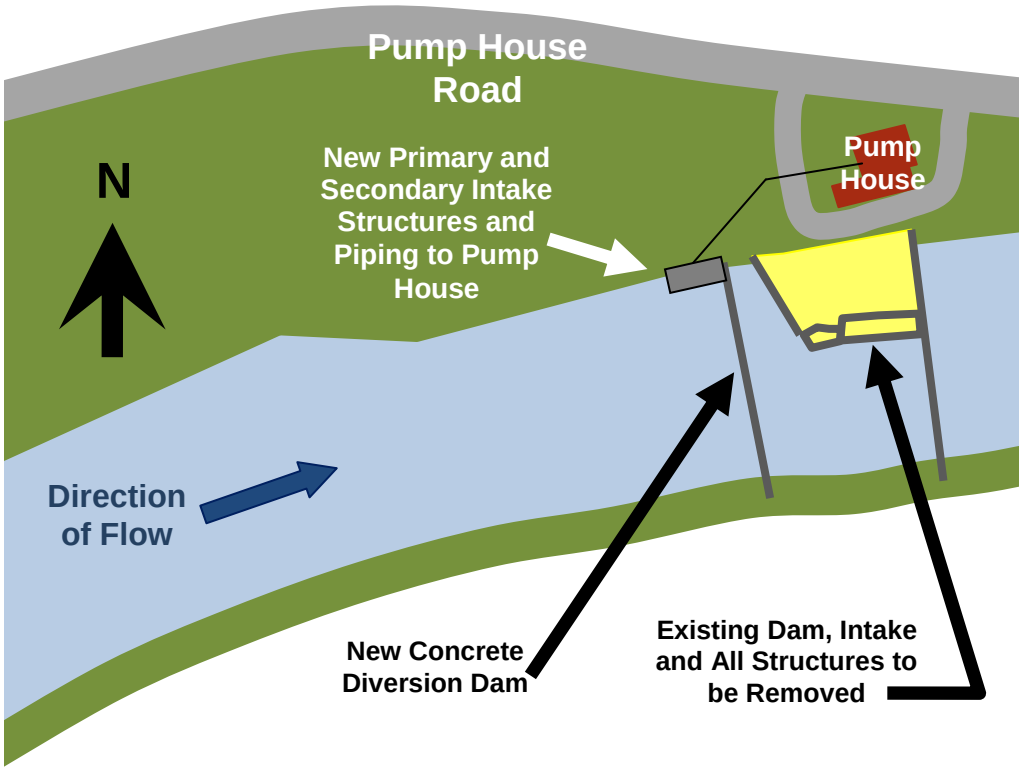
It should be noted that the Action Alternatives were designed to meet minimum functional requirements, including improved pump suction head, improved water diversion during periods of low flows, decreased sediment loading and improved trash removal, adequate design life, maximum and minimum water flow conveyance capabilities, and improved water diversion during periods of cold weather and icing. During the design process, the following Design Criteria were defined for each of the Action Alternatives.

- BSB's historical water right of 21.26 cubic feet per second (cfs) can be diverted at river flows at or above a defined low flow value of 200 cfs
- Boat passage is possible through the diversion dam at river flows at or above a defined value of 300 cfs; at lower flows, overland portage is required over certain portions of the river both up and downstream of the diversion dam
- For flows at or above the defined low flow value of 200 cfs, the minimum water surface elevation needed to provide sufficient hydraulic head is defined as 5,419 feet.

Alternative 2: Replace in Kind

Alternative 2 would replace the existing concrete diversion dam, intake structure, and intake piping with a new dam and intake system that would be nearly identical to the existing dam in location, alignment, and configuration. Figure 2-3 presents a graphical illustration of Alternative 2: Replace in Kind. Detailed drawings are presented in Appendix C.

Figure 2-3 Illustration of Alternative 2: Replace in Kind



Alternative 2 would include the removal and replacement of the existing concrete dam and all other associated components. The new concrete dam structure would be located just upstream of the existing dam to allow for continued operation of the existing system during construction activities, and would therefore require a permit for a new point of diversion through DNRC. The new in-stream dam would create a slightly higher water surface elevation upstream of the dam to improve existing pump performance.

The new concrete dam would be located at approximately Station 33+80 (see drawings provided in Appendix C). It would cross the river channel at nearly right angles and would be approximately 147 feet in length. The dam crest would be established at an elevation of 5,418.8 feet and would include a stepped dam face to eliminate the keeper wave that currently exists. An upstream grouted toe trench would be installed immediately upstream of the new dam face to preclude water from flowing beneath the dam and serve as a cutoff wall. The new dam would bear on a concrete footing placed below the river bed and would be monolithically connected to a downstream concrete apron and eventual native rock transition to the river bed. The dam would function by blocking the river flow and damming up the water level until it overtopped the dam crest. An upstream pool would be created with an approximate depth of five to six feet at

the dam face. This upstream pool would provide an upstream water surface elevation of approximately 5,419 feet at all flows. This upstream water surface elevation would establish the amount of available head that could be used to convey water to the pumps through the position of a new intake and connector piping to be located on the north shoreline.

The existing diversion dam and intake structure includes a settling basin intended to provide a protected backwater area that would enable settling out of larger particles and debris such as pine cones, leaves and small gravels prior to the flow entering the piping and eventually the pump suction lines. Based on historical reviews of maintenance activities, the effectiveness of this system has been questioned and it was determined that a sedimentation basin is no longer necessary for the following reasons:

1. The water system has been altered substantially since the original dam and diversion structures were constructed; most notably, a water treatment plant was constructed in the 1990's that intercepts the raw water flow, and provides both chemical and physical treatment of the raw water before delivering to the water users. Historically, prior to this treatment facility, raw water was simply disinfected and delivered to the end users.

2. The proposed intake structures will be fitted with screens that are sized to preclude debris and trash from entering the system. Screen and screen materials have evolved substantially in terms of availability, materials of construction, and technological advancements since the original construction of the dam and intake structure, and are very efficient at sediment and debris removal in a river setting.

3. Historically, sediment loading levels in the river are the highest during runoff events, either snow melt or rain storms. This also coincides with the highest river flows. Under existing conditions, the river flows simply overtop the upstream weir and flood the existing settling basin, thereby rendering it ineffective for sediment removal. Although the settling basin is effective in removing sediment during period of lower flows, the need is minimal because the sediment loading levels in the river are much lower during these periods.

For these reasons, new piping would convey raw water directly from the intake to the existing pumps, no longer routing through a settling basin.

The existing intake system would be replaced by a new slotted intake screen at a new primary intake on the north bank. The intake structure would consist of a simple concrete chute located adjacent to the north shoreline and integral to the north abutment of the new concrete dam. The footprint of the concrete chute would be approximately 45 feet in length parallel to the river bank and 20 feet in width. The actual chute would be approximately 24 feet in length and six feet wide. The chute would be designed such that the floor of the channel would be located at an approximate elevation of 5,414 feet. Each side of the chute would be fitted with intake screens along the entire length that would enable water flow through the screens into a collection box which would then be piped north and east into the existing pump station building. The new piping would enter the west side of the existing pump station building, proceed along the north wall of the pump bay and connect to the existing suction header on the north side. The operation of the intake would rely upon the consistent control of the upstream water surface elevation.

This upstream water surface elevation would be maintained by a control valve located on the downstream end of the concrete chute. Allowing more or less water to pass through the chute would determine water flow over the dam crest and ultimately the upstream water surface elevation.

Figure 2-4 Depiction of a Fontaine Butterfly Channel Gate

Note: Valve is constructed of stainless steel and w mounted to the side and floor of the channel.

Two design options are being considered for the intake control valve: a butterfly channel gate valve and an Obermeyer gate valve

The butterfly channel gate valve would serve as a control valve to "check" or maintain the upstream water surface elevation. The butterfly valve would be located within the concrete chute in a vertical position; through use of an operator handwheel, the valve could be positioned by rotating the valve face from completely perpendicular to the river flow to completely parallel to the river flow. As the valve is opened, it would create maximum water flow velocity along the edges of the concrete chute upstream of the valve which would enable cleaning and flushing of the upstream intake screens. Figure 2-4 shows a typical butterfly channel gate valve. The main advantage of the butterfly valve is its ability to provide operational flexibility to enable maximum system performance during variable river flows, weather conditions, and raw water demands, while the main disadvantage is the possibility of ice collection and deposition during periods of extreme cold weather, although an aeration system could be installed to reduce ice formation.

Figure 2-5 Depiction of an Installed Obermeyer Gate System

Note: Big Hole River application would only span the width of the intake chute (approximately six feet).

A second intake control valve option would involve an Obermeyer gate valve, which is most simply described as a row of steel gate panels mounted in the floor of the intake chute and supported on their downstream side by inflatable air bladders. By controlling the pressure in the bladders, the pond elevation maintained by the gates can be adjusted within the system control range (full inflation to full deflation) and accurately maintained at user-selected set-points. When fully deflated, the flowline of the chute would allow unrestricted water passage past the intake screens; when fully inflated, the gate would rise to the dam crest level, creating an increase in the upstream water surface elevation. The gate elevation could be varied dependent upon instream flows such that adequate volume and velocity of water could pass through the intake chute to enable adequate diversion, clearing of screens, and passage

of ice and debris over the top of the gate, yet could be adjusted to enable flows over the new dam. The position of the crest of the gate would control flow through both the intake channel and the main channel and also help to regulate the entire upstream water surface pool. Figure 2-5 shows a typical Obermeyer Gate installation. The main advantage of the Obermeyer Gate system is that it can be raised and lowered to efficiently pass flood flows, ice, and debris.

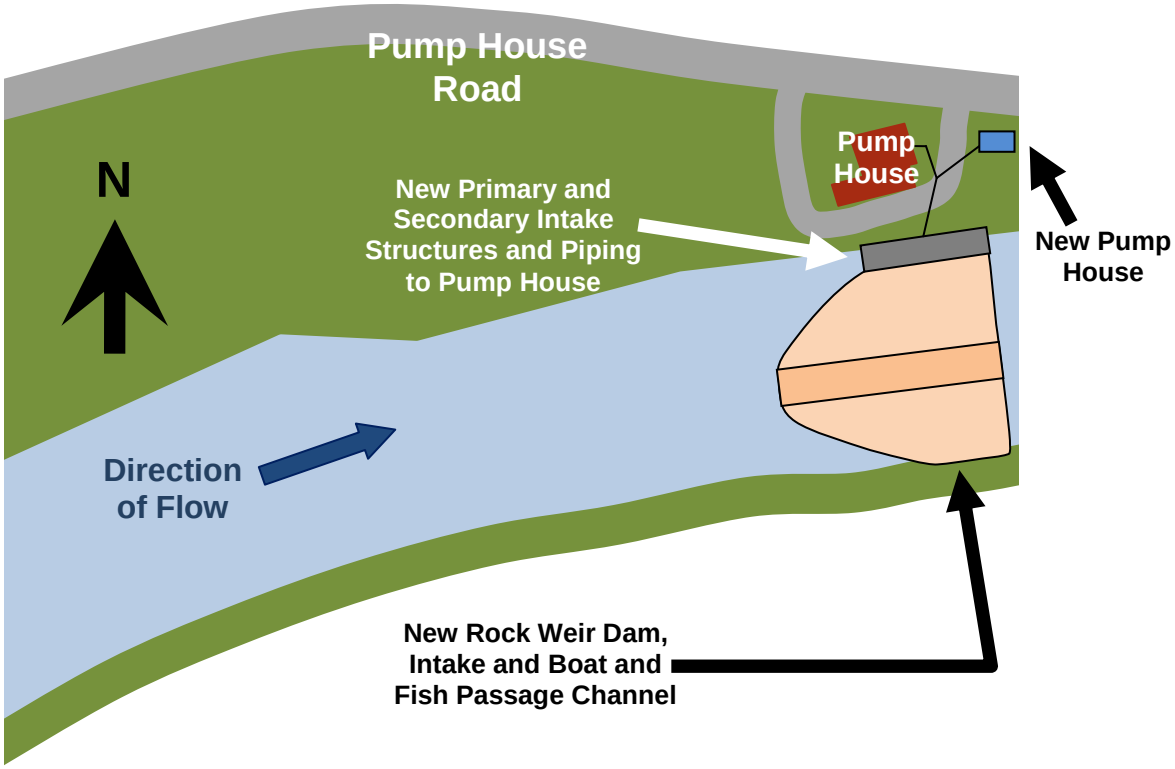
A floating boom would be installed immediately upstream of the intake chute to redirect floating debris from the intake. A secondary intake would also be installed as an integral part of the intake system to provide short-term water delivery pending repair measures in the event of primary intake failure.

This alternative would require a new penetration of the existing pump house, although the existing pump system configuration would be utilized to minimize impacts to the pump house. Upon completion of the new dam and intake system, all existing facilities, including the dam, settling basin, pier, raceway, weir, and cistern would be removed and the river channel would be restored to natural conditions. Alternative 2 would incorporate improved operational and safety features that would benefit maintenance personnel, but would not include boater or fish passage features.

Alternative 3: New Rock Weir Dam and Intake with New Pump House

Alternative 3 would involve complete removal of the existing diversion dam and associated components and installation of a new rock weir dam with a boat and fish passage channel located at the apex. Figure 2-6 presents a graphical illustration of Alternative 3: New Rock Weir Dam, Intake and Pump Station. Detailed drawings are included in Appendix C.

Figure 2-6 Illustration of Alternative 3: New Rock Weir Dam and Intake with New Pump House



Alternative 3 would be constructed in two phases. Phase I would remove the existing diversion dam and associated features, and replace it with a single concave rock weir located in approximately the same location as the existing diversion dam, thereby eliminating the need for a DNRC permit for a change in point of diversion.

As depicted in Figure 2-6, the new dam would be chevron shaped with the nose of the dam located upstream. The dam would function similarly to other dams in that it would serve as a flow impediment and thereby increase the upstream water surface profile. The new rock weir dam would extend from approximately Station 31+25 to Station 34+00 with the crest beginning at the existing dam's south bank abutment, extending upstream 150 feet to the nose of a chevron shape and then back to the existing dam's north bank abutment. The crest of the rock dam would be at elevation 5,420 feet with the upstream face gradually sloping to match the upstream river bottom elevation of 5,414 feet. The downstream face of the dam would also gradually slope to match the river invert elevation of 5,414 feet. The boat and fish passage channel would be located at approximately the river thalweg and would extend from dam crest downstream 250 feet. The spillway width would be designed to allow boaters to float through with oars extended; boaters would not experience any inconvenience while passing through the spillway. The profile of the new weir structure would include small downstream steps to gradually lose elevation down the rock face. The shape and elevation of the weir would be optimized to provide the desired upstream water surface and safe boating and fish passage. The rock weir would be visible during low flow conditions, while intake structures would remain relatively hidden from view at all times. The rock weir would be constructed of quarried rock or native round rock as

opposed to concrete in order to minimize visual impacts. The rock would be grouted to form a natural channel. The grout would be placed such that at least six inches of the rock would be exposed to create an ideal environment for aquatic organisms.

The fish and boat passage channel would consist of a "notch" through the dam that would be trapezoidal in shape and would extend from the upstream water pool through the dam section and have a bottom section width of 27 feet and a top width of 73 feet. The passage channel would include two rest pools measuring approximately 40 feet in length parallel to the river flow and 50 to 75 feet in width perpendicular to the river flow. The slope of the chute of the section immediately downstream of the crest would be approximately 4.3 percent and approximately 6.7 percent for the section between the first and second rest pools. The channel and rest pools would all be constructed from native or quarried rock grouted to form a natural channel. The grout would be placed such that at least six inches of the rock is exposed to create an ideal environment for aquatic organisms.

The new dam would be constructed from grouted rock as well and would bear on a grouted rock keyway that would anchor the structure to the river bed. The dam would function by blocking the river flow and damming up the water level until it overtopped the boat and fish passage channel weir elevation. An upstream pool would be created with an approximate depth of five to six feet at the dam face. This upstream pool would provide an upstream water surface elevation of approximately 5,419 feet at all flows. This upstream water surface elevation would establish the amount of available head that could be used to convey water to the pumps through the position of a new intake and connector piping to be located on the north shoreline.

Phase I would also include construction of new primary and secondary intake systems and new transmission piping from the intake system to the existing pump station with provisions for connection to a new pump station in the future. The primary intake would be located along the existing north wall and would include screens for sediment removal. The new intake structure and functionality would be essentially identical as described under Alternative 2, but would be located within the footprint of the existing diversion dam. Similarly, the intake control valve would involve either a butterfly gate valve or an Obermeyer gate valve with the same benefits as noted in the prior discussion. The secondary intake would be located slightly upstream and would include coarser screens or bar screens to provide short-term water delivery pending repair measures in the event of primary intake failure. As described for Alternative 2, a floating boom would be installed immediately upstream of the intake chute to redirect floating debris from the intake.

During Phase I, the new diversion dam and system components would improve upon the existing available suction head on the existing pumps in the existing pump station. The new dam would create a minimum upstream water surface profile of 5,419 feet and, when coupled with a new intake and conveyance piping, would result in minimal head loss to the existing pump suction header. As a result, Alternative 3 would ensure that the available head to the existing pumps would be equal to or greater than what is currently available over the range of anticipated operational flows. The system would be designed with a "wye" leg such that piping could be extended to and penetrate the east side of the existing pump station building for Phase I

operations, and be fitted to accommodate piping for Phase II. New piping would convey raw water directly from the intake to the existing pumps, no longer routing through a settling basin.

Phase II would involve construction of a new pump house located to the northeast of the existing pump house. New pumps, piping and controls would be a part of the new pump house. In 1995 and 1996, new pumps were installed in the existing pump house, however bedrock conditions were encountered during pump installation, preventing the pumps from being installed at the proper elevations to match with the available water surface elevation of the existing diversion dam and intake structure. As a result, pump cavitation currently occurs more frequently than desired. The new pump house facility would fully alleviate these conditions by providing a new wet well and matching the pump suction bowls to the available minimum upstream water surface elevation, thereby eliminating this concern. Under Phase II, all water delivery components would be removed from the existing pump station.

This EA will consider both Phase I and Phase II of Alternative 3, although the timing of Phase II is dependent on funding.

In analyzing Alternative 3, a river flow of 200 cfs was assumed to represent the mean average low flow required for intake function (Note: this intake function criteria should not be confused with the minimum boat passage criteria of 300 cfs, as referenced previously). By varying the flow through the intake chute, the relative volume ratio of water was determined between the intake chute and the boat and fish bypass channel. Table 2.1 illustrates this partition of flow for three conditions, as follows: 1) Fully unrestricted flow through the intake chute in which the butterfly gate valve is completely parallel to flow or the Obermeyer Gate is completely deflated; 2) Fully restricted flow through the intake chute in which the butterfly gate valve is completely perpendicular to the flow or the Obermeyer Gate is completely inflated; and 3) Partial restricted flow in which the butterfly valve is 50 percent open or the Obermeyer gate is 50 percent inflated.

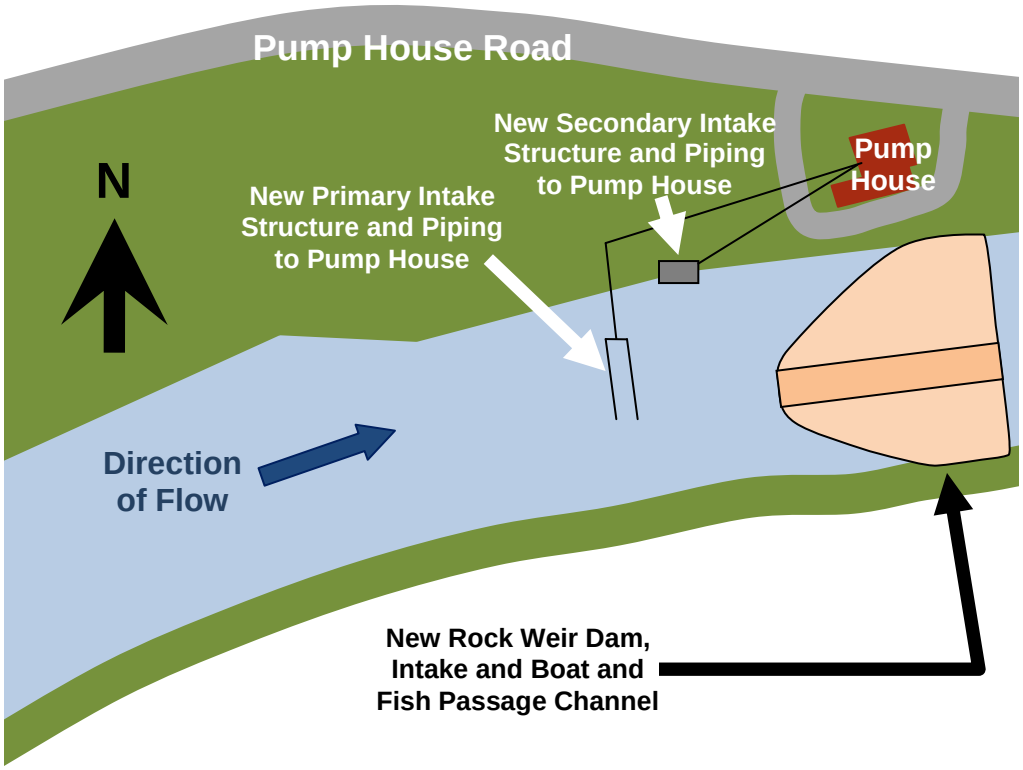
Table 2.1 Flow Volume Partitioning Through Intake Chute and Boat / Fish Bypass Channel for Alternative 3

Condition	Intake Chute Volume (cfs)	Boat / Fish Bypass Channel (cfs)
Fully Unrestricted Flow in Intake Chute	150	50
Fully Restricted Flow in Intake Chute	0	200
Partially Restricted Flow in Intake Chute	100	100

Alternative 4: New Rock Weir Dam with Floating Intake

Alternative 4 would involve removal of the existing concrete diversion dam and associated components and replacement with a new rock weir dam. Figure 2-7 presents a graphical illustration of Alternative 4: New Rock Weir Dam and Floating Intake. Detailed drawings are included in Appendix C.

Figure 2-7 Illustration of Alternative 4: New Rock Weir Dam with Floating Intake



As depicted in Figure 2-7, the rock weir dam would be nearly identical to the rock weir dam proposed under Alternative 3 with the same footprint, crest width and height, and materials of construction. As with Alternative 3, the rock weir dam would be located in approximately the same location as the existing diversion dam. The rock weir dam would include a notched spillway in the center, designed to facilitate boat and fish passage similar in size, length and arrangement as described in Alternative 3. The profile of the new weir structure would include small steps to gradually lose elevation down the rock face. By eliminating the single existing vertical drop of approximately five feet on the downstream side of the existing dam, the new weir would improve boater passage and safety. As with Alternative 3, the rock weir would not look or function like a traditional concrete dam. It would be visible during low flow conditions, while the intake structures would be relatively hidden from view. During larger flow events, however, the weir would become fully submerged. The structure would be designed to mimic native conditions and would be constructed with quarried rock or native round rock, which would be grouted together to provide connectivity and mass. The grout would be placed such that at least six inches of the rock would be exposed to create an ideal environment for aquatic organisms.

Under Alternative 4, new primary and secondary intake facilities would be located upstream of the existing dam, thereby taking advantage of the natural stream gradient which provides upstream elevation gains. This design would increase pump suction head and improve pump performance. The primary intake would consist of buried piping extending outward from the north river bank into the river. The pipes would be anchored at a point partway into the river in order to prevent movement up or downriver. From this anchor point, the buried piping would

extend further into the river, eventually extending out of the river bed and connecting to a screened end pieces, called "River Tee screens." The end piece would be bolted to a sled, allowing the intake to "float" or rest on the river bottom. The primary intake would be placed in the natural pool upstream of the existing diversion dam, allowing it to be completely submerged under all flow conditions. Because the intake would be moved upstream, a DNRC permit for a new point of diversion would be required. As with Alternative 3, this alternative would entail removal of the existing settling basin, with raw water conveyed directly from the intake to the west wall of the existing pump house via new piping. In addition, a secondary intake would be located approximately 50 feet upstream of the new dam face on the north river bank. This secondary intake would consist of a concrete collection box covered with a bar screen that would convey water via buried pipe to connect to the primary intake piping alignment, and would only be used for emergency purposes in the event of failure or regular maintenance of the primary intake.

In analyzing Alternative 4, a river flow of 200 cfs was assumed to represent the mean average low flow required for intake function. Since the new intake structure would be located upstream of the new dam and flow would not be regulated through an intake chute, all river flow would pass through the boat and fish passage channel, as shown in Table 2.2.

Table 2.2 Flow Volume in Boat / Fish Bypass Channel for Alternative 4

Condition	Intake Chute Volume (cfs)	Boat / Fish Bypass Channel (cfs)
Unrestricted Flow	NA*	200

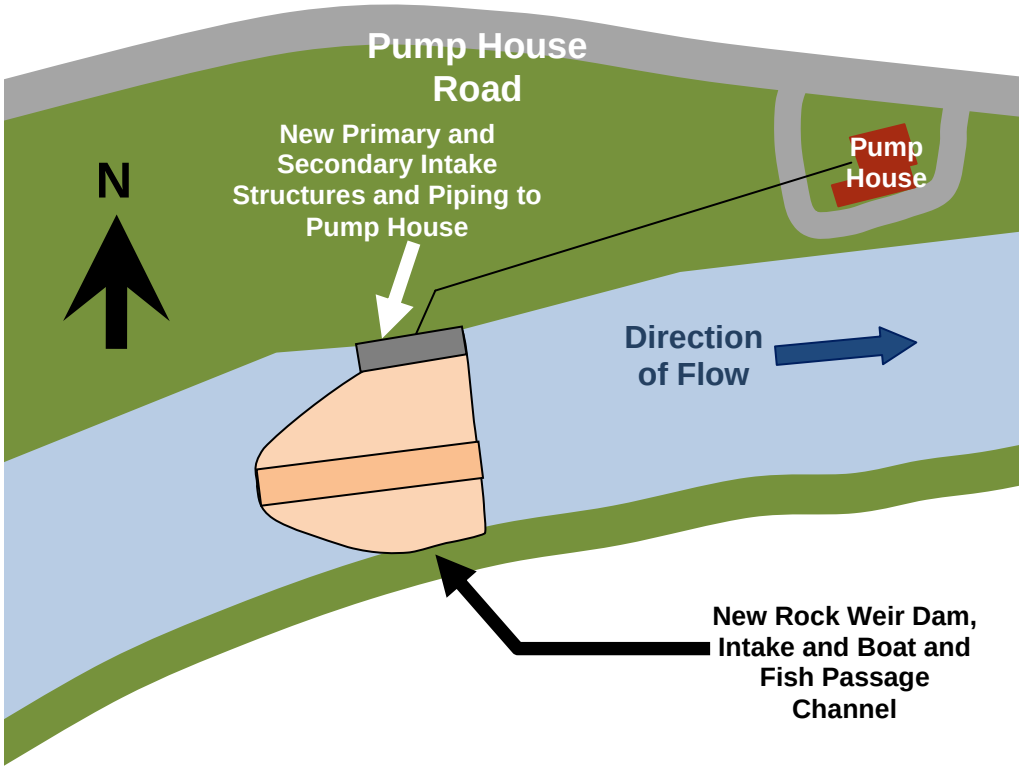
*Under Alternative 4, flows would not be regulated through an intake chute.

The dam would function by blocking the river flow and damming up the water level until it overtopped the boat and fish passage channel weir elevation. An upstream pool would be created with an approximate depth of five to six feet at the dam face. This upstream pool would provide an upstream water surface elevation of approximately 5,419 feet at all flows. This upstream water surface elevation would establish the amount of available head that could be used to convey water to the pumps through the position of a new intake and connector piping to be located on the north shoreline. The floating screens would be set at elevations 5,414 feet and 5,415 feet such that an available hydraulic head of four to five feet could be provided for conveyance of water through the intake piping and to the suction inlet of the pump station.

Alternative 5: Upstream New Rock Weir Dam and Intake

As with Alternatives 3 and 4, Alternative 5 would involve complete removal of the existing diversion dam and associated components and installation of a new rock weir dam with a boat and fish passage channel located at the apex. Figure 2-8 presents a graphical illustration of Alternative 5: New Upstream Rock Weir Dam, and Intake. Detailed engineered drawings are presented in Appendix C.

Figure 2-8 Illustration of Alternative 5: New Upstream Rock Weir Dam and Intake



As depicted in Figure 2-8, the new dam would be chevron shaped with the nose of the dam located upstream. The dam would function similarly to other dams in that it would serve as a flow impediment and thereby increase the upstream water surface profile. In Alternative 5, the existing diversion dam and associated features would be removed and replaced with a single concave rock weir located approximately 450 feet upstream.

The new rock weir dam would extend from approximately Station 35+25 to Station 38+75 with the crest beginning at a new south bank abutment, extending upstream 125 feet to the nose of a chevron shape and then back to a new north bank abutment. The crest of the rock dam would be at elevation 5,422 feet, with the upstream face gradually sloping to match the upstream river bottom elevation of 5,416 feet. The downstream face of the dam would also gradually slope to match the river invert elevation of 5,414 feet. The boat and fish passage channel would be located at approximately the river thalweg and would extend from dam crest downstream 325 feet. The spillway width would be designed to allow boaters to float through with oars extended; boaters would not experience any inconvenience while passing through the spillway. The profile of the new weir structure would include small downstream steps to gradually lose elevation down the rock face. The shape and elevation of the weir would be optimized to provide the desired upstream water surface and safe boating and fish passage. The rock weir would be visible during low flow conditions, while the intakes and intake structures would remain relatively hidden from view at all times. The rock weir would be constructed of quarried rock or native round rock as opposed to concrete in order to minimize visual impacts.

As with Alternatives 3 and 4, the fish and boat passage channel would consist of a "notch" through the dam that would be trapezoidal in shape and would extend from the upstream water pool through the dam section and blend into the downstream river channel. The channel would have a bottom section width of 27 feet and a top width of 73 feet and would include two rest pools measuring approximately 40 feet in length parallel to the river flow and 50 to 75 feet in width perpendicular to the river flow. The slope of the section of the chute immediately downstream of the crest would be approximately 3.8 percent and approximately 6.7 percent for the section between the first and second rest pools. Alternative 5 would also contain a third sloped section from the second rest pool to the existing natural pool located at approximately Station 35+25. This third sloped section would have a slope of 5.0 percent. The channel and rest pools would all be constructed from native or quarried rock grouted to form a natural channel. The grout would be placed such that at least six inches of the rock would be exposed to create an ideal environment for aquatic organisms.

The new dam would be constructed from grouted rock as well and would bear on a grouted rock keyway that would anchor the structure to the river bed. The dam would function by blocking the river flow and damming up the water level until it overtopped the boat and fish passage channel weir elevation. An upstream pool would be created with an approximate depth of five to six feet at the dam face. This upstream pool would provide an upstream water surface elevation of approximately 5,420 feet at all flows. This upstream water surface elevation would establish the amount of available head that could be used to convey water to the pumps through the position of a new intake and connector piping to be located on the north shoreline. A floating boom would be installed immediately upstream of the intake chute to redirect floating debris from the intake.

Alternative 5 would also include construction of new primary and secondary intake systems and new transmission piping from the intake system to the existing pump station. The primary intake would be located along the north river bank and would include screens for sediment removal. The new intake structure and functionality would be essentially identical as described under Alternative 2 and 3. Similarly, the intake control valve would involve either a butterfly gate valve or an Obermeyer gate valve with the same benefits as noted in the prior discussion. The secondary intake would be located slightly upstream and would include coarser screens or bar screens to provide short-term water delivery pending repair measures in the event of primary intake failure. New piping would convey raw water directly from the intake to the existing pumps, no longer routing through a settling basin. Because the existing point of diversion would be relocated, this alternative would require a point of diversion change application and approval through DNRC.

In analyzing Alternative 5, a river flow of 200 cfs was assumed to represent the mean average low flow. By varying the flow through the intake chute, the relative volume ratio of water was determined between the intake chute and the boat and fish passage channel. Table 2.3 illustrates this partition of flow for three conditions, as follows: 1) Fully unrestricted flow through the intake chute; 2) Fully restricted flow through the intake chute; and 3) Partial restricted flow.

Table 2.3 Flow Volume Partitioning Through Intake Chute and Boat / Fish Bypass Channel for Alternative 5

Condition	Intake Chute Volume (cfs)	Boat / Fish Bypass Channel (cfs)
Fully Unrestricted Flow in Intake Chute	150	50
Fully Restricted Flow in Intake Chute	0	200
Partially Restricted Flow in Intake Chute	100	100

Design features of the proposed Action Alternatives are summarized in Table 2.4.

Table 2.4 Summary of Design Features of Proposed Action Alternatives

Features	Alternative 2: Replace in Kind	Alternative 3: Rock Weir and New Pump House	Alternative 4: Rock Weir with Floating Intake	Alternative 5: Upstream Rock Weir
Dam Structure	• Remove all aspects of the existing dam and associated components • New concrete dam structure upstream of existing dam with stepped rock face to gradually lose elevation	• Remove all aspects of the existing dam and associated components • New rock weir located at existing diversion dam site with stepped rock face to gradually lose elevation	• Remove all aspects of the existing dam and associated components • New rock weir located at existing diversion dam site with stepped rock face to gradually lose elevation	• Remove all aspects of the existing dam and associated components • New rock weir located upstream of existing diversion dam site with stepped rock face to gradually lose elevation
Intake / Point of Diversion	• New primary intake located on north bank with slotted screen to block excessive sediment and debris (either butterfly gate valve or Obermeyer gate valve) • New secondary intake located on north bank upstream of primary intake • Floating boom to redirect floating debris from the intake • New point of diversion	• New primary intake located on north bank with slotted screen to block excessive sediment and debris (either butterfly gate valve or Obermeyer gate valve) • New secondary intake located on north bank upstream of primary intake • Floating boom to redirect floating debris from the intake • Utilize the existing point of diversion	• New primary intake (River Tee screens) located in natural pool approximately 300 feet upstream of existing diversion dam • New secondary intake located on north bank immediately upstream of rock weir • New point of diversion	• New primary intake approximately 450 feet upstream of existing facility with slotted screen to block excessive sediment and debris (either butterfly gate valve or Obermeyer gate valve) • New secondary intake located on north bank approximately 450 feet upstream of existing facility • Floating boom to redirect floating debris from the intake • New point of diversion
Settling Basin	• Remove existing settling basin; raw water conveyed directly to pump house	• Remove existing settling basin; raw water conveyed directly to pump house	• Remove existing settling basin; raw water conveyed directly to pump house	• Remove existing settling basin; raw water conveyed directly to pump house
Piping	• New pipe system to deliver raw water to the existing pump house	• "Wye" leg would accommodate piping to deliver raw water to the existing pump house under Phase I, as well as new piping to the new pump house under Phase II	• New pipe system to deliver raw water to the existing pump house	• New pipe system to deliver raw water to the existing pump house
Pump System	• New point of entry at existing pump house • Utilize existing pump system and configuration	• New point of entry at existing pump house during Phase I • New pump facility; existing pumps relocated at proper elevations under Phase II • New pump wet well to improve pump performance under Phase II	• New point of entry at existing pump house • Utilize existing pump system and configuration	• New point of entry at existing pump house • Utilize existing pump system and configuration
Safety Features	• Improved safety for maintenance personnel due to reduction in icing problems • Improved safety for boaters due to stepped rock face as compared to existing sharp vertical drop	• Improved safety for maintenance personnel due to reduction in icing problems • Improved safety for boaters due to stepped rock face as compared to existing sharp vertical drop	• Improved safety for maintenance personnel due to reduction in icing problems • Improved safety for boaters due to stepped rock face as compared to existing sharp vertical drop	• Improved safety for maintenance personnel due to reduction in icing problems • Improved safety for boaters due to stepped rock face as compared to existing sharp vertical drop
Boat and Fish Passage	• No boat or fish passage features	• Notched weir and stepped rock spillway provide improved boat and fish passage; Spillway width designed to allow boaters to float through with oars extended	• Notched weir and stepped rock spillway provide improved boat and fish passage; Spillway width designed to allow boaters to float through with oars extended	• Notched weir and stepped rock spillway provide improved boat and fish passage; Spillway width designed to allow boaters to float through with oars extended

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2.3 Alternatives Considered but Eliminated from Further Analysis

As noted in Section 2.2, the four Proposed Action Alternatives assume continued use of BSB's existing water right on the Big Hole River as a source of water for the Butte service area. This section documents consideration and assessment of other alternatives, which fall into the following categories: 1) Reducing Water Needs; 2) Alternative Water Sources; and 3) Diverting Water From a Different Location on the Big Hole River.

Reducing Water Needs

The Butte-Silver Bow water system was initially constructed over 100 years ago to meet the needs of the regional mining industry. Over time, serious leakage problems began to occur due to aging distribution and transmission piping. A lack of metering also contributed to high demands. BSB has been aggressively replacing leaking system components and implementing water usage metering over the past five to ten years. These conservation efforts have reduced the amount of water required, however, these improvements are not sufficient to supplant the Big Hole River source.

Alternative Water Sources

New Appropriations and Water Right Considerations

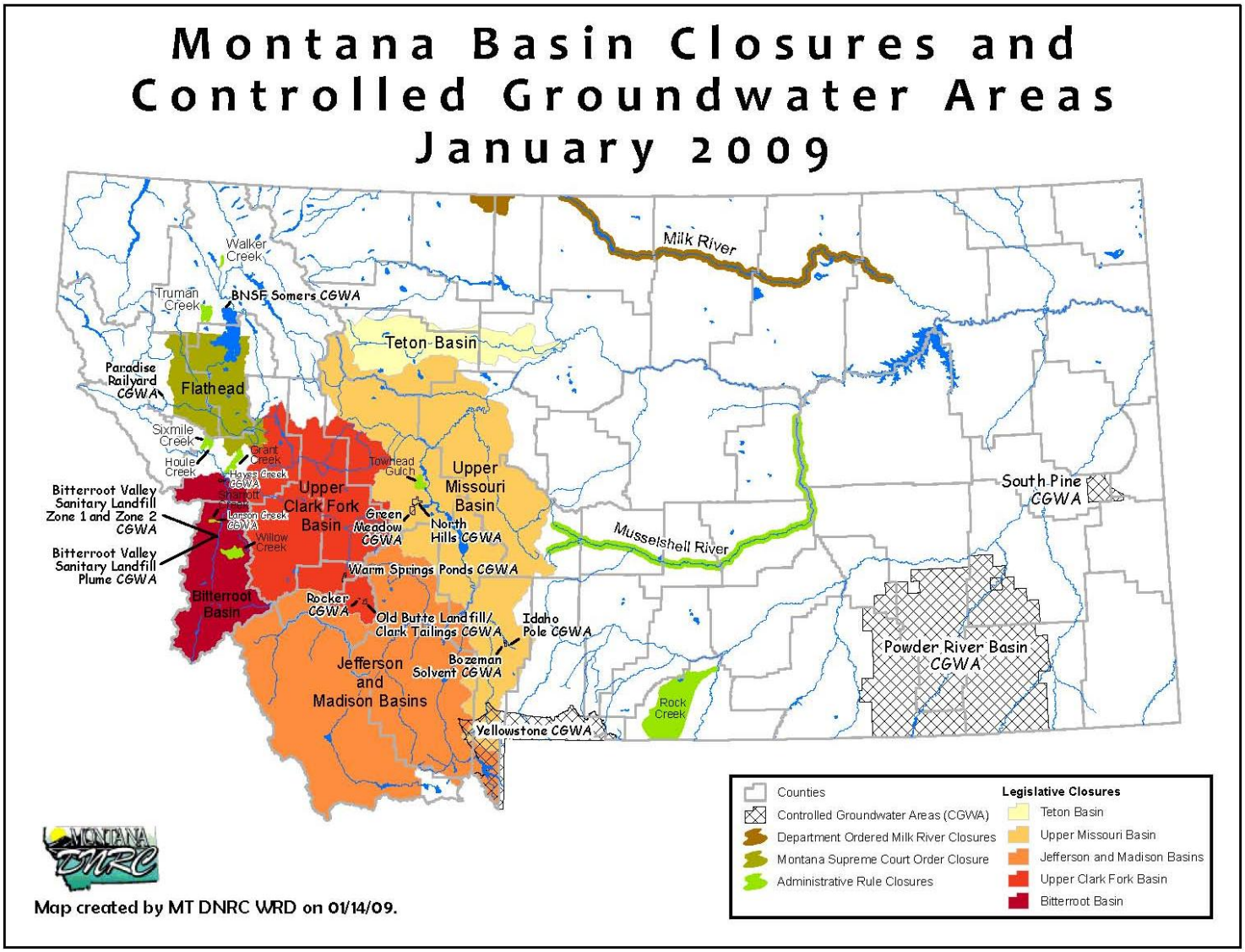
As shown in Figure 2-9, the Upper Clark Fork and the Madison and Jefferson Basins have been closed to new appropriations by legislative authority. Obtaining a new water right in a closed basin requires extensive analysis to show that the water being used will be replaced or "mitigated" such that the net loss from the basin (including groundwater and/or surface water) is zero. Mitigation could include return of highly treated wastewater to the system, or retirement of a separate existing water right to make up the difference. The Big Hole River is located in the Jefferson and Madison basin, while the Butte service area is located in the Upper Clark Fork Basin. Accordingly, retirement of the Big Hole River water right would not be considered appropriate mitigation for a new water right in the Upper Clark Fork region. It is not clear whether a basin-to-basin mitigation transfer would be possible under Montana law.

In addition to proving appropriate mitigation, the following DNRC criteria must be met:

1. Demonstrate that water is physically and legally available at the site
2. Demonstrate that nearby water resources will not be adversely affected (i.e. neighboring wells, streams, irrigation ditches, and other sources)
3. Demonstrate beneficial use

Several hydrogeological factors must be evaluated to determine if water is physically available at the site. This would most likely require the drilling of test wells to conduct aquifer tests, water quality tests, and water level monitoring. Stream flow monitoring may also be required. Once physical availability is demonstrated, legal availability must be demonstrated through identification and analysis of existing water rights in the vicinity and with regard to potentially-affected surface waters. This process involves substantial research into existing water rights and a comparison of existing legal demands to physical water availability. To demonstrate beneficial use, the proposed water use must be justifiable in regards to how it will be used as well as the quantity of water needed. In sum, acquiring additional water rights is a fairly lengthy process requiring substantial analysis.

Figure 2-9 Montana Basin Closures



Source: DNRC, 2009.

The difficulties of obtaining new groundwater and surface water sources are explained more fully below.

Groundwater

As noted in the 2008 Butte Water Master Plan, groundwater and soils in the Butte area are generally contaminated with arsenic and other heavy metals, including copper, zinc, cadmium, and lead, resulting from past mining practices. There is some question whether existing technology could treat contaminated groundwater to drinking water standards. Further, as noted previously, Butte is located in a controlled groundwater area and a closed basin. In order to pursue a new water right, additional study would be required to identify potential mitigation measures and to determine physical availability and potential adverse effects on existing uses. Even if the results of these analyses were favorable, it likely would not be possible to obtain a new water right before the existing Big Hole River diversion dam fails given the near-term risk of dam failure. At this time, it is believed that groundwater sources would not provide sufficient volumes to supplant the Big Hole River source. Lastly, utilizing a new groundwater source for Butte potable water needs would likely require new transmission piping through previously undisturbed areas, which would likely result in greater environmental impacts as compared to using the existing Big Hole River transmission system. For these reasons, groundwater sources were eliminated from further consideration.

Surface Water

Surface water sources close to the Butte service area are illustrated in Figure 2-10. Surface water contamination exists in the region; the Silver Bow Creek/Butte Area Site is on the U.S. Environmental Protection Agency's (EPA's) National Priorities List. There is some question whether existing technology could treat contaminated surface water to drinking water standards.

BSB currently has an existing Silver Lake water right, but this water right alone would not be sufficient to supply both domestic and industrial uses currently supplied by the combined Silver Lake and Big Hole River sources. Although BSB's Silver Lake water right is approximately 20 million gallons per day (mgd), the current delivery pipeline is capable of carrying only 16 to 18 mgd. Under BSB's total water right, current Silver Lake reserved uses include Renewable Energy Corporation (REC - Silicon), Montana Resources (MRI), Atlantic Richfield Company (ARCO), Northwestern Energy, the community of Anaconda, and various small-scale irrigators in the region. In addition to daily uses, MRI also has a right to a larger volume of water for planned and unplanned system failures, amounting to between 7 mgd and 18 mgd. Should an MRI system failure occur, BSB's water right is not sufficient to supply the full allotment of water to each of these users. In such an event, BSB would have to supply water to these users from its potable supply, resulting in a net loss to the BSB system.

The Silver Lake water system is a highly adjudicated surface water source. As noted previously, new or additional water rights for Silver Lake and Georgetown Lake would be very difficult to obtain in a timely manner due to basin closure restrictions; time is of the essence due to the near-term risk of dam failure at the Big Hole site. There is no unclaimed water in the Silver Lake system and it is unlikely that current users would be willing to sell their water rights to BSB.

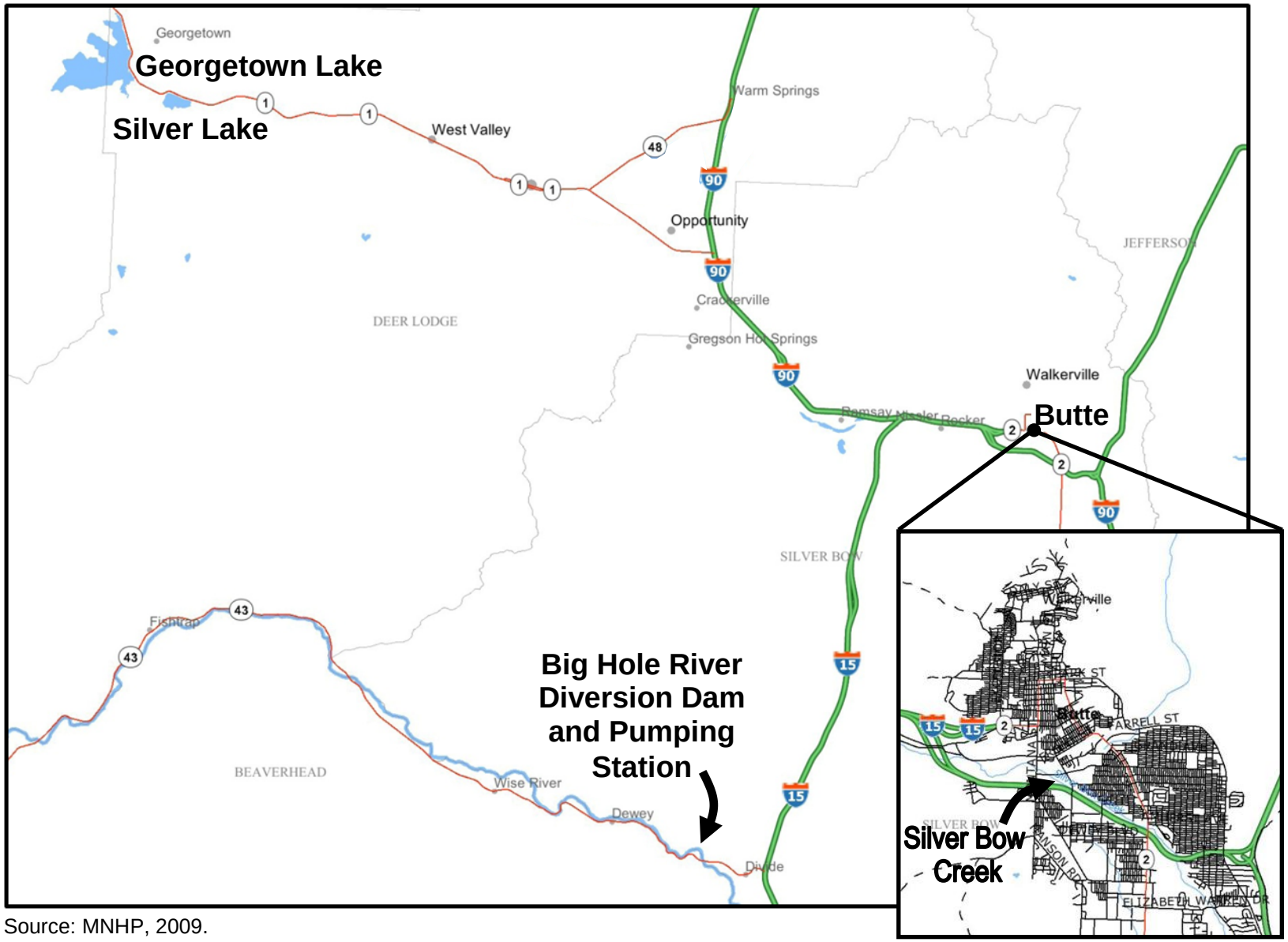
Lastly, the Silver Lake water source does not meet drinking water standards. In order to use this water source for Butte's potable water needs, the water would need to be piped to the Big Hole

Water Treatment Plant for proper treatment, and then piped back up Butte. This would require repair of existing transmission lines and construction of new transmission lines through previously undisturbed areas, which would result in greater environmental impacts as compared to using the existing Big Hole River water source. For these reasons, alternative surface water sources were eliminated from further consideration.

Diverting Water from a Different Location on the Big Hole River

During agency coordination activities, resource agencies suggested consideration of an abandoned upstream irrigation weir on the south side of the river as an alternative to a new diversion dam structure (see meeting summary contained in Appendix J). The thought was that since it would be located at a higher elevation, this alternative could provide sufficient head without use of a rock weir structure. Such an alternative would not be located on BSB-owned land, and would therefore involve right-of-way negotiations not contemplated with the other alternatives; this alternative would also require lengthy water right adjudications. Further, by providing a single drop, this alternative would result in the same "keeper wave" and associated safety concerns as the existing dam; the single suggested drop would still need to meet a minimum elevation in order to ensure water entry into the intake pipe. Lastly, the abandoned irrigation weir has naturally eroded over time; a new structure would need to be constructed in its place in order to function properly, thereby eliminating any gains from an environmental resource impact standpoint. For these reasons, use of the abandoned irrigation weir was eliminated from further consideration.

Figure 2-10 Surface Waters in Proximity to Butte Service Area



Source: MNHP, 2009.

3.0 Affected Environment

3.1 Natural and Physical Environment

3.1.1 Geology

The Big Hole River Diversion Dam is located on the eastern edge of the Pioneer Mountain Range. As noted in the Geotechnical Data Report prepared for this project (Appendix E), existing geologic mapping for this area shows that this site consists of Quaternary alluvium overlaying Cretaceous- to Mississippian-age marine sedimentary rocks dipping steeply to the east.

3.1.2 Topography

According to the Geotechnical Data Report, topography at the project site is characterized by a deeply incised V-shaped valley sloping up steeply to the north and south of the Big Hole River. A broad, relatively flat alluvial terrace is present along the south side of the river about 30 to 35 feet above the river surface elevation. Surrounding topography is generally mountainous to the east, north, and south, opening up into a broader floored river valley towards the east. Due to the mountainous conditions at the site, the Big Hole River does not naturally meander widely.

3.1.3 Soils

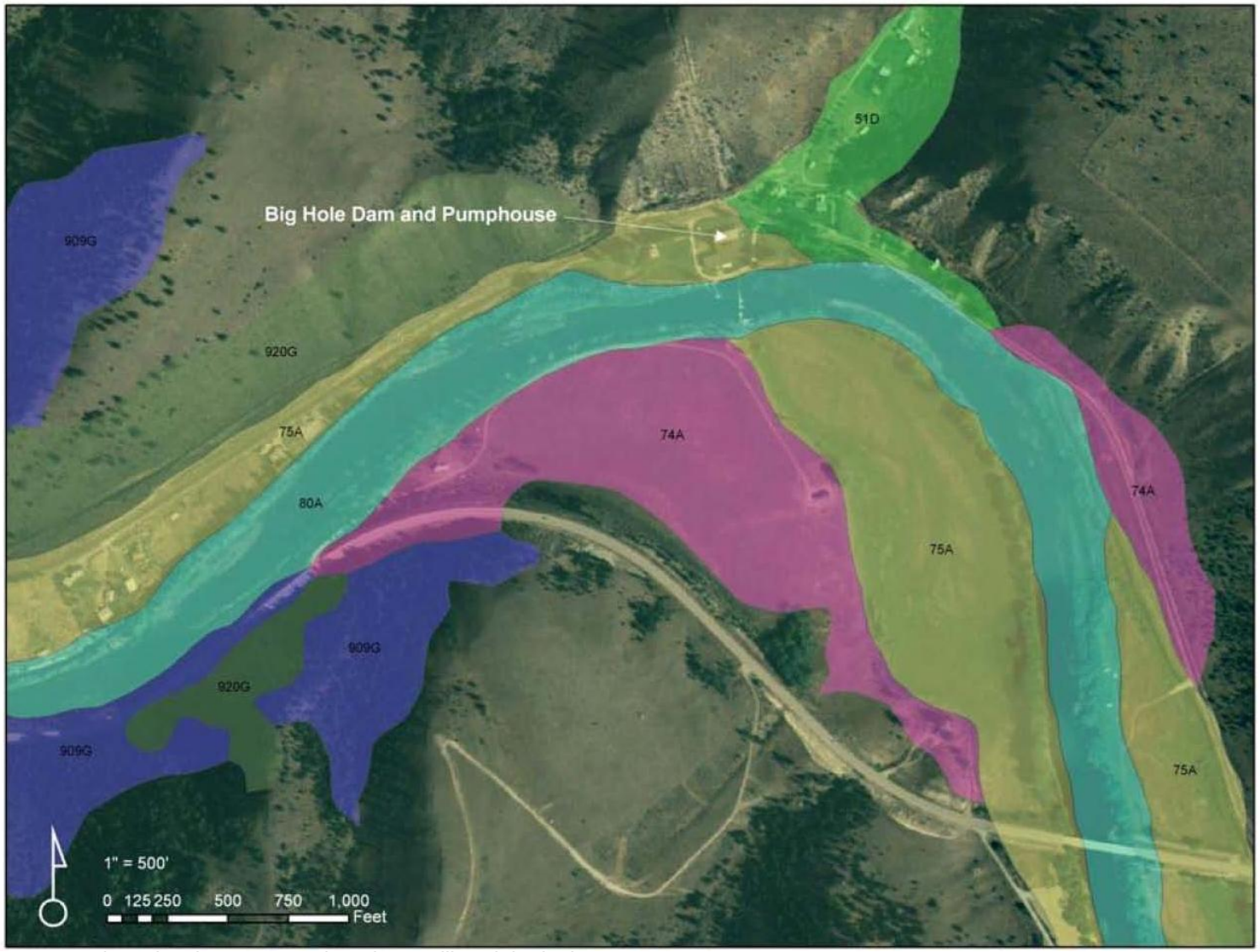
Based on a review of the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, there are six soil types within the vicinity of the project area, which are presented in Table 3.1 and Figure 3-1.

Table 3.1 Soils within Project Area

Soil Symbol	Soil Name and Description
51D	Foxgulch-Libeg complex, 6 to 25 percent slopes, stony
74A	Bearmouth very cobbly sandy loam, 0 to 2 percent slopes, very stony
75A	Danielvil loam, 0 to 2 percent slopes
80A	Water-Riverwash complex
909G	Rubick, rubbly–Rubble land complex, 40 to 75 percent slopes
920G	Poin, rubbly-Rubble land-rock outcrop complex, 40 to 80 percent slopes

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

Figure 3-1 Soils within Project Area



Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

As noted in the Butte Water Master Plan (RPA, 2008), soils within the general project area are shallow and moderately deep cobbly loams, silt loams, and sandy loams, some with heavier textured loam and clay loam subsurface layers. Alpine glaciation has modified portions of the landscape in the area. Soils are moderately susceptible to erosion and some are susceptible to rutting and compaction.

3.1.4 Vegetation

Vegetation in the study area consists primarily of native grasses with scattered brush on the south side of the river and maintained lawn areas, native grasses, brush, and trees on the north side of the river. A vegetation inventory conducted for this project identified 18 trees/shrubs, 30 forbs, 13 grasses, and one macrophyte species within the project area. The riparian vegetation present along the banks of the Big Hole River consists of a mosaic of cottonwood/red-osier dogwood, willow/herbaceous, and Douglas fir-dominated community types. A moderately rich diversity of shrubs and herbaceous understory is present along both banks of the river, with the exception of the maintained and manicured area directly adjacent to the intake facility. Willows, alder, serviceberry, currant, and chokecherry are the dominant shrubs throughout the riparian areas. The herbaceous community transitions from predominately hydrophytes, including water knotweed, spike rush and horsetail, to canary reedgrass, mannagrass and foxtail barley, and then into upland species within a short distance from the river bank. Irrigation ditches run along both sides of the river and sustain a narrow band of hydrophytic vegetation along the edges of these canals. The arid uplands adjacent to the southern bank are characterized by sagebrush, skeleton weed, wheatgrass and needle and thread grass. The Biological Resources Report (BRR) prepared for this project contains a full listing of vegetative species found within the project area and is included in Appendix F.

Threatened and Endangered Species / Species of Special Concern

The Montana Natural Heritage Program (MNHP) lists the Sapphire rockcress, a state Species of Special Concern, as occurring within the township and range where the existing Big Hole Diversion Dam and Pump House are located. No Threatened or Endangered plant species or plant Species of Special Concern were observed during site visits or are known to exist within the project area.

Noxious Weeds

Six Category 1 and one Category 2 noxious weed species were identified within the project area, as listed in Table 3.2.

Table 3.2 Noxious Weeds Identified at Project Site

Common Name	Scientific Name	Noxious Weed Category
Spotted knapweed	*Centaurea stoebe*	Category 1
Common tansy	*Tanacetum vulgare*	Category 1
Canada thistle	*Cirsium arvense*	Category 1
Yellow toadflax	*Linaria vulgaris*	Category 1
Houndstongue	*Cynoglossum officinale*	Category 1
Oxeye daisy	*Chrysanthemum leucanthemum*	Category 1
Rush skeletonweed	*Chondrilla juncea*	Category 2

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

Category 1 noxious weeds are defined by the Montana Department of Agriculture as weeds that are currently established and generally widespread in many counties of the state. Management criteria include awareness and education, containment and suppression of existing infestations, and prevention of new infestations. These weeds are capable of rapid spread and render land unfit or greatly limit beneficial uses. Category 2 noxious weeds are defined as having recently been introduced into the state or rapidly spreading from their current infestation sites. These weeds are capable of rapid spread and invasion of lands, rendering lands unfit for beneficial uses. Management criteria include awareness and education, monitoring and containment of known infestations, and eradication where possible.

3.1.5 National Wildlife Refuges, Parks, Preserves, Monuments & Wild & Scenic Rivers

There are no National Wildlife Refuges, National Parks, Preserves, Monuments, or Wild and Scenic Rivers in the project vicinity.

3.1.6 Wildlife

As noted in the BRR prepared for the proposed project, the Big Hole Dam lies within an area that is diverse in wildlife habitat. The dam and intake facility are located within a transitional area of the Big Hole River as it exits a canyon and enters a broader valley. The facility lies at the foot of the Pioneer Mountains, which provide habitat for several big-game species including whitetail deer, mule deer, moose, and elk. The facility lies adjacent to dry, upland habitats, suitable for mountain lion, coyotes, red fox, bobcats, black bear, and upland birds such as Hungarian partridge and ruffed grouse. Birds of prey including owls, hawks, eagles, and osprey are commonly found within the area. The site lies within the riparian zone of the river, which provides habitat for several species of migratory songbirds and mammals such as otter, beaver, and muskrat. Several species of waterfowl utilize the river corridor for feeding, nesting, and migration.

Threatened and Endangered Species / Species of Special Concern

According to the MNHP database, three mammals, two birds, and one amphibian that may occur within the vicinity of the project area are classified as Species of Special Concern, and are listed in Table 3.3.

Table 3.3 Wildlife Species of Special Concern in the Vicinity of the Project Area

Species	Global Rank	State Rank	FWS Status	USFS Status	BLM Status
Mammals					
Gray Wolf (*Canis lupus*)	G4	S3	DM	Sensitive	Sensitive
Wolverine (*Gulo gulo*)	G4	S3		Sensitive	Sensitive
Canada lynx (*Lynx Canadensis)*	G5	S3	LT	Threatened	Special Status
Birds					
Northern goshawk (*Accipiter gentilis*)	G5	S3			Sensitive
Brewer's sparrow (*Spizella breweri*)	G5	S3B			Sensitive
Amphibians					
Western toad (*Bufo boreas*)	G4	S2		Sensitive	Sensitive

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

S1/G1 At high risk because of extremely limited and/or rapidly declining population numbers, range, and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.
S2/G2 At risk because of very limited and/or potentially declining population numbers, range, and /or habitat, making it vulnerable to global extinction or extirpation in the state
S3/G3 Potentially at risk because of limited and/or declining numbers, range and/or habitat, may be abundant in some areas.
S4/G4 Apparently secure, thought it may be quite rare in parts of its range, and/or suspected to be declining.
S5/G5 Demonstrably secure, though it may be quite rare in parts of its range
B Breeding – Rank refers to the breeding population of the species in Montana.
DM Recovered, delisted, and being monitored - Any previously listed species that is now recovered, has been delisted, and is being monitored.
LT Listed threatened - Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (16 U.S.C. 1532(20)).

3.1.7 Fisheries

The Big Hole River is considered a "Blue Ribbon" trout stream due to its superb recreational fishing opportunities. According to the FWP Montana Fisheries Information System (MFISH) database, there is a moderately diverse mix of native and introduced fish species present in the Big Hole River near the project site, as listed in Table 3.4. It should be noted that the MFISH database assigns upstream and downstream endpoints based on river stationing beginning at the mouth of the river. River Mile 0.0 is located at the confluence of the Big Hole River with the Jefferson River; River Mile 153.1 represents the upstream extent of the Big Hole River. The existing Big Hole River Diversion Dam and Pump House are located at River Mile 54.1.

Table 3.4 Fish Distribution Data for the Big Hole River in the Vicinity of River Mile 54.1

River Mile (Begin Point)	River Mile (End Point)	Species	Abundance	Use Type	Origin
0	56.5	Arctic Grayling*	Rare	Year-round resident	Native
56.5	115	Arctic Grayling*	Common	Year-round resident	Native
0	63	Brook Trout	Rare	Year-round resident	Introduced
63	95	Brook Trout	Common	Year-round resident	Introduced
0	81.4	Brown Trout	Abundant	Year-round resident	Introduced
0	73.6	Burbot	Common	Year-round resident	Native
0	153	Longnose Dace	Common	Year-round resident	Native
0	153	Longnose Sucker	Common	Year-round resident	Native
0	153	Mottled Sculpin	Common	Year-round resident	Native
0	153	Mountain Sucker	Rare	Year-round resident	Native
0	143.4	Mountain Whitefish	Abundant	Year-round resident	Native
6.2	86.7	Rainbow Trout	Abundant	Year-round resident	Introduced
54.9	68.8	Westslope Cutthroat Trout*	Rare	Unknown	Native
61.5	68.7	Westslope X Rainbow	Rare	Unknown	Unknown
0	89.3	White Sucker	Common	Year-round resident	Native

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.
*State Species of Special Concern

The Big Hole River is considered an outstanding resource due to high sport and habitat classifications. It should be noted that there is a backwater pool located upstream of the existing diversion dam structure that provides important habitat for fish.

Threatened and Endangered Species / Species of Special Concern

The Big Hole River contains two state Species of Special Concern within the vicinity of the existing dam: the arctic grayling and the westslope cutthroat trout. No Threatened or Endangered fish species exist in the Big Hole River.

Fish Passage

The configuration of the existing diversion dam likely creates a fish passage barrier at various flows. At low flows, fish passage is limited due to the height of the dam above the bed of the river. At high flows, fish passage is limited due to high velocities as water passes over the dam. However, fish are likely to pass over the dam at intermediate flows that do not restrict jumping height or burst speeds. Fish may also pass through the existing dam at various flows in locations where temporary rocks have been placed to stabilize undercuts in the dam.

When considering fish passage at structural facilities, three aspects of fish swimming speeds may be considered. These include 1) cruising speed, or a speed that can be maintained for a number of hours; 2) sustained speed, or a speed that can be maintained for minutes; and 3) darting speed, which is a single, bursting effort that is not sustainable. Fish passage may be restricted if water velocities in the vicinity of in-stream structures exceed the sustained speed of a particular fish species.

Table 3.5 presents cruising, sustained, and darting speeds for adult fish that are known to exist within the project area. It is assumed that each of these species would attempt to pass upstream of the dam during seasonal migrations. No data for rainbow trout were available; however, it is

assumed that rainbow trout have similar swimming speeds as brown and cutthroat trout. Based on these data, fish passage will be achievable for trout and grayling when water velocities at the dam are below 6 fps, and below 4 fps for whitefish. For purposes of this project, the maximum velocity supporting fish passage has been established at 6 fps in coordination with FWP.

Table 3.5 Swimming Speeds for Adult Fish found in the Big Hole River

Species	Cruising Speed (ft/sec)	Sustained Speed (ft/sec)	Darting speed (ft/sec)
Cutthroat trout	2	6	14
Brown trout	2	7	13
Grayling	2	7	14
Whitefish	1	4	9

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

Passage over the dam may also be limited by fish size. While larger, stronger fish may be capable of successfully jumping over or swimming past the dam crest, younger and smaller size classes may not. Table 3.5 presents swimming speeds of adult trout and whitefish, which typically reach maturity at three years. Therefore, the presence of the dam could additionally limit passage for younger age classes; during higher flows, passage may be possible only for adult age classes.

Based on modeling efforts conducted for this project, the highest velocity estimated for the study area under existing conditions is 12 fps for the 100-year flood event at Section 31+12, which is located approximately 90 feet downstream of the existing dam. Velocities for the 100-year flood event range from 6 to 8 fps at other intervals throughout the project area.

Seasonal behavior of grayling and trout includes upstream migration during spawning periods. Spawning habitat has been documented in many tributary streams and upper reaches of the mainstem Big Hole River above the existing diversion dam. Fish species that spawn during spring months (April-June) include arctic grayling, rainbow trout, and cutthroat trout. The existing diversion dam may serve as a barrier to these species during spawning migrations that can overlap with high flow events during spring runoff. During periods of low flow (September-November), the existing dam may act as a barrier to upstream movement by species that spawn in the fall, including brown and brook trout, due to the height of the dam as compared to jumping heights of fish.

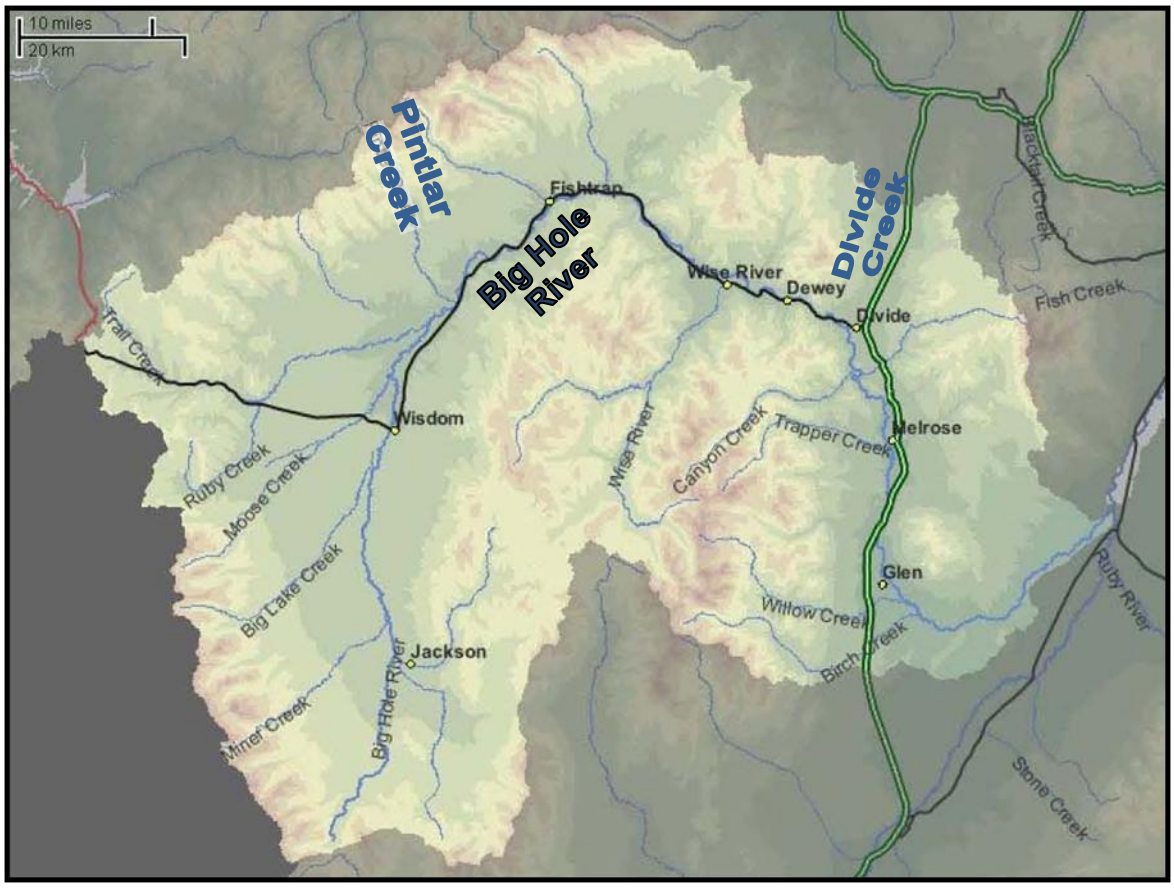
Fish passage barriers are increasingly being used by fisheries managers to protect the genetic integrity of native species. Genetically pure populations of Westslope cutthroat trout currently exist in headwater and tributary streams upstream of the Big Hole Dam. The placement or maintenance of passage barriers at strategic locations within the watershed may aid in protecting the genetic integrity of cutthroats from introgression by rainbow trout. Barriers may also restrict colonization by non-native species such as brown and brook trout, which may out-compete native cutthroat trout and grayling in overlapping habitats. However, maintenance of the existing dam as a passage barrier would not be an effective strategy for protecting cutthroat genetics or preventing non-native species from inhabiting the upper portions of the river, as non-native species have already colonized upstream of the dam. Brown trout and rainbow trout have been documented well upstream of the Big Hole Dam; therefore, removal of the dam would not allow

upstream migration of these species to areas where they do not currently exist. Removal of the dam would provide year-round passage opportunities for all fish, both native and non-native, to reaches of the Big Hole River upstream of the dam.

3.1.8 Water Resources and Water Quality

The Big Hole River Diversion Dam and Pump House lie within the Big Hole Subbasin of the Upper Missouri River Basin. The Big Hole Subbasin is defined as Hydrologic Unit Code (HUC) 10020004 and is illustrated in Figure 3-2. The Big Hole Subbasin is further divided into individual watersheds; the project area is located in the Divide watershed (HUC 1002000411), which encompasses approximately 170.7 square miles and 109,265 acres in Silver Bow and Beaverhead Counties.

Figure 3-2 Big Hole Subbasin of the Upper Missouri River Basin



Source: Montana Big Hole Watershed Mapping Project, 2009.

As noted in the Butte Water Master Plan (RPA, 2008), the Big Hole River's headwaters are located in the Beaverhead Mountains of the Bitterroot Range southwest of Jackson, Montana. The river flows for approximately 150 miles before joining with the Beaverhead River at Twin Bridges to form the Jefferson River. Within the vicinity of the project area, the Big Hole River generally flows from west to east and forms the boundary between Silver Bow and Beaverhead Counties. As noted in Section 3.1.2, the Big Hole River is generally constrained in a V-shaped valley and does not meander widely, as there is little room to diverge from its current course.

The Big Hole River between Divide Creek and Pintlar Creek is listed as impaired on the Montana Department of Environmental Quality (DEQ) 2008 Integrated 303(d) Water Quality Assessment Database for not supporting aquatic life, cold water fisheries, or domestic drinking water. Probable causes of impairment are metals, low flow alterations, substrate alterations, water temperature, and other streamside habitat alterations. The probable sources of impairment are associated with past mining activities, grazing, irrigated crop production, and construction activities like road building.

The State of Montana classifies the Big Hole River as an A-1 surface water. A-1 surface waters are to be maintained suitable for drinking, culinary, and food processing purposes after conventional treatment for removal of naturally present impurities. Water quality must be maintained suitable for bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

3.1.9 Floodplains

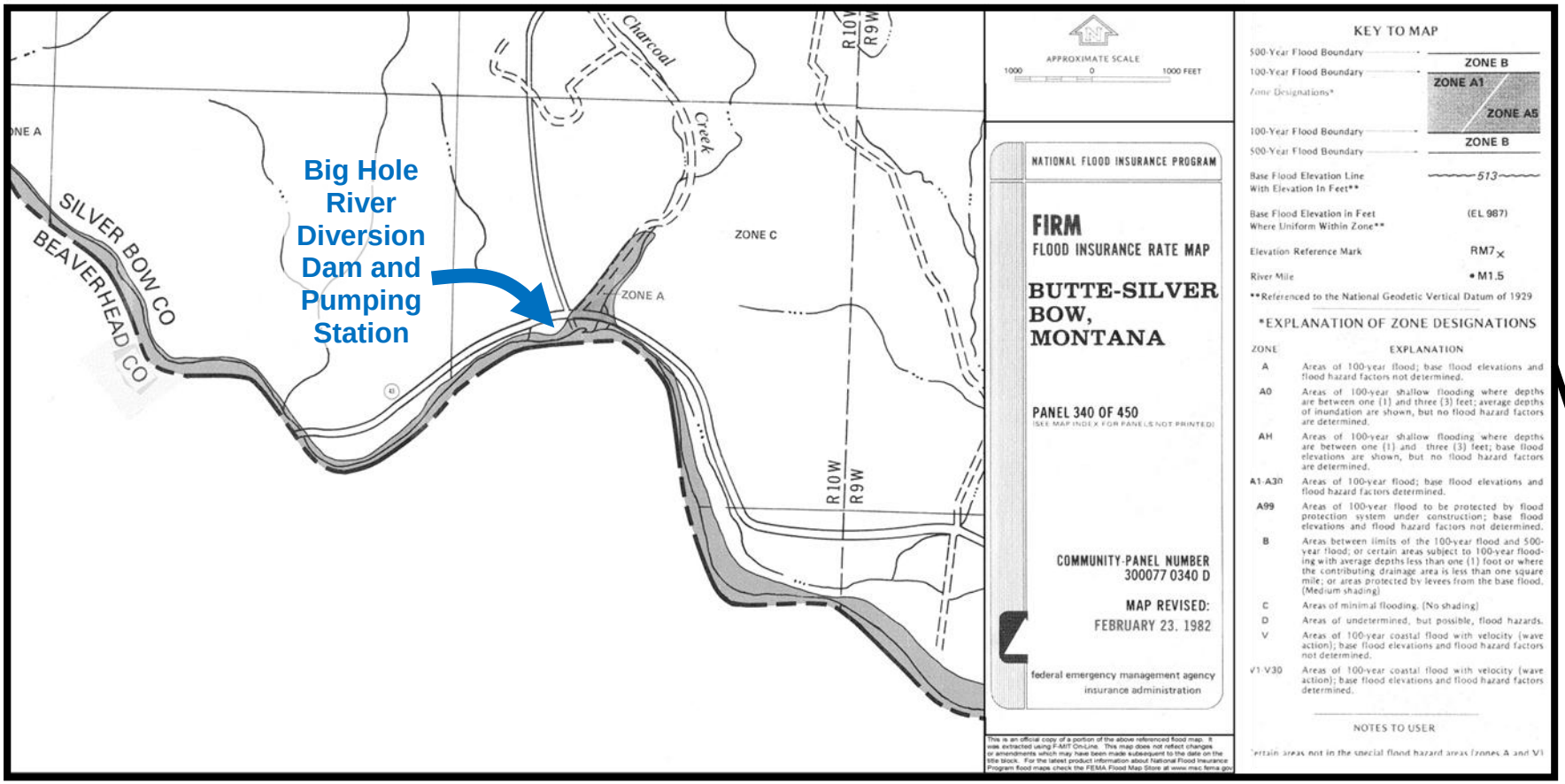
Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) floodplain mapping is only available for the portion of the proposed project located in Silver Bow County. There is no floodplain mapping for Beaverhead County.

As depicted in Figure 3-3, the proposed project is located within a regulatory 100-year floodplain. A 100-year flood event is defined as having a 100-year recurrence interval, or a one in 100 (one percent) probability of occurrence in any given year. It should be noted that the existing pump house is located within the 100-year floodplain.

As shown in Figure 3-3, the available NFIP mapping illustrates areas of inundation, but does not provide flood elevations. In the absence of elevation mapping, baseline floodplain information was developed using a model that estimated approximate water surface elevations expected to result during low flow (200 cfs), two-year (7,239 cfs), and 100-year (16,712 cfs) flow events under existing conditions. Based on the results of this model, the existing pump house is expected to be inundated during a 100-year flood event.

As noted in Chapter 2, the low flow value of 200 cfs was selected as the minimum instream flow under which the intake and pumping system must remain operable. All Action Alternatives are expected to function under these low flow conditions, but system performance would be diminished at flows below 200 cfs.

Figure 3-3 NFIP Floodplain Mapping within Project Area



Zone A: Area of 100-Year flood; base flood elevations and flood hazard factors not determined.

3.1.10 Wetlands and Other Regulated Areas

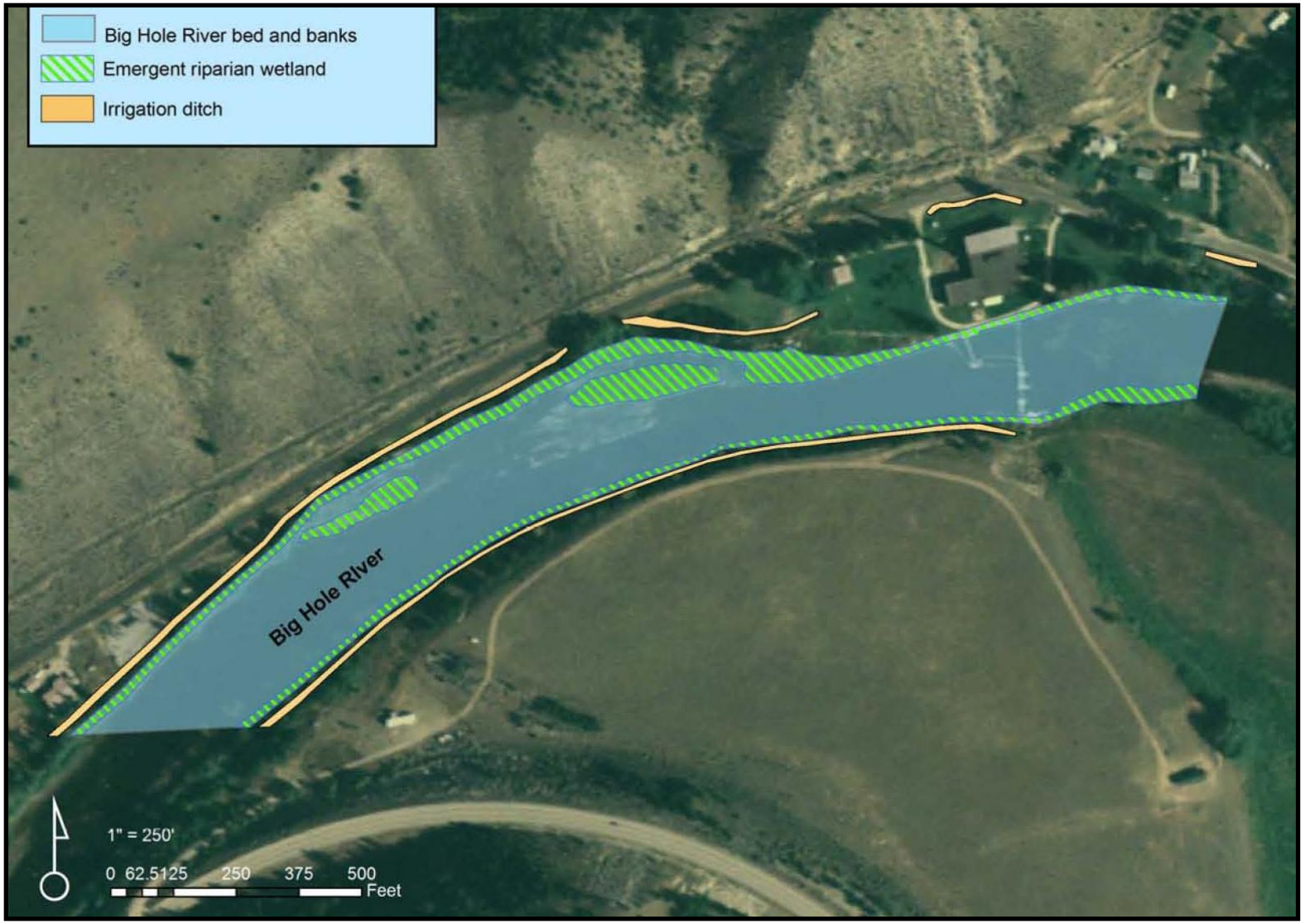
A wetland delineation was conducted during site visits in August 2009 from approximately 500 feet downstream of the existing diversion dam to approximately one-half mile upstream of the structure. The delineation was conducted in compliance with the 1987 Corps of Engineers Wetland Delineation Manual of the U.S. and the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (April 2008). A functions and values assessment of wetlands was also conducted using methods developed by the Montana Department of Transportation (MDT) (Berglund, 1999).

Waters of the U.S. and Irrigation Ditches

The Big Hole River is considered a Water of the U.S.; areas within its bed and banks as defined by the ordinary high water mark are therefore considered jurisdictional under USACE Section 404 permitting guidelines. Delineated boundaries and their respective classifications are illustrated in Figure 3-4. It should be noted that all areas classified as wetlands were found within the high water mark of the Big Hole River; no isolated wetlands were identified within the project area. Fill material placed within regulated Waters of the U.S. and/or jurisdictional wetlands require compensatory mitigation at ratios determined by the U.S. Army Corps of Engineers. Potential impacts resulting from each Action Alternative are discussed in Chapter 4 of this document.

Irrigation ditches running to the north and south of the river were not surveyed during the site visit; ditches were assessed from topographic survey maps of the project reach. Incidental groundwater seepage from the irrigation canal contributes to wetland hydrology along the margins of the riparian zone and extends the boundary of the wetland up gradient in these select areas. The irrigation ditch along the north bank has an apparent surface water nexus to the Big Hole River and may be jurisdictional. The irrigation ditch along the south bank does not appear to have a significant nexus and does not appear to be jurisdictional. Preliminary jurisdictional determinations are subject to USACE concurrence.

Figure 3-4 Delineated Wetland, River and Irrigation Features within Project Area



Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

3.1.11 Air Quality

The proposed project is located in an unclassifiable/attainment area of Montana for air quality under 40 CFR 81.327, as amended. As such, this proposed project is not covered under EPA's "Final Rule" of September 15, 1997 on Air Quality Conformity.

3.2 Human Environment

3.2.1 Land Use / Right of Way and Easements / Utilities

Land Use

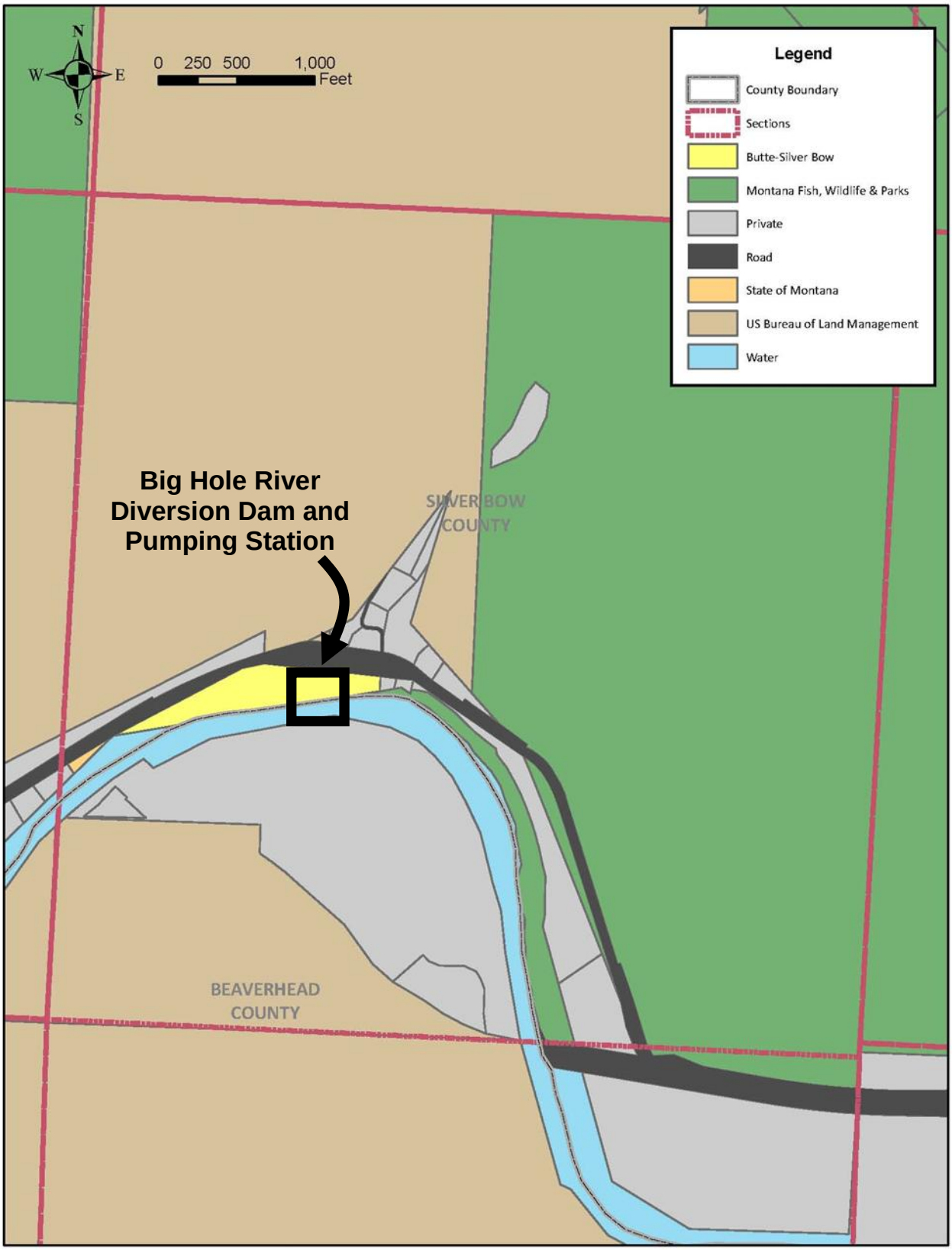
Land use in the immediate vicinity of the existing diversion dam is generally shrubland and grassland, with evergreen forests located in proximity to the project area.

Right-of-Way and Easements

Land near the project site is generally in private, state, or federal ownership. The existing diversion dam and pump house are located on lands owned by BSB. It is anticipated that no new right-of-way would be needed for this project. Figure 3-5 illustrates existing land ownership within the project area.

A search of the FWP website found that the Fleecer Mountain Wildlife Management Area (WMA) is located within close proximity to the existing Big Hole River Diversion Dam. The intent of the WMA is to provide year-round habitat for wildlife, emphasizing winter range for elk and mule deer and to provide public outdoor recreational opportunities. There are no conservation easements or designated wilderness areas within the immediate project area.

Figure 3-5 Land Ownership



Source: NRIS, 2009; DOWL HKM, 2009.

Utilities

The dam, existing pump house, and adjoining facilities are currently served with overhead electrical power and individual propane storage and heaters. Potable water supplies are provided from groundwater wells and sanitary service is provided via individual permitted septic systems. No utility relocations are anticipated for any of the alternatives, although if BSB elects to construct a new pump station, the service point would need to be relocated from the existing pump house to the new pump house.

3.2.2 Historic, Cultural, and Archaeological Resources

The existing Big Hole River diversion dam and associated settling basin are considered contributing resources to the Big Hole Pump Station, which was built in 1899, expanded in 1906, and listed on the National Register of Historic Places (NRHP) in 1980 (Smithsonian Trinomial 24SB257). The existing concrete dam and settling basin, constructed in 1927, replaced the original timber and rock dam located at the site, which was built concurrent with the Pump Station in 1899 and was destroyed by flood in June 1927. Remnants of the original dam are visible in the form of the rock wall on either side of the concrete abutment on the north bank. The Historic Resources Report (Appendix G) contains a full description of the historic, cultural and archaeological resources found within the project area.

Remnants of the original diversion dam, built in 1899, are still evident in the rubble rock retaining wall on the north shore. HRA, 2009.

3.2.3 Noise

Existing noise sources in the project area are from agricultural and recreational activities, traffic on State Highway 43, and birds and animal life. The pump house operations produce minimal noise.

3.2.4 Farmlands

None of the soils identified within the vicinity of the project area are classified as Prime Farmland, Unique Farmland, or Farmlands of Statewide or Local Importance.

3.2.5 Transportation Facilities

Transportation facilities near the project area include Montana State Highway 43, Pump House Road, Charcoal Gulch Road, and several other local access roadways. The existing dam is accessed via Montana Highway 43 and Pump House Road.

3.2.6 Socio-Economic Conditions

Economic Activity

Ranching, agriculture, forestry, and mining activities play a major role in the region. The nearby economic centers of Butte and Dillon support a number of additional industries, including retail, government, construction, education, health care, entertainment, and hospitality services.

Recreation

The Powerhouse Bridge Fishing Access Site (maintained by FWP) and the Divide Bridge Campground (maintained by the Bureau of Land Management [BLM]) are located approximately three miles west of Divide on State Highway 43, or approximately one half mile to the east and west of the existing diversion dam site, respectively. Recreational uses include fishing, boating, camping, picnicking, hiking, and wildlife viewing.

Boaters on the Big Hole River upstream of the existing diversion dam. DOWL HKM, 2009.

Recreational activities on the Big Hole River are restricted during periods of extreme high or low flows. Fishermen and recreational boaters report that the Big Hole River becomes impassable for rafts and boats in the late summer due to low flows. As noted in Section 2.2, 300 cfs was defined as the low flow limit for boat passage; flows below this benchmark are considered insufficient for boating activities. As noted in Chapter 2, all Action Alternatives that include boat and fish bypass channels would be navigable at flow values at or above 300 cfs.

Communities

The town of Divide, Montana is located approximately two miles to the east of the existing dam; no U.S. Census data is available for this community. In 2000, the nine Census blocks immediately adjacent to the project site had a total population of 17 people, all of whom were classified as "white" by the U.S. Census Bureau. Butte is located approximately 25 miles northeast of the existing dam. Butte-Silver Bow is classified as a Consolidated City by the U.S. Census Bureau and had a population of 34,606 in 2000, while Beaverhead County had a population of 9,202.

Risks / Health Hazards

There are two main safety concerns at the existing dam site. As noted in Chapter 1 of this document, BSB personnel often must venture onto the ice in winter months in order to remove ice blockages, placing themselves at risk of injury or drowning. Further, anecdotal evidence suggests that there have been a number of incidents at the diversion dam site in recent years involving boaters becoming trapped in the standing wave that is formed immediately downstream of the dam crest, requiring rescue.

Emergency Response

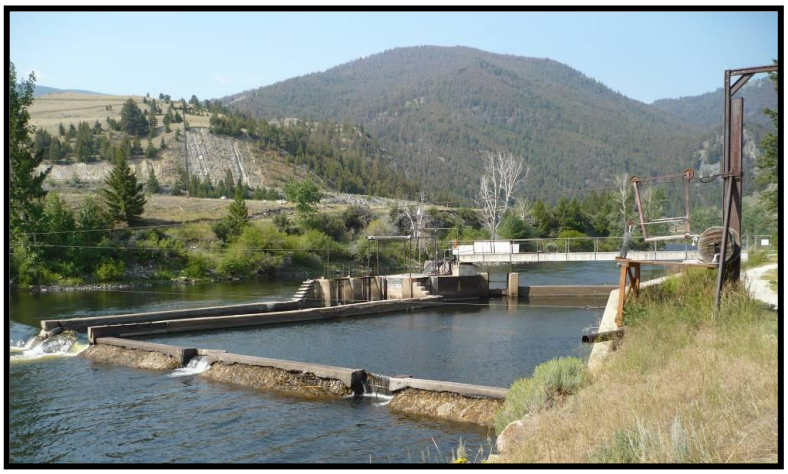
The community of Wise River, located approximately 11 miles west of Divide, provides emergency response services for the area. The nearest hospital is located in Butte. Anecdotal evidence suggests that local residents have historically aided those in immediate danger at the existing dam site.

3.2.7 Hazardous Waste Sites

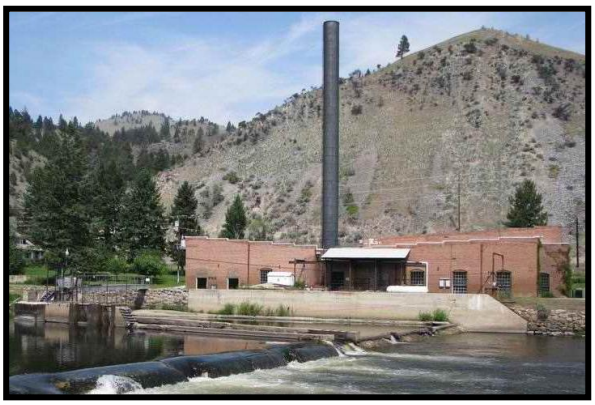
Based on a review of the Natural Resource Information System (NRIS) database, there are no contamination releases, spills, or leaking underground storage tanks within the immediate project area. A Phase I Environmental Site Assessment will not be prepared for this project.

3.2.8 Visual Resources

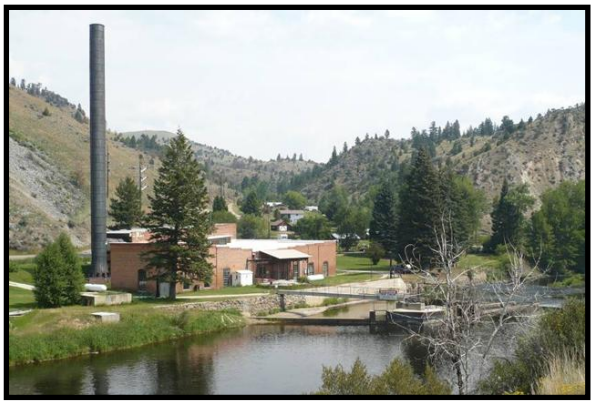
The proposed project area is located in the Big Hole River canyon. The existing diversion dam spans the width of the Big Hole River, running roughly northeast to southwest. The dam is constructed of reinforced, cast-in-place concrete, with concrete abutment walls along the banks of the river. The existing pump house is constructed of brick and stands on the north bank of the river. As depicted in the photographs below, the diversion dam, pump house, and a riveted metal smoke stack are visible in the foreground, with views of treed hillsides extending in the background. Vegetation lines the river banks, with manicured lawns and mature trees surrounding the pump house facility.



The Big Hole River Diversion Dam, facing southwest. HRA, 2009.



The Big Hole River Diversion Dam, pump house, and riveted metal smoke stack. HRA, 2009.



The Big Hole River Diversion Dam and Pump Station, facing northeast. HRA, 2009.

4.0 Impacts and Mitigation

This chapter contains information on potential social, economic, and environmental resource impacts anticipated to result from each alternative. This information was developed in cooperation with local, state, and federal agencies and members of the general public and is intended to satisfy Montana and National Environmental Policy Act (NEPA/MEPA) requirements.

4.1 Resources Not Affected

It was determined that the Action Alternatives would have no impacts on the following resources:

- Geology
- National Wildlife Refuges, Parks, Preserves, Monuments, and Wild & Scenic Rivers
- Farmlands
- Environmental Justice
- Hazardous Waste Sites

No mitigation would be required for these five resource areas.

4.2 Effects on Natural and Physical Environment

4.2.1 Topography and Soils

Effects of No Action

No effect.

Effects of Action Alternatives

Localized impacts would occur as a result of the Action Alternatives. Under Alternative 2, approximately 0.25 acres would be permanently disturbed within the immediate project area, while approximately one acre would be permanently disturbed under Alternatives 3, 4, and 5. A staging area for equipment and materials occupying approximately 0.5 acres within the arid, upland vegetated area on the terrace to the south of the river would also be temporarily disturbed.

Mitigation for Action Alternatives

Under all proposed Action Alternatives, upland areas temporarily disturbed during project construction and staging activities would be reclaimed and reseeded following project completion. Mitigation for permanent impacts to USACE jurisdictional areas is discussed later in this section.

4.2.2 Vegetation

Effects of No Action

Existing riparian and upland vegetation would not be affected.

Effects of Action Alternatives

Under each of the Action Alternatives, river bank armoring would be needed for structural stability to tie the new structures into the stream banks and to protect new intake systems. The use of rock materials in these locations would result in the permanent removal of riparian vegetation from both the north and south banks of the river, as detailed in Table 4.1.

Table 4.1 Permanent Impacts to Riparian Vegetation

Permanent Impact	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres
Permanent Impact	1,960	0.05	5,619	0.13	5,350	0.12	9,934	0.23

Under Alternative 5, the dam structure would be located further upstream as compared to the other alternatives. The north and south river banks are not currently armored in this upstream location, and therefore Alternative 5 would result in a greater total impacted area.

Under all Action Alternatives, temporary impacts to vegetation would occur within a staging area for equipment and materials. The staging area would occupy approximately 0.5 acres within the arid, upland vegetated area on the terrace to the south of the river.

Mitigation for Action Alternatives

Bioengineered bank treatments have become a viable alternative to the use of large stone and rock structures for stabilizing river banks. Bioengineering techniques aim to use native materials such as soil lifts, biodegradable fabric, and dense vegetation to stabilize eroding banks and to either slow or prevent lateral movement of stream banks. These techniques have been used successfully in many projects across Montana as a softer approach to the traditional use of riprap.

The use of bioengineered banks was considered for Action Alternatives in areas where large rock, stone, and grouted stone is proposed along the banks of the Big Hole River. Upon consideration of these techniques, it was noted that all proposed hardened rock features are designed to permanently secure the structural components of the rock weir and intake pipe walls to the river's bed and banks. It is critically important that each of these structures is permanently secured in place to meet the project's maintenance and operational objectives. As a result, the use of bioengineered river banks in the immediate vicinity of the proposed dam and intake structures was determined an inappropriate technique in these locations. However, bioengineered stabilization in other locations up and downstream of the actual dam and intake structures will be considered in final design. Such applications may be used to protect and enhance the reclaimed stream banks due to construction access, to promote natural re-vegetation of impacted areas, and to minimize flood inundation areas.

Armoring of the north bank has the potential to impact mature cottonwoods. Since this species appears to have a limited amount of advanced regeneration currently present at the site, avoidance of mature cottonwoods is recommended. If impact to the mature vegetation is unavoidable, replanting disturbed vegetation with the same or similar species in the vicinity of the impacts is recommended to minimize habitat disturbance.

Proper reclamation of the staging and borrow pit area following completion of the project would include reseeding and erosion control along access roads. Additionally, as a result of multiple Category 1 weeds present within the project area, efforts would be taken to prevent further spread of these weeds during project construction. Construction activities would comply with the Montana Noxious Weed Control Law (MCA §§ 7-22-2101 through 2154).

4.2.3 Wildlife

Effects of No Action

Existing wildlife habitat would not be affected.

Effects of Action Alternatives

Short-term construction impacts to wildlife would include increased activity and noise in the project area under each of the Action Alternatives. During construction activity, more mobile species such as adult birds and mid-size to large mammals generally move to adjacent habitats to avoid direct mortality from construction activities. Temporary loss of nesting, foraging, and cover habitat may occur from temporary vegetation clearing for construction staging activities.

Permanent impacts to riparian habitat would result from each of the alternatives, as presented in Table 4.1.

Mitigation for Action Alternatives

Mitigation for the removal of riparian vegetation could include offsite riparian enhancement measures such as cottonwood and willow planting or livestock fencing in sensitive riparian areas.

4.2.4 Fisheries

Effects of No Action

Existing fisheries habitat would not be affected. The existing dam would continue to impeded fish passage, reducing access to spawning and rearing habitats.

Effects of Action Alternatives

Alternative 2:

Under this alternative, the new diversion dam would continue to serve as a barrier to fish passage. Alternative 2 would position the new dam approximately 160 feet upstream of the existing dam at an elevation nearly one foot higher than the existing dam. Constructing the new dam upstream of the existing dam would create a backwater pool which would extend further upstream of the current backwater; however, overall pool size and habitat quality would not be affected by moving the dam slightly upstream of its current location.

Replacement of the settling basin with a screened intake may reduce fish losses, as the existing intake structure is not screened to prevent fish entrainment.

Construction activities may temporarily increase turbidity in the Big Hole River, adversely affecting fish.

Alternatives 3, 4, and 5:

Alternatives 3, 4, and 5 would improve fish passage by gradually stepping the drop in water elevation downstream of the new dam structure. This would allow smaller fish to pass over the dam due to shorter jumping heights, as well as reducing the water velocity across the dam crest.

It is understood that “ideal” fish passage occurs when velocities remain below 6 fps, as this represents the approximate sustained speed for the majority of adult fish that are known to exist within the project area. With all Action Alternatives, velocities of less than 6 fps are achieved

over the range of typical flows from 200 to 2,000 cfs, with the exceptions of the crest of the upper drop, the upper drop pool, and the crest of the lower drop. It is important to note that these calculated velocities reference a single cross-section and are not representative of velocities along the entire flow path. Although calculated velocities approach 12.5 fps in certain locations, this is still well below the darting velocities of 13 to 14 fps for the fish species located within the project area; further, these higher velocities only occur at river flows in excess of 2,000 cfs. Additional refinement of the final hydraulics will determine the anticipated velocity profiles throughout the reach. A wider opening in the boat and fish channel to further reduce the velocities in these sections may be considered in the final design phase. With a wider opening, the cross-sectional area would be increased, resulting in a lower velocity for the same flow rate.

Fish passage would be improved during all times of the year as a result of improved hydraulics. Providing fish passage would allow trout, grayling, suckers, burbot, and whitefish to freely move throughout this portion of the Big Hole watershed, whereas the existing dam may reduce fish passage to spawning and rearing habitats. The re-establishment of fish passage at the Big Hole Dam is considered a substantial benefit to fish populations utilizing this portion of the watershed.

Under Alternatives 3 and 4, the new dam structure would be set approximately 145 feet upstream of the existing dam. The crest of the new dam would be at nearly the same elevation as the existing dam, and would maintain a backwater pool upstream of the new dam crest. The length of the existing backwater pool would be shortened by 145 feet (approximately 20 percent of the existing pool length), which is equivalent to the distance between the existing dam and the proposed location of the new dam. Alternative 5 would position the nose of the new rock weir dam approximately 630 feet upstream of the existing dam, with a new dam crest approximately 1.1 feet higher than the existing dam crest, creating a backwater pool extending further upstream from the existing backwater pool feature. The increase in crest elevation as compared to the existing dam would maintain equivalent, important habitat upstream of the new dam.

Alternatives 3, 4 and 5 would improve the water intake component of the facility. The intake would be positioned to allow fish and debris to pass the screened intake, reducing the possibility of entrainment.

These alternatives would require placement of grouted rock within the channel. The use of large stone within these areas would create aquatic features which may attract fish due to increased habitat complexity. Conversely, the use of large stone would replace native bed materials which currently provide habitat for macroinvertebrates, a key source of food for fish. Overall, the conversion of native bed materials to large stone, when combined with the creation of fish passage and the new screened intake, is considered a substantial improvement as compared to existing conditions for fish.

As with Alternative 2, construction activities may temporarily increase turbidity in the Big Hole River, adversely affecting fish.

Mitigation for Action Alternatives

Alternatives 3, 4, and 5 would re-establish unrestricted fish passage at the site. This is considered a substantial improvement for fish populations utilizing this portion of the watershed. Unrestricted fish passage would allow fish to easily move upstream of the facility to spawning

and rearing sites. Additionally, rock features associated with drop pools would increase habitat complexity, which is also considered a benefit to fisheries. Replacement of the settling basin with new screened intakes would likely prevent fish entrainment and reduce fish losses. Overall, these alternatives would provide improved conditions for fisheries in this portion of the Big Hole River.

Under all alternatives, control measures such as dewatering and/or diverting water away from active construction activity would minimize increases in turbidity. Instream construction timing restrictions would be established in coordination with regulatory agencies through the Clean Water Act (CWA) Section 404 and Stream Protection Act (SPA) 124 regulatory processes.

4.2.5 Water Resources and Water Quality

Effects of No Action

No effect.

Effects of Action Alternatives

The project would have no long-term effects on upstream or downstream surface water or groundwater quantity. Short-term, temporary water quality impacts may occur due to potential increases in turbidity during construction.

As noted in Section 4.2.2, bioengineered streambank stabilization measures may be considered in final design. Such applications may be used to protect and enhance reclaimed stream banks due to construction access, to promote natural re-vegetation of impacted areas, and to minimize flood inundation areas.

Mitigation for Action Alternatives

Water quality impacts would be minimized through the use of controls including dewatering and/or diverting water away from active construction activity and erosion and sediment control measures. Bioengineered streambank stabilization measures will be considered during final design.

4.2.6 Floodplains

Effects of No Action

No effect.

Effects of Action Alternatives

Alternatives 2, 3, and 4 would slightly raise the 100-year water surface elevation at the crest of the proposed dams as compared to existing conditions, while Alternative 5 would slightly lower the water surface elevation. Floodplain impacts are considered negligible due to the relatively minor change in water surface elevations under the proposed Action Alternatives.

Mitigation for Action Alternatives

Measures to reduce water surface elevations and protect structures located within the 100-year floodplain will be considered during final design efforts. These measures may include adjusting the height of various system components and using streambank stabilization techniques, which may also have an added benefit of promoting the growth of wetland and upland vegetative

species. Use of such mitigation measures could result in an improvement over existing conditions.

4.2.7 Wetlands and Other Regulated Areas

Effects of No Action

Existing wetlands and waterways would not be affected. No compensatory mitigation would be required as a result of this alternative.

Effects of Action Alternatives

Alternatives 3, 4, and 5 would result in temporary impacts where sections of pipe would be buried within the delineated boundary of the Big Hole River. This activity would result in the temporary removal of riparian vegetation along the bank during placement of the pipes. Once these intake pipes are buried, the affected area would be re-seeded and vegetation would regenerate along the river bank. Areas of temporary impacts in regulated areas are presented in Table 4.2.

Table 4.2 Temporary Impacts in USACE Regulated Areas

Temporary Impacts	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres
Intake Pipes and Walls	0	0	229	0.01	922	0.02	544	0.01

In addition to these temporary impacts, the Action Alternatives would also result in permanent impacts within regulated Waters of the U.S. These impacts include permanent removal of riparian vegetation along the north and south river banks, placement of fill on an island with emergent riparian vegetation, and placement of fill within the active river bed. None of the proposed options would affect irrigation ditches along either side of the river. All delineated wetland areas lie between the high water mark on each bank of the Big Hole River; no isolated wetlands occur within the project area.

Each of the Action Alternatives would involve removal of the existing diversion dam and settling basin, including the concrete and rock currently spanning the river and the material used to tie the dam into the banks. These areas lie within regulated Waters of the U.S. and therefore can be calculated as on-site mitigation to offset anticipated permanent impacts resulting from project alternatives. The gross and net areas of anticipated permanent impacts resulting from each alternative are presented in Table 4.3.

Table 4.3 Permanent Impacts in USACE Regulated Areas

	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres	Square Feet	Acres
A. Gross Permanent Impacts								
North Bank	1,304	0.03	3,155	0.07	2,885	0.07	6,028	0.07
South Bank	656	0.02	2,464	0.06	2,465	0.05	3,906	0.09
Island	0.00	0.00	0.00	0.00	0.00	0.00	2,886	0.07
Riverbed	4,211	0.10	48,665	1.12	49,008	1.13	44,311	1.02
Total	**6,171**	**0.15**	**54,284**	**1.25**	**54,358**	**1.25**	**57,131**	**1.31**
B. Onsite Mitigation								
Removal of Existing Dam	4,165	0.10	4,165	0.10	4,165	0.10	4,165	0.10
Removal of Settling Basin	2,480	0.06	2,480	0.06	2,480	0.06	2,480	0.06
Total	**6,645**	**0.16**	**6,645**	**0.16**	**6,645**	**0.16**	**6,645**	**0.16**
Net Area of Permanent Impacts (A – B)	**(-474)**	**(-0.01)**	**47,639**	**1.09**	**47,713**	**1.09**	**50,486**	**1.15**

Source: Big Hole River Dam and Intake Facility Biological Resources Report, 2009.

Mitigation for Action Alternatives

Permanent project impacts anticipated within regulated areas that exceed the area of on-site mitigation will need additional, off-site mitigation (indicated by the net area of permanent impacts in Table 4.3). Final areas and specific types of mitigation required will be determined in coordination with USACE.

Under Alternative 2 the footprint of the new diversion dam would be smaller than the existing footprint, resulting in a net decrease in impacted area. As a result, no additional compensatory mitigation would be required for this alternative.

For Alternatives 3, 4, and 5, the new footprint would be approximately 1.09 to 1.15 acres larger than the footprint of the existing facilities. Accordingly, mitigation measures beyond removal of the existing structures would likely be required to offset the additional impacts of the proposed structures. If it is determined that on-site mitigation opportunities are limited to the removal of the existing structures, an appropriate off-site mitigation area would need to be identified and developed within the watershed to compensate for proposed impacts resulting from these alternatives.

Wetland mitigation opportunities within the immediate project area are limited by the relatively confined floodplain as the Big Hole River exits the canyon. Compensatory mitigation opportunities within the project area include enhancement of the existing riparian corridor along other portions of the Big Hole River, preservation of the existing riparian areas through a conservation easement, establishment of an upland buffer, construction of a new wetland area, expansion of an existing wetland, or incorporation of project impacts into a wetland mitigation bank. FWP, the U.S. Fish and Wildlife Service (FWS), and the Big Hole Watershed Committee are entities currently involved in many restoration and enhancement projects in the Big Hole Watershed and may be resources for identifying appropriate mitigation projects.

Mitigation ratios are based on the type and timing of compensatory mitigation. Wetland restoration (re-establishment) activities completed prior to any anticipated impacts would follow a 1:1 ratio, meaning that one square foot of compensatory wetlands would be required for each square foot of proposed impact. If mitigation is completed at the same time or after the impact, mitigation ratios vary and may range from 1.5:1 to 5:1, depending on the quality of wetland impacted, the type of compensatory mitigation proposed, and the distance between the impacted wetland and mitigation areas. Negotiations with USACE would be required to determine the actual compensatory mitigation required for the project, as well as determination of whether an Individual or Nationwide Clean Water Act 404 permit would be required.

4.2.8 Air Quality

Effects of No Action
No effect.

Effects of Action Alternatives
Minor and temporary dust and vehicle emissions would be created by heavy equipment during construction, but would end after completion of the project.

Mitigation for Action Alternatives
If necessary, dust control would be implemented by using either water or another approved dust-suppressant.

4.3 Effects on Human Environment

4.3.1 Land Use / Right-of-Way and Easements / Utilities

Effects of No Action
No effect.

Effects of Action Alternatives
No land use impacts are anticipated as a result of this project. None of the Action Alternatives would have a substantive impact on existing recreation opportunities or on the location, distribution, density, or growth rate of the area's population. No new right-of-way would be needed for this project. No utility relocations are anticipated.

Mitigation for Action Alternatives
None required.

4.3.2 Historic, Cultural, and Archaeological Resources

Effects of No Action
The No Action Alternative would have no potential to affect historic resources. While the existing diversion dam would not be removed, continued deterioration of the existing diversion dam structure would likely occur.

Effects of Action Alternatives

Alternatives 2, 3, 4, and 5 would vary substantially from the design of the existing dam and waterworks, and would necessitate the complete removal of the existing diversion dam, intake structure, settling basin, cistern, rock retaining walls, and piping. These alternatives would not be classifiable as a preservation treatment, as defined by the National Park Service in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Removal of the existing dam may constitute an adverse effect, which would likely require mitigation. In addition, new piping and other new construction would impact the Big Hole Pump Station, a historic property listed on the NRHP.

Phase II of Alternative 3 would incorporate construction of a new pump station, relocating existing water conveyance functions from the historic Big Hole pump station. This aspect may allow for easier public access to, and preservation of, the historic resource; however, it would alter the primary use of the facility from a pump station, which may be considered an adverse effect and would likely require mitigation.

It should be noted that all proposed Action Alternatives would require ground-disturbing activities. As with any involving ground-disturbing activities, there is a possibility of encountering archaeological resources. During a pedestrian survey of the site, architectural historians encountered a trash scatter of bricks, worked stone, and concrete upstream of the pump station along the north bank. Ground disturbing activities may encounter archaeological evidence from the initial construction of the Big Hole Pump Station (1899), the subsequent addition (1906), the extant dam (1929), and possible foundation remains from outbuildings at the site that have since been removed. Because the site is located at a river, the chance of encountering prehistoric archaeological resources is probable.

Mitigation for Action Alternatives

All Action Alternatives would include removal of the existing diversion dam in its entirety, including various associated components, which would constitute an adverse effect. Phase II of Alternative 3 would also involve construction of a new pump house, altering the primary use of the existing facility, which may be considered an adverse effect. Accordingly, appropriate consultation with the Montana State Historic Preservation Office (SHPO) and other stakeholders would be required to determine which mitigation measures should be undertaken. Mitigation measures to be considered include:

- Historic American Engineering Record (HAER) recordation (Level II).
- Interpretation and education (e.g., install signs or salvaged components at the BSB Public Works Department office or a city park; print a brochure or small pamphlet telling the history of the project; develop a brief documentary film and post it on the BSB website).
- Mitigation through "positive effects" on an historic resource, specifically restoration of the Big Hole Pump Station building. Appropriate mitigation of the Big Hole Pump Station could be limited to exterior character-defining features. This may include re-pointing and repair to structural brick and masonry on the building and smoke stack, and restoration of window and door openings, where appropriate.

In the event that archaeological resources are discovered during construction, appropriate mitigation measures should be followed to ensure their identification, evaluation, and

disposition. BSB should assess the site, in conjunction with a qualified archaeologist and in consultation with SHPO, regarding the nature and condition of the discovered item(s). All construction activity should be suspended until the site is handled properly, and in accordance with state and federal laws.

4.3.3 Noise

Effects of No Action
No effect.

Effects of Action Alternatives
Noise levels would increase temporarily during the construction period for each of the Action Alternatives. The increased noise would end upon completion of the project.

Mitigation for Action Alternatives
The project's contractor would be subject to all state and local laws to minimize construction noise by having mufflers on all equipment.

4.3.4 Transportation Facilities

Effects of No Action
No effect.

Effects of Action Alternatives
All proposed Action Alternatives would result in increased construction-related traffic on State Highway 43.

Mitigation for Action Alternatives
The project's contractor would be subject to all state and local laws to minimize construction noise by having mufflers on all equipment. Dust control would also be implemented by using either water or another approved dust-suppressant. Traffic interruptions would be minimized to the extent possible using appropriate traffic control measures.

4.3.5 Socio-Economic Conditions

Effects of No Action
The dam would continue to deteriorate over time; failure of the dam would adversely affect the residential and commercial water users dependent on the Big Hole River as a source of potable water, resulting in negative effects to the health, safety, and economic activity of the Butte population.

Additionally, the existing dam would remain a safety hazard for boaters and maintenance personnel.

Effects of Action Alternatives
All proposed Action Alternatives would improve safety for maintenance personnel by reducing icing problems at the facility. Action Alternatives would also improve boater safety at the site, potentially reducing the ongoing need for emergency response services. Recreational activities on this portion of the Big Hole River would be enhanced due to the safety improvements

included in the design of the new diversion structure. The dangerous "keeper wave" would be eliminated under these alternatives.

Additionally, under Alternatives 3, 4, and 5, boating passage would also be enhanced due to the design of the chute through the middle of the rock weir. This chute would allow boat passage at the facility during periods of low flow even when other portions of the Big Hole River would be non-navigable due to the shallow depth associated with the natural terrain. At flows of 300 cfs and above, the spillway width would allow boaters to float through with oars extended; boaters would not experience any inconvenience while passing through the spillway.

Under Alternatives 3 and 4, fishing opportunities would be enhanced through the likely creation of a new pool upstream of the existing dam. Alternative 5 would also create a new pool, but would impact the existing pool.

The Action Alternatives would result in a positive effect on economic activity and employment in the region. The project itself may result in short-term construction-related employment opportunities, while a new diversion structure would ensure continued economic vitality for the Butte area.

Mitigation

None required.

4.3.6 Visual Resources

Effects of No Action

The existing concrete diversion dam would continue to span the Big Hole River. No new visual impacts would result.

Effects of Action Alternatives

Under Alternative 2, a new structure similar in size and material would be constructed in the same location as the existing dam. There would be minimal new visual impacts as compared to existing conditions.

Alternatives 3, 4, and 5 would involve removal of the existing dam in its entirety and construction of a rock weir dam using native materials. Under these alternatives, the proposed structures would be visible during low flows, but would better blend into the surroundings as compared to the existing concrete structure. During periods of high flow, the river would overtop the structures, resulting in no visual impact.

With all Action Alternatives, there would be temporary visual impacts resulting from clearing of vegetation.

Mitigation for Action Alternatives

No new visual impacts would result under Alternative 2. Under Alternatives 3, 4, and 5, there would be a net positive visual impact due to the use of native construction materials as compared to the concrete structures currently in place. Under all Action Alternatives, disturbed areas would be reseeded with desirable vegetation.

4.4 Cumulative Effects

While Sections 4.2 and 4.3 disclosed individual impacts resulting exclusively from the proposed project, this section considers the cumulative effects of this project in addition to other past, present, and reasonably foreseeable future projects noted below.

Past Projects

- Construction of the existing diversion dam
- Maintenance activities associated with the existing diversion dam (see full accounting in Appendix B)

Present Projects

- None known (apart from proposed project)

Reasonably Foreseeable Projects

- Continued replacement of deteriorated transmission piping

Past Projects: Effects of No Action

The No Action Alternative would leave the existing diversion dam in place. This structure would continue to impede fish and boater passage. Debris and sediment would continue to accumulate along the entire width of the dam, requiring routine and periodic maintenance by BSB. Due to unabated icing problems at the site, maintenance personnel would continue to work in unsafe conditions. Over time, the dam would continue to deteriorate, posing an increasing risk of failure. Should the dam fail, the Butte service area would lose a major source of potable water, which could negatively affect human health and welfare in addition to economic activity in the Butte area. In the event of dam failure, a full emergency repair would difficult, costly, and would negatively impact the water customers in Butte.

Present Projects: Effects of Action Alternatives

Under Alternative 2, the existing diversion dam would be replaced with a structure nearly identical in size and location. It would largely continue to function as before, and would continue to impede fish and boater passage, although boater safety would be improved through elimination of the "keeper wave." Safety for maintenance personnel would be improved with the relocation of the intake structure from the middle of the river to the north bank and simplification of the operating protocols. The new structure would eliminate the risk of failure and would provide a reliable source of water for Butte. Under Alternatives 3, 4, and 5, the existing diversion dam would be replaced with a new rock weir dam constructed of native materials. These alternatives would provide the benefits noted under Alternative 2, in addition to improved boat and fish passage.

Under all of the proposed Action Alternatives, repair or replacement of the existing diversion dam would guarantee reliable water delivery to Butte, and thereby encourage continued economic growth and development in the Butte area. The proposed project would also have a positive cumulative effect on safety at the site for both maintenance personnel and for boaters and recreationalists. The proposed project would not induce land use changes or promote unplanned growth in the immediate project area; no new developments or new land uses are anticipated within the immediate vicinity as a result of this project.

Reasonably Foreseeable Projects

BSB intends to continue to replace old, leaking water transmission lines throughout the Butte water system as funding allows, improving the efficiency and reliability of water delivery and resulting in a positive cumulative effect on Butte water users. There are no other known projects planned for the foreseeable future within 10 miles of the diversion dam site that would contribute to cumulative impacts when considered in conjunction with the proposed project.

4.5 Summary of Impacts

Table 4.4 summarizes impacts and associated mitigation commitments for each alternative.

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Table 4.4 Summary of Impacts and Mitigation Commitments

Resource Area	Alternative 1: No Action		Alternative 2: Replace in Kind		Alternative 3: Rock Weir and New Pump House		Alternative 4: Rock Weir with Floating Intake		Alternative 5: Upstream Rock Weir	
	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation
Topography & Soils	No effect	None required	Permanent impact of 0.25 acres; temporary impact of 0.5 acres for staging area	Reclamation and reseeding for areas temporarily impacted; mitigation for permanent impacts to jurisdictional areas to be determined in coordination with USACE	Permanent impact of 1.0 acres; temporary impact of 0.5 acres for staging area	Reclamation and reseeding for areas temporarily impacted; mitigation for permanent impacts to jurisdictional areas to be determined in coordination with USACE	Permanent impact of 1.0 acres; temporary impact of 0.5 acres for staging area	Reclamation and reseeding for areas temporarily impacted; mitigation for permanent impacts to jurisdictional areas to be determined in coordination with USACE	Permanent impact of 1.0 acres; temporary impact of 0.5 acres for staging area	Reclamation and reseeding for areas temporarily impacted; mitigation for permanent impacts to jurisdictional areas to be determined in coordination with USACE
Vegetation	No effect	None required	Permanent impact of 0.05 acres; temporary impact of 0.5 acres for staging area	Consider use of bioengineered streambank stabilization; utilize reclamation, reseeding, and erosion control measures	Permanent impact of 1.0 acres; temporary impact of 0.13 acres for staging area	Consider use of bioengineered streambank stabilization; utilize reclamation, reseeding, and erosion control measures	Permanent impact of 1.0 acres; temporary impact of 0.12 acres for staging area	Consider use of bioengineered streambank stabilization; utilize reclamation, reseeding, and erosion control measures	Permanent impact of 0.23 acres; temporary impact of 0.5 acres for staging area	Consider use of bioengineered streambank stabilization; utilize reclamation, reseeding, and erosion control measures
Wildlife	No effect	None required	Short-term construction impacts including increased activity and noise in the project area; temporary loss of nesting, foraging, and cover habitat	Minimize noise and utilize offsite riparian enhancement measures	Short-term construction impacts including increased activity and noise in the project area; temporary loss of nesting, foraging, and cover habitat	Minimize noise and utilize offsite riparian enhancement measures	Short-term construction impacts including increased activity and noise in the project area; temporary loss of nesting, foraging, and cover habitat	Minimize noise and utilize offsite riparian enhancement measures	Short-term construction impacts including increased activity and noise in the project area; temporary loss of nesting, foraging, and cover habitat	Minimize noise and utilize offsite riparian enhancement measures
Fisheries	Existing dam would continue to impede fish passage	None required	New dam would continue to impeded fish passage; screened intake may reduce fish losses; project may temporarily increase in turbidity	Utilize control measures to minimize increases in turbidity; coordinate with regulatory agencies regarding instream construction timing	Rock weir would improve fish passage; screened intake may reduce fish losses; project may temporarily increase in turbidity	Utilize control measures to minimize increases in turbidity; coordinate with regulatory agencies regarding instream construction timing	Rock weir would improve fish passage; screened intake may reduce fish losses; project may temporarily increase in turbidity	Utilize control measures to minimize increases in turbidity; coordinate with regulatory agencies regarding instream construction timing	Rock weir would improve fish passage; screened intake may reduce fish losses; project may temporarily increase in turbidity	Utilize control measures to minimize increases in turbidity; coordinate with regulatory agencies regarding instream construction timing

Resource Area	Alternative 1: No Action		Alternative 2: Replace in Kind		Alternative 3: Rock Weir and New Pump House		Alternative 4: Rock Weir with Floating Intake		Alternative 5: Upstream Rock Weir	
	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation
Water Resources and Water Quality	No effect	None required	Short-term, temporary water quality impacts may occur	Utilize control measures to minimize increases in turbidity; consider bioengineered stabilization measures to protect reclaimed stream banks	Short-term, temporary water quality impacts may occur	Utilize control measures to minimize increases in turbidity; consider bioengineered stabilization measures to protect reclaimed stream banks	Short-term, temporary water quality impacts may occur	Utilize control measures to minimize increases in turbidity; consider bioengineered stabilization measures to protect reclaimed stream banks	Short-term, temporary water quality impacts may occur	Utilize control measures to minimize increases in turbidity; consider bioengineered stabilization measures to protect reclaimed stream banks
Floodplains	No effect	None required	Slight increase in water surface elevation during 100-year flood event	Consider measures to reduce water surface elevations and protect structures, including adjusting the height of various system components and using streambank stabilization techniques	Slight increase in water surface elevation during 100-year flood event	Consider measures to reduce water surface elevations and protect structures, including adjusting the height of various system components and using streambank stabilization techniques	Slight increase in water surface elevation during 100-year flood event	Consider measures to reduce water surface elevations and protect structures, including adjusting the height of various system components and using streambank stabilization techniques	Slight decrease in water surface elevation during 100-year flood event	None required
Wetlands and Other Regulated Areas	No effect	None required	Net decrease in impacted area	None required	Temporary impact of 0.01 acres; Permanent impact of 1.09 acres	On-site or off-site mitigation would be required; final areas and specific types of mitigation to be determined in coordination with USACE	Temporary impact of 0.02 acres; Permanent impact of 1.09 acres	On-site or off-site mitigation would be required; final areas and specific types of mitigation to be determined in coordination with USACE	Temporary impact of 0.01 acres; Permanent impact of 1.15 acres	On-site or off-site mitigation would be required; final areas and specific types of mitigation to be determined in coordination with USACE
Air Quality	No effect	None required	Minor and temporary dust and vehicle emissions	If necessary, dust control measures would be implemented	Minor and temporary dust and vehicle emissions	If necessary, dust control measures would be implemented	Minor and temporary dust and vehicle emissions	If necessary, dust control measures would be implemented	Minor and temporary dust and vehicle emissions	If necessary, dust control measures would be implemented
Land Use / Right-of-Way and Easements / Utilities	No effect	None required	No effect	None required	No effect	None required	No effect	None required	No effect	None required

Resource Area	Alternative 1: No Action		Alternative 2: Replace in Kind		Alternative 3: Rock Weir and New Pump House		Alternative 4: Rock Weir with Floating Intake		Alternative 5: Upstream Rock Weir	
	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation	Impact	Mitigation
Historic, Cultural, and Archaeological Resources	Continued deterioration of the diversion dam structure	None required	Complete removal of the existing diversion dam, intake structure, settling basin, rock retaining walls, and piping; new piping into existing pump house	Historic American Engineering Record (HAER) recordation (Level II); interpretation and education; mitigation through "positive effects" (i.e., restoration of existing pump house)	Complete removal of the existing diversion dam, intake structure, settling basin, rock retaining walls, and piping; new piping into existing pump house; construction of new pump house in Phase II	Historic American Engineering Record (HAER) recordation (Level II); interpretation and education; mitigation through "positive effects" (i.e., restoration of existing pump house)	Complete removal of the existing diversion dam, intake structure, settling basin, rock retaining walls, and piping; new piping into existing pump house	Historic American Engineering Record (HAER) recordation (Level II); interpretation and education; mitigation through "positive effects" (i.e., restoration of existing pump house)	Complete removal of the existing diversion dam, intake structure, settling basin, rock retaining walls, and piping; new piping into existing pump house	Historic American Engineering Record (HAER) recordation (Level II); interpretation and education; mitigation through "positive effects" (i.e., restoration of existing pump house)
Noise	No effect	None required	Temporary increase in noise during construction	Minimize construction noise by having mufflers on all equipment	Temporary increase in noise during construction	Minimize construction noise by having mufflers on all equipment	Temporary increase in noise during construction	Minimize construction noise by having mufflers on all equipment	Temporary increase in noise during construction	Minimize construction noise by having mufflers on all equipment
Transportation Facilities	No effect	None required	Temporary increase in construction-related traffic	Utilize measures to minimize dust, noise, and traffic interruptions	Temporary increase in construction-related traffic	Utilize measures to minimize dust, noise, and traffic interruptions	Temporary increase in construction-related traffic	Utilize measures to minimize dust, noise, and traffic interruptions	Temporary increase in construction-related traffic	Utilize measures to minimize dust, noise, and traffic interruptions
Socio-Economic Conditions	No effect	None required	Improved safety for maintenance personnel and recreational users; enhanced economic activity and employment in region	None required	Improved safety for maintenance personnel and recreational users; enhanced boating and fishing opportunities; enhanced economic activity and employment in region	None required	Improved safety for maintenance personnel and recreational users; enhanced boating and fishing opportunities; enhanced economic activity and employment in region	None required	Improved safety for maintenance personnel and recreational users; enhanced boating opportunities; enhanced economic activity and employment in region	None required
Visual Resources	No effect	None required	Minimal new visual impacts	None required	Rock weir would be visible during low flows, but would better blend into the surroundings; during periods of high flow, the river would overtop the weir resulting in no visual impact.	None required	Rock weir would be visible during low flows, but would better blend into the surroundings; during periods of high flow, the river would overtop the weir resulting in no visual impact.	None required	Rock weir would be visible during low flows, but would better blend into the surroundings; during periods of high flow, the river would overtop the weir resulting in no visual impact.	None required

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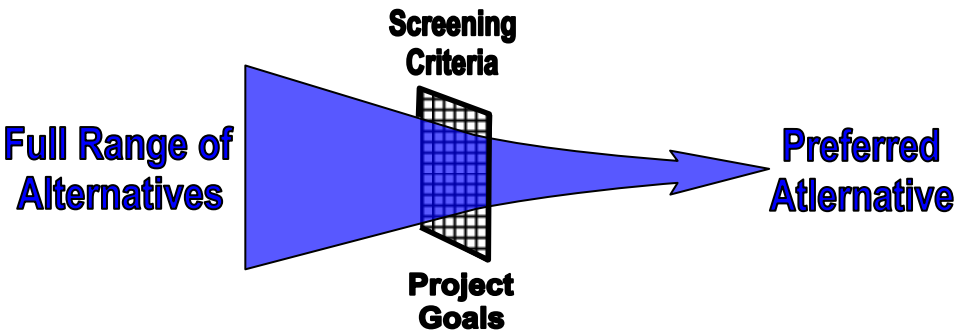
5.0 Alternatives Evaluation and Selection of Preferred Alternative

5.1 Evaluation of Alternatives

This section describes how the broad range of initial alternatives was evaluated using a set of defined Screening Criteria. As noted in Section 1.5, project goals were developed to aid in evaluation of the proposed project alternatives and selection of the Preferred Alternative. As illustrated in Figure 5-1, alternatives were assessed to determine their ability to meet project goals. Based on its ability to best meet project goals, the Preferred Alternatives is presented at the end of this chapter. It should be noted that project goals are not listed in order of importance. For purposes of clarity, Alternative 1 is considered the No Action Alternative and Alternatives 2, 3, 4 and 5 are considered Action Alternatives.

Figure 5-1 Alternatives Screening Process



Goal 1: Provide a Reliable Source of Water for BSB Service Area

The No Action Alternative would not provide any improvement to existing conditions and therefore does not meet Goal 1. It is carried forward, however, as a baseline for comparative analysis and as a viable option if the impacts of the proposed project appear to outweigh the benefits.

All proposed Action Alternatives would provide a more reliable diversion system than currently exists. Under Alternatives 2, 3, and 5, the new intake system would use either a butterfly valve or an Obermeyer gate valve, and would provide operational flexibility to enable maximum system performance during variable river flows, weather conditions, and raw water demands, allowing adequate diversion, clearing of screens, and passage of ice and debris. Alternative 4 would utilize an intake system with River Tee screens designed to maximize suction head for the existing pumps, although the intake may be vulnerable to damage from debris moving downstream during large flow events.

All Action Alternatives would provide a secondary intake system, which does not currently exist. This is considered an important benefit because it would ensure continued service should the primary intake system fail or require maintenance.

Under Alternative 2, the concrete dam would be durable and long-lasting. The downstream toe would be protected with concrete rubble and a layer of native angular rock would protect the intake against erosion and scour. The rock weirs in alternatives 3, 4, and 5 are designed to be reliable and self-maintaining. The combined rock and grout used for the weirs provide an extremely durable material that can withstand hydraulic forces, erosion and scour, and freeze-thaw damage.

As noted in Section 2.2, all four Action Alternatives were designed to meet minimum function requirements, and therefore meet Goal 1.

Goal 2: Reduce Maintenance Requirements

The No Action Alternative would not provide any improvement over existing conditions and therefore does not meet Goal 2.

Alternatives 2, 3, and 5 would reduce the formation of ice by allowing water to continuously flow through the new intake structure during winter months with velocities sufficient to sluice ice and maintain submergence on the intake screens. These closed intake structures can also be fitted with air bubbler systems to minimize ice buildup. Additionally, these new intake structures would also have sufficient flow velocities to flush debris and sediment accumulations. These factors would greatly reduce the ice buildup, thereby reducing maintenance requirements for BSB personnel. Alternative 4 involves submerging the intake screens in an upstream pool well beneath any potential ice buildup.

Alternatives 3, 4, and 5 incorporate a stepped grouted rock weir with a minimal application of gates and stop logs for flow management. This simplified design of the new dam would reduce required operator interface and future maintenance.

Alternatives 2, 3, and 5 would also optimize debris handling and sediment flushing. A debris boom would collect surface debris at the site, while a gate system would allow screen flushing as needed based on flow conditions. Under Alternative 4, the intake system would be submerged under all flows, negating the need for debris handling and sediment flushing.

In addition, the construction of new facilities would inherently reduce the amount of required routine maintenance.

While the intake system would be located along the river bank under Alternatives 2, 3, and 5, Alternative 4 would involve instream intake system components. These components would be vulnerable to damage by trash and debris during high flow events. Further, these system components are designed to float in a natural pool upstream of the existing dam; it is not clear how the new rock weir structure would affect future scour patterns in the riverbed. Over time, sedimentation may fill in this pool, negating the advantage of a floating intake system.

All four Action Alternatives meet Goal 2, although Alternative 4 may not be as effective at meeting this goal as compared to Alternatives 2, 3, and 5.

Goal 3: Reduce Icing Problems

The No Action Alternative would not provide any improvement over existing conditions and therefore does not meet Goal 3.

As noted previously, all Action Alternatives would reduce the formation of ice and therefore all Action Alternatives meet Goal 3.

Goal 4: Improve Fish Passage

The No Action Alternative would not provide any improvement over existing conditions and therefore does not meet Goal 4.

As documented in Chapter 4, Alternative 2 would continue to impede fish passage, limiting access to important spawning and rearing habitats, and therefore fails to meet Goal 4.

Alternatives 3, 4, and 5 would provide improved fish passage through the use of notched weirs and the installation of a fish passage channel with rest pools. Providing fish passage would allow trout, grayling, suckers, burbot, and whitefish to freely move throughout this portion of the Big Hole watershed. The re-establishment of fish passage at the Big Hole Dam is considered a substantial benefit to fish populations utilizing this portion of the watershed. These alternatives pass Goal 4.

Goal 5: Improve Boat Passage Safety

The No Action Alternative would not provide any improvement over existing conditions and therefore does not meet Goal 5.

Under Alternative 2, the design of the concrete dam would include a stepped dam face to eliminate the keeper wave that currently exists, thereby improving boater safety. Alternative 2 would not improve boat passage, however, and therefore fails to meet Goal 5.

Spring 2009 runoff conditions illustrating keeper wave at the existing diversion dam. WHPacific, 2009.

In addition to a stepped rock face that would eliminate the existing keeper wave, Alternatives 3, 4 and 5 would provide improved boat passage at the site through the use of notched weirs in the rock dam and the installation of a boat passage channel with rest pools. The spillway would be designed to minimize boater inconvenience and optimize boat passage even during periods of low flows when other stretches of the river would be non-navigable. These three alternatives pass Goal 5.

Goal 6: Minimize Impacts to Environmental Resources

The No Action Alternative would not involve any new impacts to environmental resources.

Although Alternative 2 would not involve placement of additional fill material in the river, it would continue to impede fish passage. As documented in Chapter 4, Alternative 2 would

prevent fish access to important spawning and rearing habitats. Accordingly, Alternative 2 fails to meet Goal 6.

Alternatives 3, 4, and 5 would all provide improved fish passage through the use of a notched rock weir design and the installation of a fish passage channel with rest pools. As noted previously, the re-establishment of fish passage at the Big Hole Dam is considered a substantial benefit to fish populations utilizing this portion of the watershed.

Of the four proposed Action Alternatives, Alternative 3 is considered the least impactful as its entire footprint is located within the historical footprint of the existing dam. It would provide fish passage and would require the least amount of new fill in the river. This alternative best meets Goal 6, while Alternatives 2, 4, and 5 are less favorable with more impact, larger footprints and more fill in the river.

Goal 7: Improve Safety for Maintenance Personnel

The No Action Alternative would not provide any improvement to existing conditions and therefore does not meet Goal 7.

As noted previously, all Action Alternatives would reduce the formation of ice. Maintenance personnel would no longer need to venture onto the ice to maintain flow to the intake system, thereby eliminating the risk of personal injury. Alternatives 2, 3, and 5 would further improve safety by relocating the intake structure along the north shore of the Big Hole River as opposed to the current instream location, which would greatly improve access and safety should BSB operators be required to conduct work or maintenance on the structure. All Action Alternatives meet Goal 7.

Goal 8: Minimize Project Costs

The No Action Alternative would only involve costs related to the preliminary design and environmental compliance efforts conducted to date, and would not involve any construction costs. It should be noted, however, that without reconstruction or major rehabilitation of the existing facility, costly emergency repairs would likely be needed on a continuing basis. Due to its low cost, this alternative meets Goal 8.

Alternatives 2, 3, 4, and 5 are considered moderately costly, ranging from $4.0 to $9.5 million. All Action Alternatives meet Goal 8. It should be noted that the second phase of Alternative 3 would cost approximately $4.4 million are considered separately; construction of Phase II is dependent on future funding availability.

Table 5.1 has been prepared to summarize the analysis of the five different alternatives against the eight project goals in matrix form. Each alternative was either given a “pass” or “fail” when analyzed against each specific project goal. “Passing” grades were assigned a value of 1, while “failing” grades were given a value of 0. The highest score reflects the alternative best meeting the project goals.

Table 5.1 Summary of Screening Process

Screen Component	Alternatives				
	One: No Action	Two: Replace in Kind	Three: New Rock Weir Dam, Intake and Pump Station	Four: New Rock Weir Dam and Submerged Upstream Intake	Five: New Upstream Rock Weir Dam and Intake
Goal 1: Provide a reliable source of potable water for the BSB service area	No improvement over existing conditions; system failure or malfunction is expected at any time **Score = 0**	New dam and intake structure would improve reliability of water diversion by increasing the ability to modulate flow and upstream water levels via the intake control system. This would enable flushing the intake works, reduction in ice buildup and frazzle ice accumulation, improved debris handling, and increased operator safety. **Score = 1**	New dam and intake structure would improve reliability of water diversion by increasing the ability to modulate flow and upstream water levels via the intake control system. This would enable flushing the intake works, reduction in ice buildup and frazzle ice accumulation, improved debris handling, and increased operator safety. Phase II would involve construction of a new pump house, thereby improving reliability of the raw water delivery system. **Score = 1**	New submerged intake structure would improve reliability of water diversion by locating the intakes below the ice levels and in the deeper upstream pool. This alternative also provides increased upstream water surface levels and increased suction head on existing pumps. **Score = 1**	New upstream dam and intake structure would improve reliability of water diversion by increasing the ability to modulate flow and upstream water levels via the intake control system. This would enable flushing the intake works, reduction in ice buildup and frazzle ice accumulation, improved debris handling, and increased operator safety. This alternative also provides for increased upstream water surface levels and increased suction head on existing pumps. **Score = 1**
Goal 2: Reduce maintenance requirements	No improvement over existing conditions; intensive maintenance requirements would be ongoing **Score = 0**	Reduced level of required maintenance due to new facilities and simplified operations with minimal application of flow control gates and stop logs. **Score = 1**	Reduced level of required maintenance due to new facilities and simplified operations with minimal application of flow control gates and stop logs. **Score = 1**	Reduced level of required maintenance due to new facilities and simplified operations with minimal application of flow control gates and stop logs. **Score = 1**	Reduced level of required maintenance due to new facilities and simplified operations with minimal application of flow control gates and stop logs. **Score = 1**
Goal 3: Reduce icing problems	No improvement over existing conditions; ice formation would continue to pose problems for system functionality **Score = 0**	Design would minimize icing through increased sluicing velocities and application of air bubbler systems **Score = 1**	Design would minimize icing through increased sluicing velocities and application of air bubbler systems. **Score = 1**	Design would minimize icing by submerging intake screens below ice levels in the river **Score = 1**	Design would minimize icing through increased sluicing velocities and application of air bubbler systems **Score = 1**
Goal 4: Improve fish passage	No improvement over existing conditions; fish passage would continue to be impeded **Score = 0**	New facility would not provide fish passage **Score = 0**	Notched weir design with fish passage channel and rest pools would enable unrestricted fish passage **Score = 1**	Notched weir design with fish passage channel and rest pools would enable unrestricted fish passage **Score = 1**	Notched weir design with fish passage channel and rest pools would enable unrestricted fish passage **Score = 1**
Goal 5: Improve boat passage	No improvement over existing conditions; "keeper wave" would continue to pose safety risk for boaters **Score = 0**	While "keeper wave would be eliminated, new facility would not provide boat passage **Score = 0**	Notched weir design with boat passage channel and rest pools would provide safe boat passage **Score = 1**	Notched weir design with boat passage channel and rest pools would provide safe boat passage **Score = 1**	Notched weir design with boat passage channel and rest pools would provide safe boat passage **Score = 1**
Goal 6: Minimize impacts to environmental resources	No new impacts **Score = 1**	This alternative would remove existing dam and replace with new structure that would inhibit fish passage. New dam and intake would be outside the historical footprint and would require a point of diversion change. **Score = 0**	This alternative would remove existing dam structure. The new structure footprint is located within the historical footprint and requires the least amount of new fill in the river of the three alternatives providing fish passage. Alternative would not require a point of diversion change **Score = 1**	Alternative would remove existing dam, but require new fill material for rock weir located well outside the historical footprint. This alternative would require a change in the point of diversion **Score = 0**	Alternative would remove existing dam, but require new fill material for rock weir located well outside the historical footprint. This alternative would require a change in the point of diversion **Score = 0**
Goal 7: Improve safety for maintenance personnel	No improvement over existing conditions; maintenance personnel would continue to risk personnel injury when maintaining existing system **Score = 0**	Design would improve safety for maintenance personnel through reduced ice removal efforts. Intake would be located adjacent to north bank, and would not require access to the middle of the river. **Score = 1**	Design would improve safety for maintenance personnel through reduced ice removal efforts. Intake would be located adjacent to north bank, and would not require access to the middle of the river. **Score = 1**	Design would improve safety for maintenance personnel through reduced ice removal efforts due to the submerged intake design. **Score = 1**	Design would improve safety for maintenance personnel through reduced ice removal efforts. Intake would be located adjacent to north bank, and would not require access to the middle of the river. **Score = 1**
Goal 8: Minimize total project costs*	Low cost ($0.5 million) **Score = 1**	Moderate cost ($4.0 million) **Score = 1**	High total cost ($9.5 million), but moderate cost for Phase I ($5.1 million)** **Score = 1**	Moderate cost ($5.3 million) **Score = 1**	Moderate cost ($5.3 million) **Score = 1**
Alternative Screening Score	**2**	**5**	**8**	**7**	**7**

Note: Red text indicates failure to meet screen component; blue text indicates ability to meet screen component.
*Estimates include costs associated with design, environmental compliance and permitting, and construction.
**Phase II would cost approximately $4.4 million; construction of Phase II is dependent on funding availability.

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Preferred Alternative

As discussed in this section and as shown in Table 5.1, Alternative 3 is the only proposed Action Alternative able to meet all of the Project Goals. Phase I of Alternative 3 would ensure improved system reliability, reduced maintenance and icing problems, improved safety, and improved fish and boat passage. Alternative 3 would not require a permit for a change in point of diversion, eliminating the need for a potentially lengthy permitting process and the risk of re-adjudication of BSB's existing water right. Additionally, of the alternatives providing fish and boat passage, Phase I of Alternative 3 would require the least amount of new fill material in the Big Hole River and would be the least costly. Lastly, the second phase of Alternative 3 would provide an additional operational benefit over other alternatives through construction of a new pump house, which would enable the placement of new or existing pumps at proper elevations to eliminate pump cavitation. Because Alternative 3 is best able to meet the Purpose and Need and the Project Goals, it has been identified as the Preferred Alternative.

Design Options and Other Refinements

As noted in prior discussions, refinements will likely be made to the Preferred Alternative during the final design phase. These design refinements include:

1. Establishing final dam crest elevations;
2. Finalizing dam configuration, crest width, and keyway into river bed and abutment connections;
3. Determination of optimal weir width, elevation, and configuration with respect to velocity profiles, boat and fish passage, and upstream water surface elevations;
4. Final design features including channel width and slope and pool sizing and depth for boat and fish passage channel;
5. Applicability and extent of bioengineered bank treatments;
6. Selection of the preferred control valve system for proposed intake control;
7. Final extent of flood inundation limits and potential mitigation and protection to existing structures;
8. Final screen sizing, both in terms of surface area and opening size;
9. Final intake piping alignments, appurtenances, existing pump station access and connection to existing suction header piping; and
10. Final geotechnical recommendations for upstream cut off walls.

6.0 Permits and Authorizations

It is anticipated that this project will require the following permits and consultation activities:

- SPA 124 Permit from FWP
- Federal Clean Water Act Section 404 Permit from USACE
- Clean Water Act Section 401 Water Quality Certification from USCOE and DEQ
- Short-term Water Quality Standard for Turbidity (318 Authorization) from DEQ
- Montana Pollutant Discharge Elimination System (MPDES) General Permit for Storm Water Discharges Associated with Construction Activity from DEQ
- MPDES General Permit for Discharges Associated with Construction Dewatering from DEQ
- Montana Land-Use License or Easement on Navigable Waters from DNRC
- Floodplain Development Permit from Silver Bow and Beaverhead County Floodplain Administrators
- National Historic Preservation Act Section 106 Consultation with SHPO
- Demolition Permit from the Butte Historic Preservation Commission (HPC)

7.0 List of Preparers

The members of the interdisciplinary team that aided in the preparation of the Big Hole River Diversion Dam Environmental Assessment are listed below:

Preparer / Reviewer Name & Affiliation	Role
Dan Dennehy Butte-Silver Bow	Project Sponsor
Rick Larson Butte-Silver Bow	Project Sponsor
Marty Hovan Butte-Silver Bow	Project Sponsor
Dick Talley, P.E. DOWL HKM	Project Manager and Lead Engineer
Sarah Nicolai, E.I. DOWL HKM	Environmental Planner
Jay Thom, P.E. DOWL HKM	Senior Water Resources Design Engineer
Kristen Hansen DOWL HKM	Senior NEPA/MEPA Practitioner
Maryellen Tuttell, AICP DOWL HKM	Senior Planner and NEPA/MEPA Practitioner
Maria Shepherd DOWL HKM	Senior Biologist
Gary Elwell, P.E. DOWL HKM	Senior Hydrology and Hydraulics Engineer
Jim Potts, E.I.T. DOWL HKM	Hydrogeologist / Water Rights Specialist
Brian Chevalier, P.E. WHPacific	Senior Water Resources Design Engineer

8.0 Distribution List

Federal Agencies

U.S. Army Corps of Engineers
Helena Regulatory Office
10 West 15th Street, Suite 2200
Helena, MT 59626
Attn: Todd Tillinger, State Program Manager
Vicki Sullivan, Project Manager

U.S. Army Corps of Engineers
Seattle District
CENWS-PM-CP-CJ
PO Box 3755
Seattle, WA 98124-3755
Attn: Lynn Wetzler, Project Manager

U.S. Army Corps of Engineers
Omaha District
1616 Capitol Avenue
Omaha, NE 68102-4901
Attn: Matthew D. Vandenberg,
Environmental Resource Specialist

U.S. Environmental Protection Agency
Region 8 Office
1595 Wynkoop Street
Denver, CO 80202-1129
Attn: Toney Ott, Environmental Scientist

U.S. Department of the Interior
Fish & Wildlife Service
Montana Field Office
585 Shepherd Way
Helena, MT 59601
Attn: R. Mark Wilson, Field Supervisor
Doug Peterson, Fishery Biologist

U.S. Bureau of Land Management
Butte Field Office
106 North Parkmont
Butte, MT 59701
Attn: Richard Hotaling, Field Manager
Renee Johnson, Assistant Field Manager

U.S. Environmental Protection Agency
Region 8, Montana Operations Office
Federal Building, 10 NW 15th Street, Suite 3200
Helena, MT 59626-0096
Attn: Julie DalSoglio, Acting Director
Steve Potts, NEPA Coordinator

State Agencies

MT Dept. of Natural Resources & Conservation
1625 11th Avenue
P.O. Box 201601
Helena, MT 59104-0437
Attn: Mary Sexton, Director
Terry Eccles, Regional Manager
Dana Boruch, Right-of-Way Specialist

Montana Fish, Wildlife & Parks
Region 3 Office
1400 South 19th
Bozeman, MT 59718
Attn: Bruce Rich, Regional Fisheries Manager

Montana Department of Environmental Quality
1520 East 6th Avenue, P. O. Box 200901
Helena, MT 59620-0901
Attn: Judy Hanson, Administrator, Permitting & Compliance Division
Tom Ellerhoff, Administrative Officer
Jeff Ryan, Environmental Science Specialist
Chris Romankiewicz, Compliance Inspector

Montana Fish, Wildlife & Parks
Butte Area Resource Office
1820 Meadowlark Lane
Butte, MT 59701
Attn: Jim Olsen, Fisheries Biologist

Natural Resource Damage Program
65 East Broadway
Butte, MT 59701
Attn: Pat Cunneen, Environmental Science Specialist

Montana Department of Transportation
2701 Prospect Avenue
P.O. Box 201001
Helena, MT 59620-1001
Attn: Jim Lynch, Director
Bryan Miller, Bridge Area Engineer

Montana Environmental Quality Council
Legislative Environmental Policy Office
P. O. Box 201704
Helena, MT 59620-1704
Attn: Todd Everts

Office of the Governor
Montana State Capitol Bldg.
P.O. Box 200801
Helena, MT 59620-0801
Attn: Governor Brian D. Schweitzer

Montana State Library
P.O. Box 201800, 1515 East 6th Avenue
Helena, MT 59620-1800
Attn: James Kammerer, Information Services Manager

Local Agencies

Butte-Silver Bow
Planning Department, Community Development
Room 115, Courthouse
155 W. Granite
Butte, MT 59701
Attn: Steve Hess, Floodplain Administrator
Jim Jarvis, Historic Preservation Officer

Beaverhead County
2 South Pacific St., STE #12
Dillon, MT 59725
Attn: Larry Laknar, Floodplain Administrator
Lori Casey, Senior Planner

Beaverhead County Conservation District
420 Barrett St.
Dillon, MT 59725
Attn: Danette Watson

Butte –Silver Bow Historic Preservation Committee
403 West Quartz
Butte, MT 59701
Attn: Jim Shive, Committee Member

Mile High Conservation District
P.O. Box 890
Whitehall, MT 59759
Attn: Kris Hugulet

9.0 Public and Agency Coordination

Advisory Committee

An Advisory Committee (AC) was developed in order to gain input and address the concerns of interested stakeholders. The AC was comprised of the following members:

Al Lefor, Big Hole River Foundation and adjoining landowner
Tony Schoonen, Skyline Sportsman Association
Pat Bailey, adjoining landowner
Leo Jense, Anaconda Sportsman Club
Jim Hagenbarth, Big Hole Watershed Committee
Mike Bias, Big Hole River Foundation
Steve Parker, Big Hole River Foundation and Montana Tech
Steve Luebeck, George Grant Chapter Trout Unlimited

The first AC Meeting was held on July 22, 2009. The purpose of the meeting was to explain the intent of the committee, discuss the purpose and need for the proposed project, present the proposed project timeline, discuss preliminary project alternatives, and solicit input regarding environmental constraints and project goals. Committee members asked questions regarding the process and project intent, but did not voice any objections to the project.

The second AC Meeting was held on November 9, 2009. This meeting was held to provide an update on the project development activities, a briefing of agency interaction and concerns, and to present the refined design alternatives resulting from the scoping process and input from the public, agencies, and the AC representatives. Each project alternative was discussed in detail at this meeting and AC members provided input as to further refinements and comments from their respective interest groups.

Landowner Coordination

Members of the project team informally met with adjacent landowners at their respective properties and at the project site in order to discuss the proposed project and potential impacts to private property.

An on-site meeting was held with Jack Kambich. Mr. Kambich owns land located immediately downstream of the existing diversion dam, which is serviced by irrigation waters from the ditch that flows through the project area. Mr. Kambich also owns land that could be used as a borrow source for construction materials for the proposed project. The meeting consisted of an on-site review of the dam, an explanation of preliminary project alternatives, a review of the potential borrow source, and a review of the irrigation ditch operations. Mr. Kambich had no objections to any of the project alternatives or the project as a whole.

An on-site meeting was held with Al Lefor. Mr. Lefor owns property adjacent to the project site on the north side of the river and also operates a flyfishing and outfitting company. The purpose of the meeting was to explain and present the project alternatives and to solicit information on boater incidents at the dam, as well as incidents involving high water, ice blockages, and fish

passage concerns. Mr. Lefor objected strongly to Alternatives 1 and 2 as they do not provide boat and fish passage. He had no objections to Alternatives 3, 4 or 5.

An on-site meeting was held with Pat Bailey. Mr. Bailey owns all lands adjacent to the project site on the south side of the river both up and downstream of the existing diversion dam. The purpose of the meeting was to explain and present the project alternatives and to seek Mr. Bailey's permission to use a portion of his land for construction staging and materials storage purposes and to obtain access to the site from the south side of the river. Mr. Bailey had no objections to any of the project alternatives presented, but believed that Option 4 may present the best scenario for recreational use and would probably be the most economical solution. Mr. Bailey also stated he would be agreeable to a construction easement on his property for an extended period during project development and construction.

Agency Coordination

Local, state and federal agencies were asked to participate in the EA process in order to foster communication, identify and resolve issues, and provide timely and constructive comments. Scoping letters were sent to regional, state, and federal regulatory agencies as a notification that BSB proposes to replace the Big Hole River diversion dam and intake structure (Appendix H). Through these letters, BSB requested each agency's participation in identifying any concerns that would need to be addressed through the environmental review process. Agency response letters are included in Appendix I.

Agency Coordination Meeting #1

An Agency Coordination Meeting was held in Butte on September 1, 2009. Agencies with jurisdiction, interest, or expertise on issues within the study corridor were invited to attend. The purpose of the meeting was to present and discuss the Purpose and Need and goals of the proposed project, alternatives to be considered in the EA, and preliminary research results. Representatives from BSB, DEQ, DNRC, FWP, NRDP, USACE, EPA, and FWS attended the meeting. Minutes from this meeting are included in Appendix J.

Agency Coordination Meeting #2

A second Agency Coordination Meeting was held in Butte on November 3, 2009 to provide a progress update on the development and analysis of project alternatives and to present the Preliminary Preferred Alternative. Representatives from BSB, DEQ, DNRC, FWP, USACE, EPA, and FWS attended the meeting. The purpose of the meeting was to discuss agency roles and responsibilities and to review the project alternatives. Minutes from this meeting are included in Appendix J.

Coordination with Special Interest Groups

A number of presentations were given to special interest groups and civic organizations over the course of the project, including the Big Hole River Foundation Board (October 2009), Big Hole River Watershed Committee (October 2009), Silver Bow Kiwanis (October 2009), and the Butte Exchange Club (November 2009). Members of the project team explained the proposed project, presented the alternatives under consideration, and provided an overview of the Environmental Assessment process.

Tribal Coordination

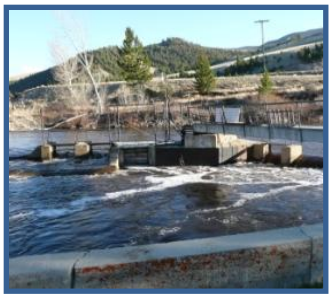
In November 2009, scoping letters were sent to the Confederated Salish & Kootenai, Crow, Northern Cheyenne, Chippewa Cree, Blackfeet, Little Shell, Fort Belknap, and Fort Peck Tribal Historic Preservation Offices informing them of the project and requesting their knowledge of or concerns regarding historic sites within the project area (Appendix H). No reply letters have been received to date.

Public Scoping Meeting

An initial public information meeting was held at the Council Chambers located in the Butte-Silver Bow Courthouse on August 27, 2009. The meeting was advertised in the Montana Standard newspaper on August 15, 20, and 27, 2009. The meeting took place from 6:00 p.m. to 8:00 p.m. Approximately 20 people attended the meeting. The meeting format included a formal presentation followed by a question and answer period. The purpose of the meeting was to discuss the Purpose and Need and goals of the project and to present preliminary project alternatives. Following the formal presentation, members of the public commented on a number of aspects of the project including habitat impacts and mitigation; regulatory agency involvement; icing, sediment and debris problems; project costs; vandalism and safety concerns; historic preservation; permitting concerns; and technical questions regarding design of each of the alternatives. No written public comments were received. The newspaper advertisement and a summary of the first public meeting are included in Appendix K.

Public Hearing

Public Hearings were held at the Council Chambers located in the Butte-Silver Bow Courthouse on December 15, 2009 and at the Grange Hall in Divide, MT on December 16, 2009. The meetings were advertised in the Montana Standard newspaper on November 25, December 2, and December 9, 2009 (see Appendix K). The meetings took place from 6:00 p.m. to 9:00 p.m. The meeting format included a formal presentation followed by a question and answer period. Summary to be included following the close of the public and agency comment period.



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX A

LETTER FROM DNRC WATER RESOURCES REGARDING EXISTING POINT OF DIVERSION

DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
HELENA WATER RESOURCES REGIONAL OFFICE

BRIAN SCHWEITZER
GOVERNOR

DIRECTOR'S OFFICE (406) 444- 2074
TELEFAX NUMBER (406) 444-2684

STATE OF MONTANA

HELENA REGIONAL OFFICE PHONE: (406) 444-6999
TELEFAX NUMBER: (406) 444-9317

1424 9TH AVENUE
PO BOX 201601
HELENA, MT 59620-1601

December 4, 2009

DOWL HKM
Attn: Sarah Nicolai
104 East Broadway, Suite G-1
PO box 1009
Helena MT 59624

Subject: Change Application requirement for Point of Diversion on Big Hole River diversion dam

Dear Sarah:

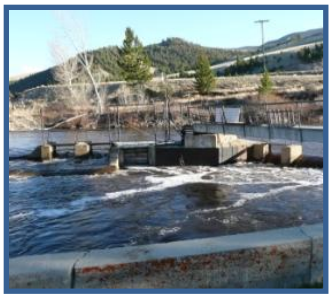
During several meetings there were a number of discussions concerning the requirement to complete a point of diversion change application on the Big Hole diversion dam reconstruction project. Throughout those discussions it became apparent that the project and the point of diversion were confined to the immediate influence of the current diversion structure.

In addition to the current diversion structure there were discussions that pertained to historical construction activities, maintenance of the facility, and the overall influence of the diversion both immediately upstream and downstream of the facility. This was referred to as the "footprint of influence". It is because of these reasons; historical, maintenance, and influence it has been determine that a change application will not have to be filed to complete this project. It is also apparent as described in the preferred alternative the project is staying well within the "footprint of influence" of the current structure.

If there are any questions concerning this project not requiring the submission of a change application for the point of diversion please do not hesitate to contact me.

Sincerely,

Terry Eccles
Helena/Bozeman Regional Manager



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX B

DESCRIPTION OF HISTORIC DIVERSION DAM FOOTPRINT FOR DNRC TRUST LANDS PERMITTING

Historic Footprint for Purposes of DNRC Trust Lands Permitting

The historic footprint of the Big Hole River Diversion Dam and Intake structure is defined as not only the structure and its placement on, under, or above the streambed, but also that area which has historically been used for both maintenance and original construction of the existing structure. This historical footprint has been defined through surveys of the existing structure, mapping of adjacent features and topography, and through discussions with Butte Silver Bow (BSB) maintenance employees, Utilities Division managers and operators.

In recent years, BSB has conducted repairs to both the upstream and downstream portions of the diversion dam and intake. In 1998, BSB accessed the streambed immediately downstream of the dam to buttress the dam footings with imported rock fill. This buttressing was required due to undercutting of the dam on the downstream side and to preclude imminent failure of the dam's ability to check up the water surface. The imported rock was hauled to the south shore of the river and then machine placed across the downstream face of the dam with excavation equipment and cranes. This effort was again repeated in 2006 with similar access and activities. During the 2006 repairs, BSB also placed riprap along the south shore dam abutment approximately 100 feet up and downs stream of the abutment to correct streambank erosion that was threatening the south abutment walls.

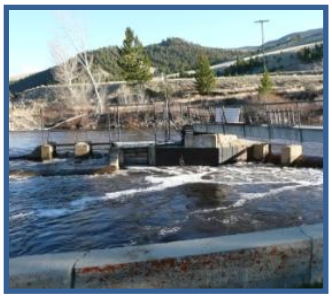
In 2003, BSB completed emergency repairs to the upstream face of the pier located in the middle of the river. The upstream face of the existing concrete pier was deteriorating and in jeopardy of failing. The activities including constructing coffer dams upstream of the pier, dewatering the site, installing a new steel nose plate structure on the pier and then placing concrete between the triangular nose plate and the existing pier. This activity required BSB to access the streambed upstream of the structure and the use of cofferdams and equipment to facilitate the repair.

On a more frequent basis, BSB maintenance crews continually access the streambed for 100 to 150 feet downstream of the dam for purposes of ice and trash removal as part of their routine maintenance activities. In addition, BSB personnel routinely access the streambed upstream of the dam for the same purposes of ice removal, establishing flow channels in the ice and to remove debris and trash that are detained on the structure. These upstream activities are nominally contained to 100 to 150 feet upstream of the existing structures.

In recent years, BSB has also installed safety cable and emergency retrieval trolley chairs to improve operational safety and to promote safer and more immediate rescue of stranded boaters. These installations have required access to the streambed both up and downstream of the structures for purposes of installation and maintenance of these safety cable and retrieval chair systems.

In the 1960's, BSB personnel installed an infiltration gallery and a series of perforated pipes within the river streambed that were manifolded together into a collection box on the north river bank that the fed the pump suction headers. These perforated pipes and collection box required access to the streambed and also periodic maintenance activities. This system is still in place today and remains operable albeit with marginal effectiveness and is not used regularly.

Through these discussions and documentation of events, the historical footprint has been defined as an area approximately 400 feet in length by the width of the river comprising about 1.6 acres more or less. More specifically, the area is defined as shown on Sheet No. 1 of the Preliminary Alternatives Drawings as Station 30+50 downstream and Station 34+50 upstream and by the north and south banks of the river.



ENVIRONMENTAL ASSESSMENT

for the

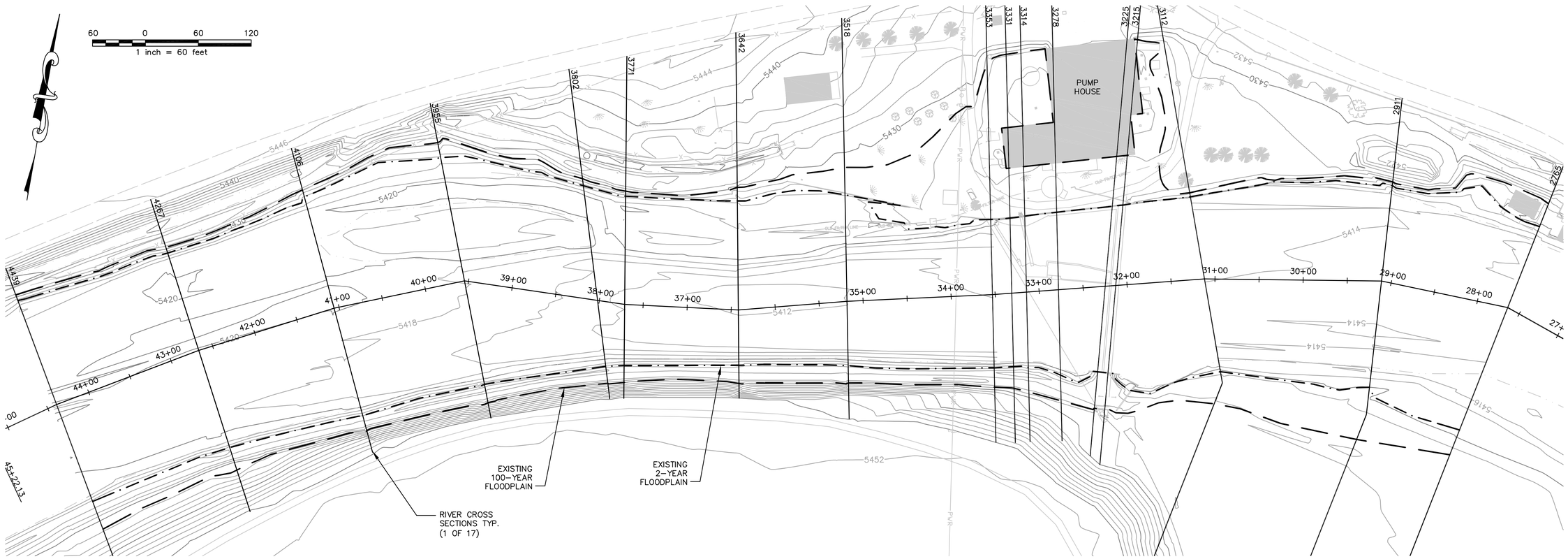
Big Hole River Diversion Dam

in

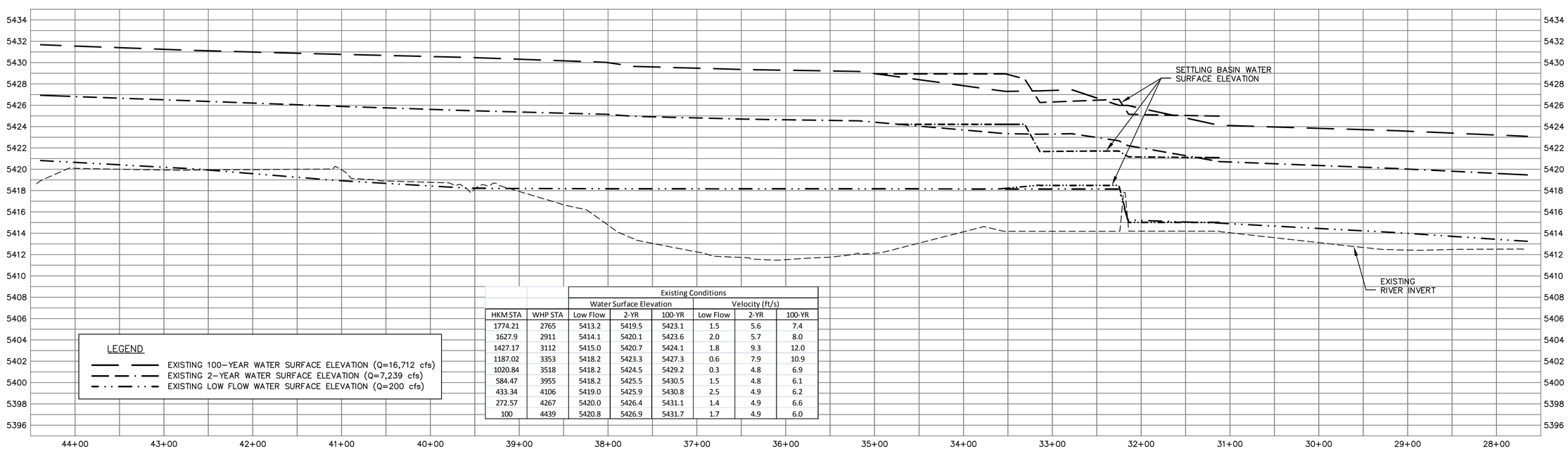
Silver Bow and Beaverhead Counties, Montana

APPENDIX C

PRELIMINARY DESIGN DRAWINGS OF PROJECT ALTERNATIVES



PLAN



		Existing Conditions					
		Water Surface Elevation			Velocity (ft/s)		
HKM STA	WHP STA	Low Flow	2-YR	100-YR	Low Flow	2-YR	100-YR
1774.21	2765	5413.2	5419.5	5423.1	1.5	5.6	7.4
1627.9	2911	5414.1	5420.1	5423.6	2.0	5.7	8.0
1427.17	3112	5415.0	5420.7	5424.1	1.8	9.3	12.0
1187.02	3353	5418.2	5423.3	5427.3	0.6	7.9	10.9
1020.84	3518	5418.2	5424.5	5429.2	0.3	4.8	6.9
584.47	3955	5418.2	5425.5	5430.5	1.5	4.8	6.1
433.34	4106	5419.0	5425.9	5430.8	2.5	4.9	6.2
272.57	4267	5420.0	5426.4	5431.1	1.4	4.9	6.6
100	4439	5420.8	5426.9	5431.7	1.7	4.9	6.0

PROFILE

No.	Revision	By	Date

WARNING
0 1/2 1
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ALTERNATIVE 1 PLAN AND PROFILE

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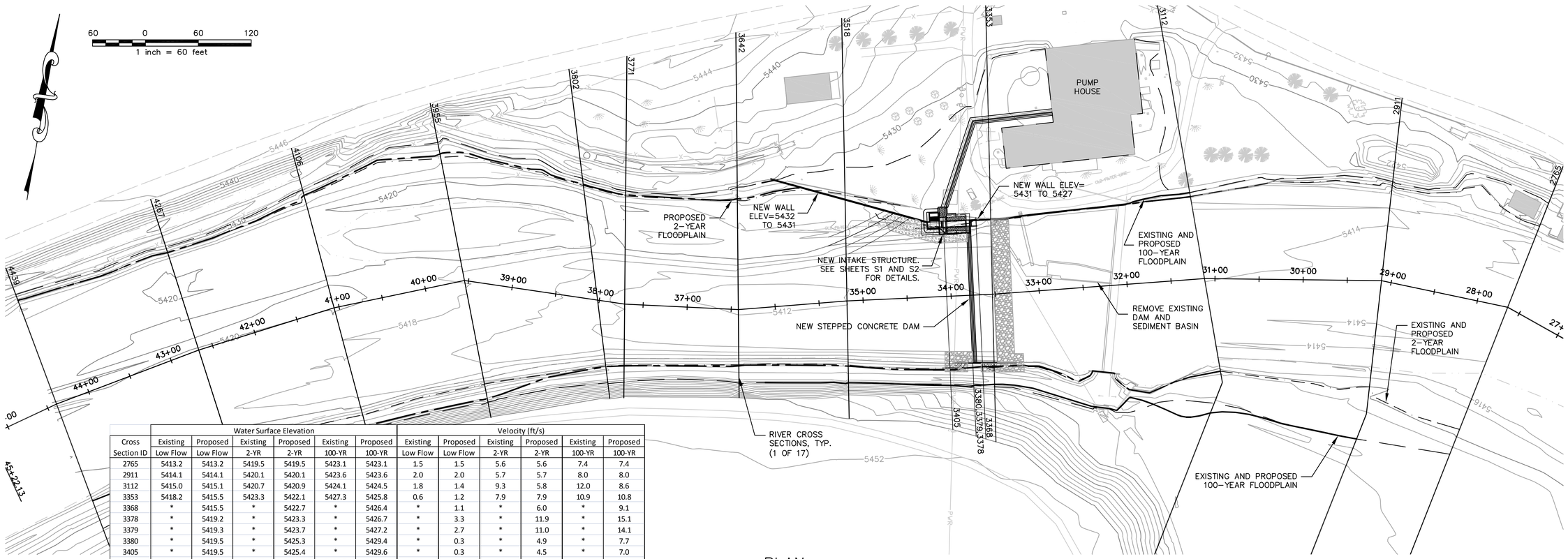
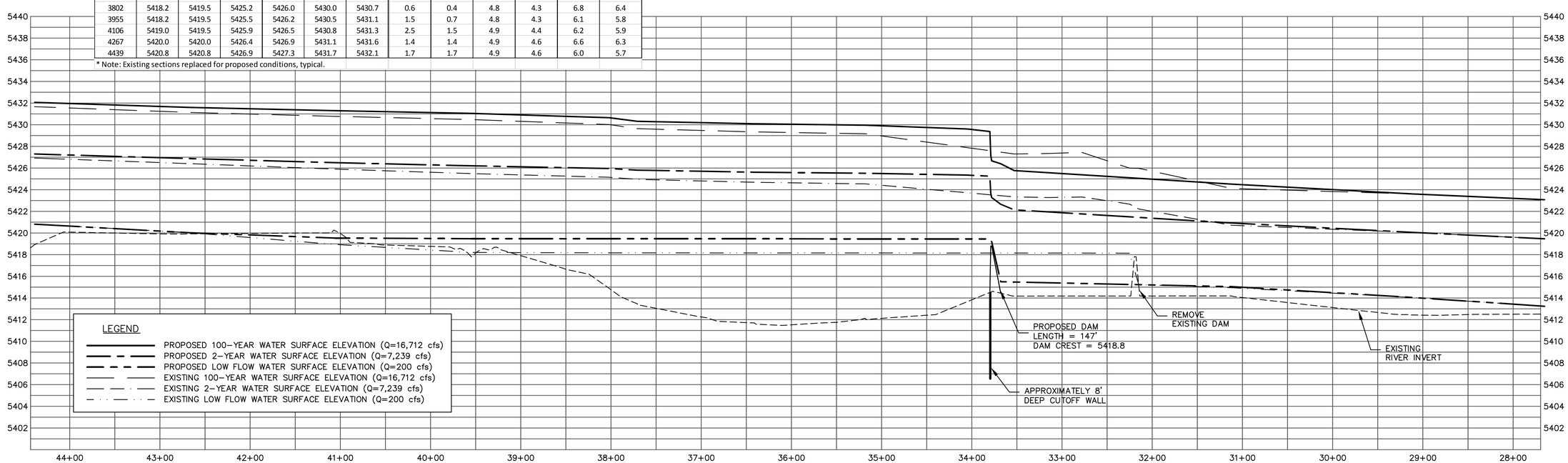


PLAN

Cross Section ID	Water Surface Elevation Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR	Velocity (ft/s) Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3353	5418.2	5415.5	5423.3	5422.1	5427.3	5425.8	0.6	1.2	7.9	7.9	10.9	10.8
3368	*	5415.5	*	5422.7	*	5426.4	*	1.1	*	6.0	*	9.1
3378	*	5419.2	*	5423.3	*	5426.7	*	3.3	*	11.9	*	15.1
3379	*	5419.3	*	5423.7	*	5427.2	*	2.7	*	11.0	*	14.1
3380	*	5419.5	*	5425.3	*	5429.4	*	0.3	*	4.9	*	7.7
3405	*	5419.5	*	5425.4	*	5429.6	*	0.3	*	4.5	*	7.0
3518	5418.2	5419.5	5424.5	5425.5	5429.2	5430.0	0.3	0.3	4.8	4.3	6.9	6.4
3642	5418.2	5419.5	5424.7	5425.6	5429.3	5430.1	0.4	0.3	5.5	4.9	7.9	7.4
3771	5418.2	5419.5	5425.0	5425.8	5429.6	5430.3	0.5	0.4	5.6	5.1	8.2	7.8
3802	5418.2	5419.5	5425.2	5426.0	5430.0	5430.7	0.6	0.4	4.8	4.3	6.8	6.4
3955	5418.2	5419.5	5425.5	5426.2	5430.5	5431.1	1.5	0.7	4.8	4.3	6.1	5.8
4106	5419.0	5419.5	5425.9	5426.5	5430.8	5431.3	2.5	1.5	4.9	4.4	6.2	5.9
4267	5420.0	5420.0	5426.4	5426.9	5431.1	5431.6	1.4	1.4	4.9	4.6	6.6	6.3
4439	5420.8	5420.8	5426.9	5427.3	5431.7	5432.1	1.7	1.7	4.9	4.6	6.0	5.7

* Note: Existing sections replaced for proposed conditions, typical.



PROFILE

No.	Revision	By	Date

WARNING
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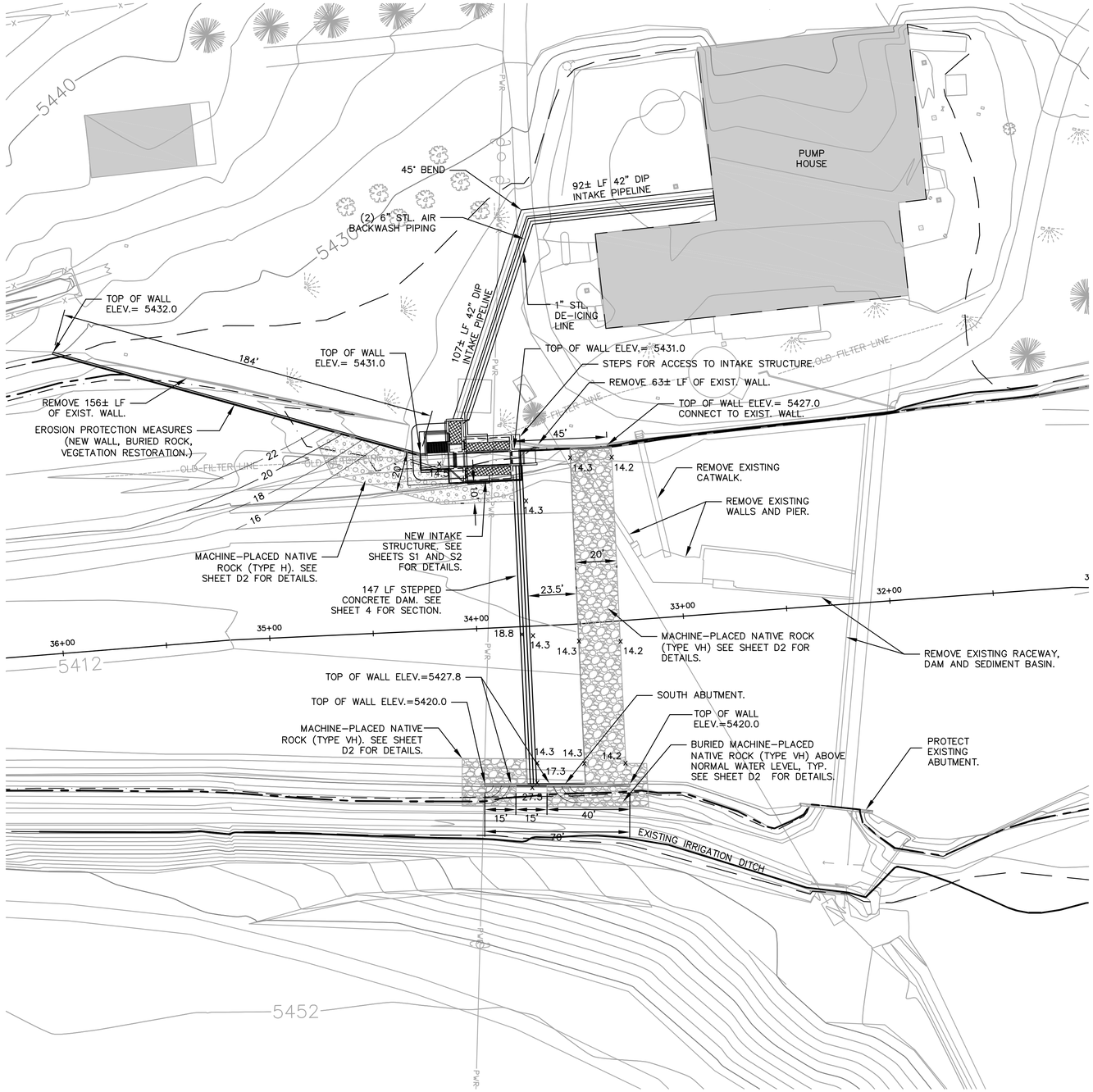

SITE PLAN
1" = 30'-0"

No.	Revision	By	Date

WARNING
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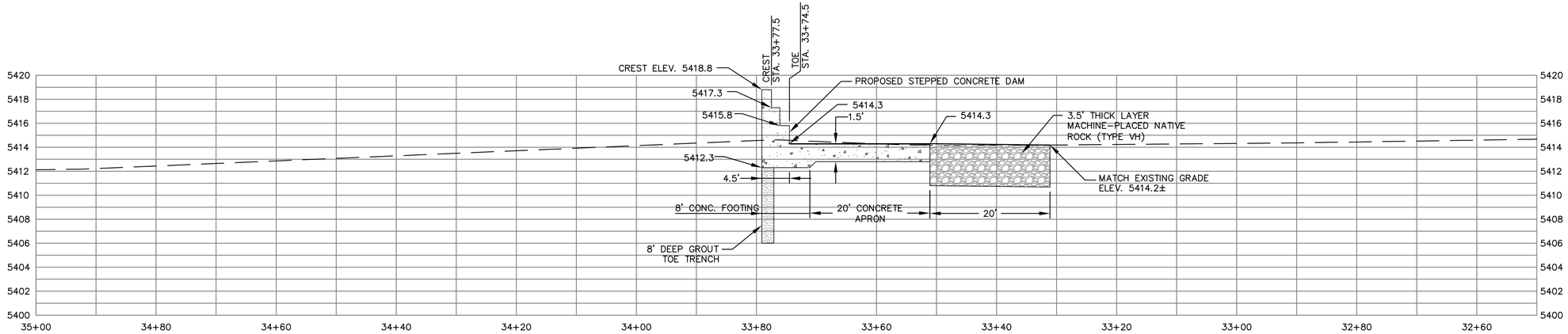

PROPOSED DAM PROFILE

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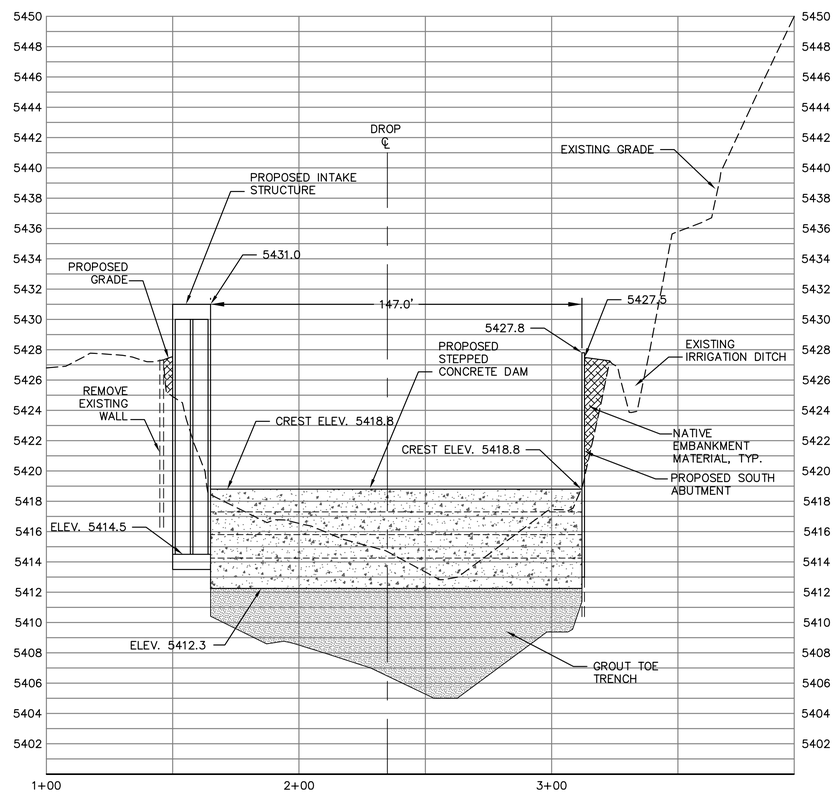
1" = 5' VERTICAL



WEIR SECTION

1" = 30' HORIZONTAL
1" = 5' VERTICAL
LOOKING DOWNSTREAM

No.	Revision	By	Date

WARNING
0 1/2 1
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

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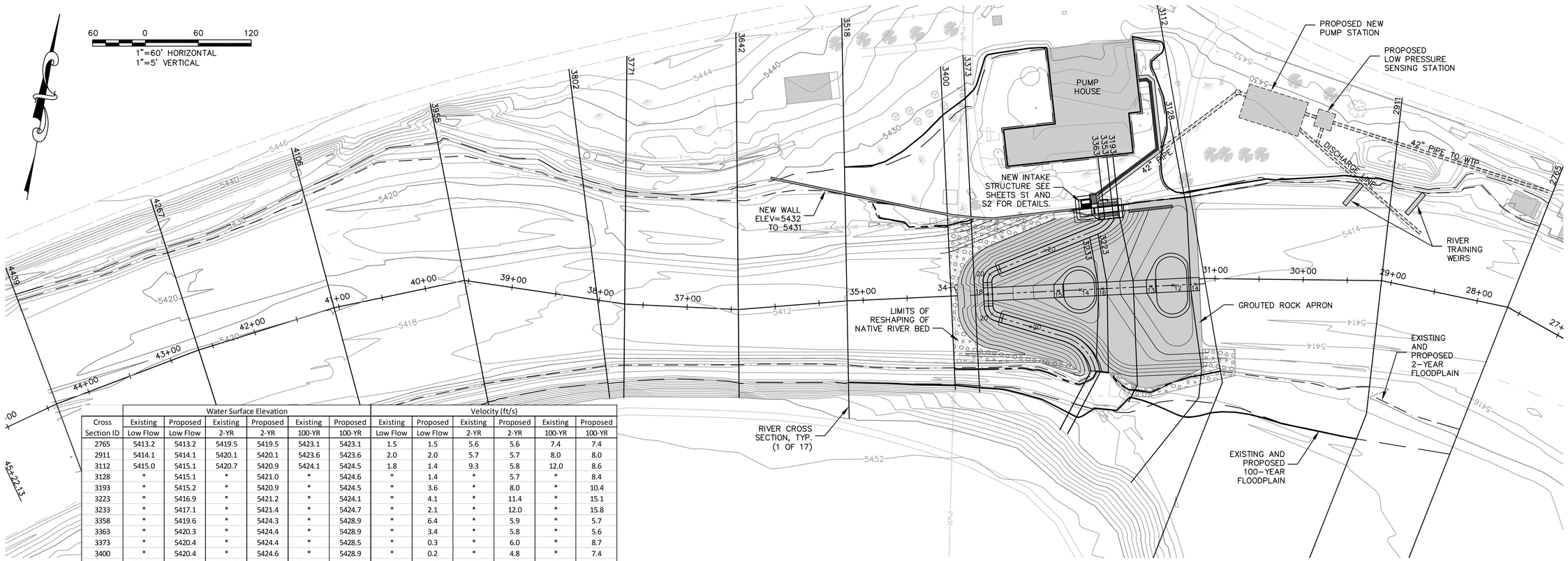
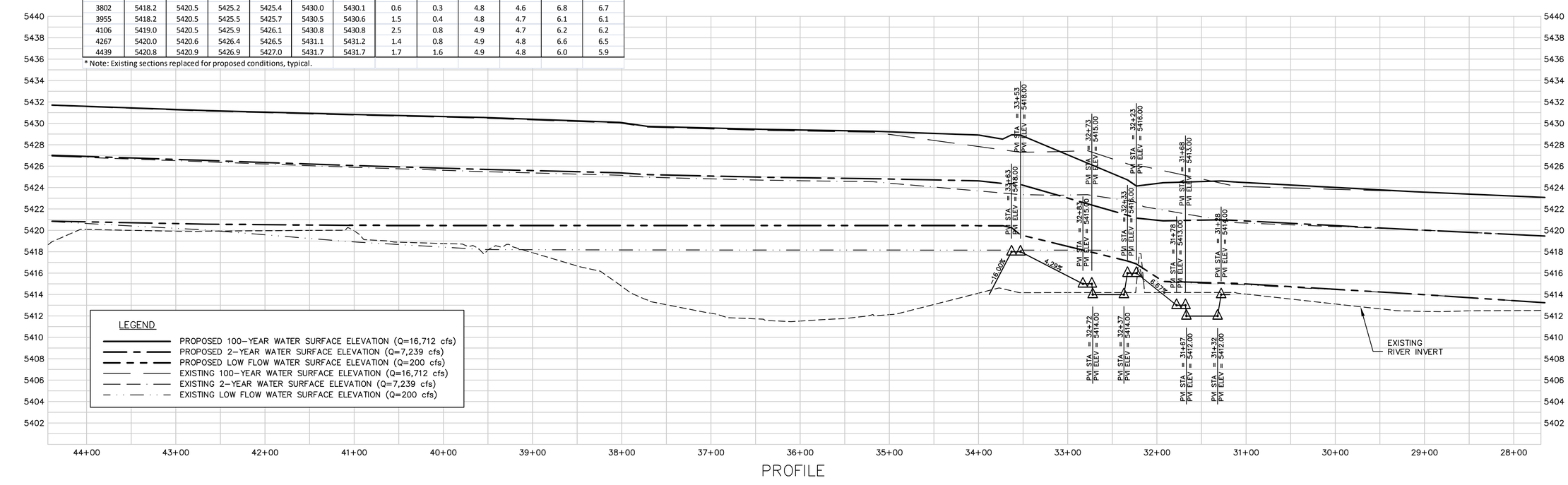


PLAN

Cross Section ID	Water Surface Elevation Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR	Velocity (ft/s) Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3128	*	5415.1	*	5421.0	*	5424.6	*	1.4	*	5.7	*	8.4
3193	*	5415.2	*	5420.9	*	5424.5	*	3.6	*	8.0	*	10.4
3223	*	5416.9	*	5421.2	*	5424.1	*	4.1	*	11.4	*	15.1
3233	*	5417.1	*	5421.4	*	5424.7	*	2.1	*	12.0	*	15.8
3358	*	5419.6	*	5424.3	*	5428.9	*	6.4	*	5.9	*	5.7
3363	*	5420.3	*	5424.4	*	5428.9	*	3.4	*	5.8	*	5.6
3373	*	5420.4	*	5424.4	*	5428.5	*	0.3	*	6.0	*	8.7
3400	*	5420.4	*	5424.6	*	5428.9	*	0.2	*	4.8	*	7.4
3518	5418.2	5420.5	5424.5	5424.8	5429.2	5429.3	0.3	0.2	4.8	4.7	6.9	6.9
3642	5418.2	5420.5	5424.7	5425.0	5429.3	5429.4	0.4	0.3	5.5	5.3	7.9	7.8
3771	5418.2	5420.5	5425.0	5425.2	5429.6	5429.7	0.5	0.3	5.6	5.4	8.2	8.2
3802	5418.2	5420.5	5425.2	5425.4	5430.0	5430.1	0.6	0.3	4.8	4.6	6.8	6.7
3955	5418.2	5420.5	5425.5	5425.7	5430.5	5430.6	1.5	0.4	4.8	4.7	6.1	6.1
4106	5419.0	5420.5	5425.9	5426.1	5430.8	5430.8	2.5	0.8	4.9	4.7	6.2	6.2
4267	5420.0	5420.6	5426.4	5426.5	5431.1	5431.2	1.4	0.8	4.9	4.8	6.6	6.5
4439	5420.8	5420.9	5426.9	5427.0	5431.7	5431.7	1.7	1.6	4.9	4.8	6.0	5.9

* Note: Existing sections replaced for proposed conditions, typical.



PROFILE

No.	Revision	By	Date

WARNING
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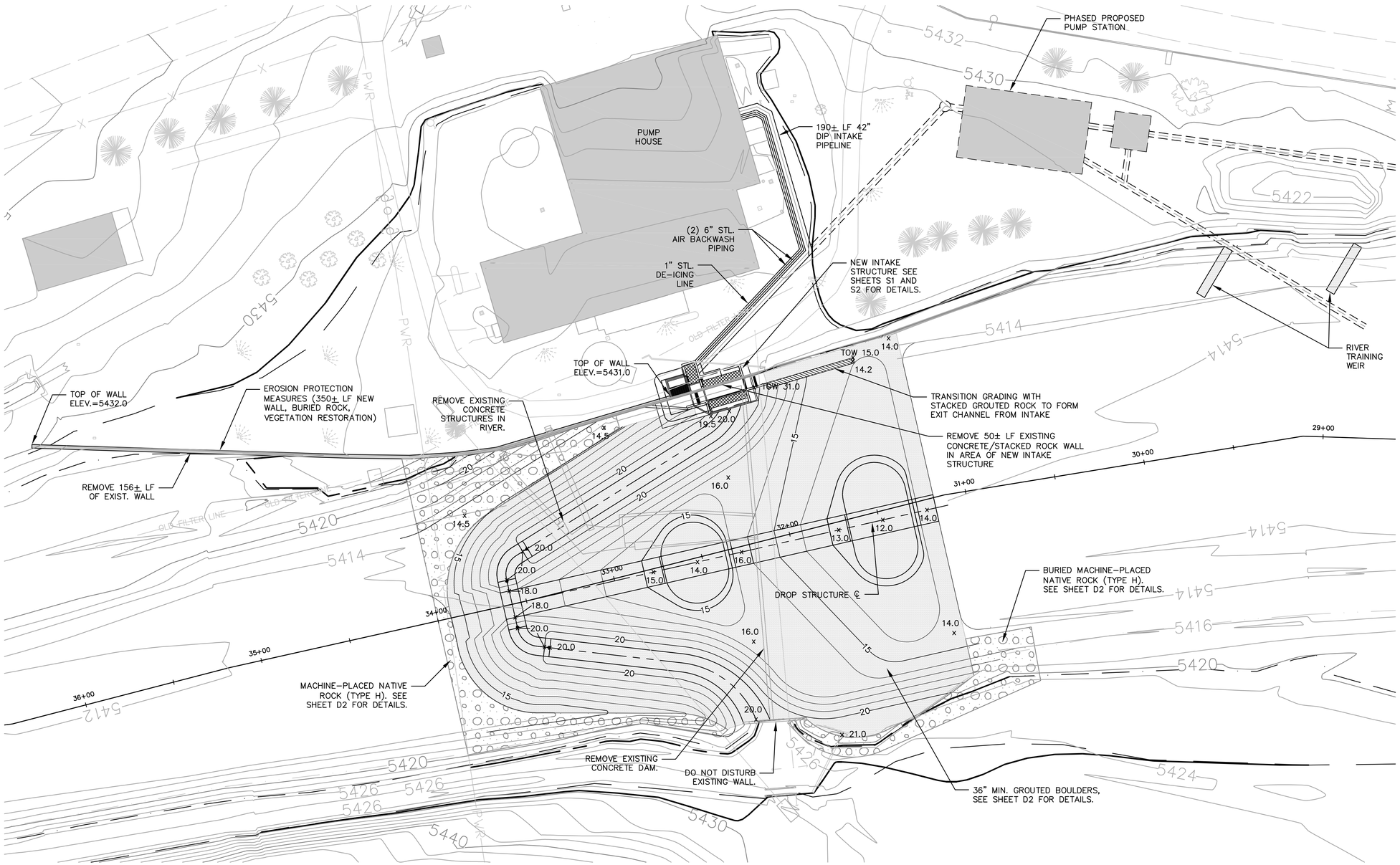
1"=5' VERTICAL



SITE PLAN
1" = 30'-0"

No.	Revision	By	Date

WARNING
0 1/2 1
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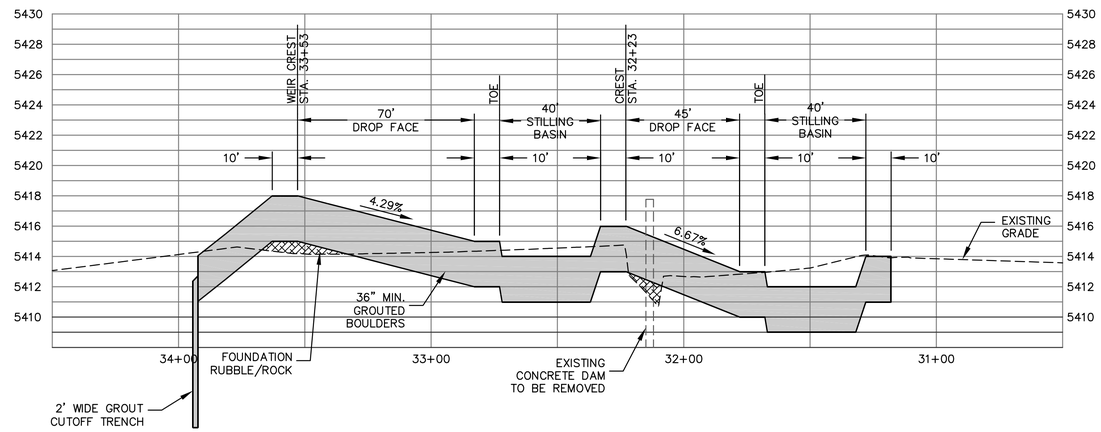
1"=30' HORIZONTAL
1"=5' VERTICAL



BOAT BYPASS PROFILE

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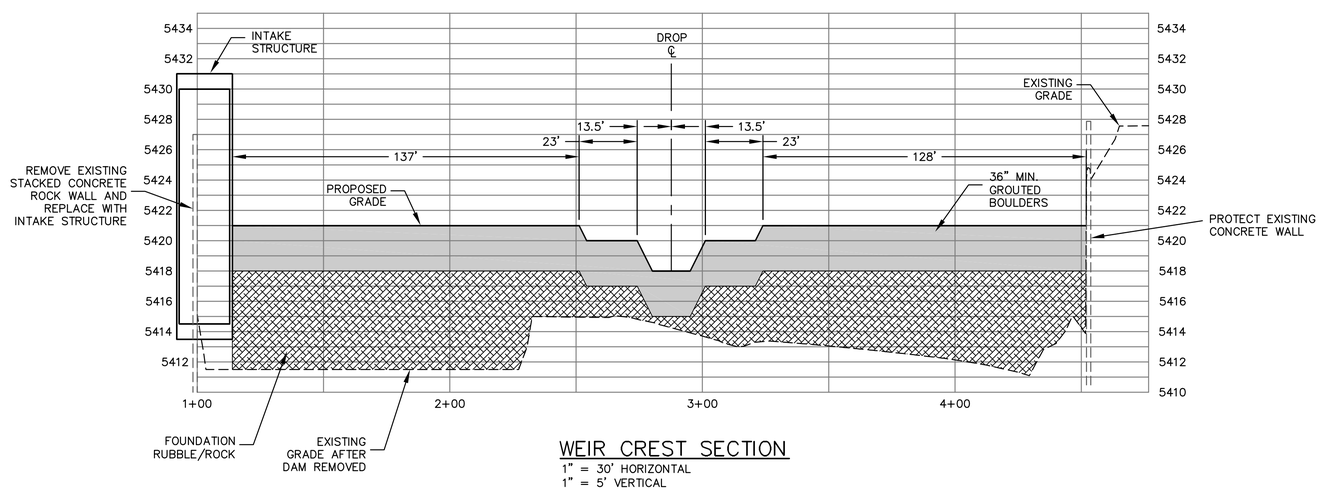
1" = 5' VERTICAL



WEIR CREST SECTION

1" = 30' HORIZONTAL
1" = 5' VERTICAL

No.	Revision	By	Date

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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 3 PROFILE AND SECTION

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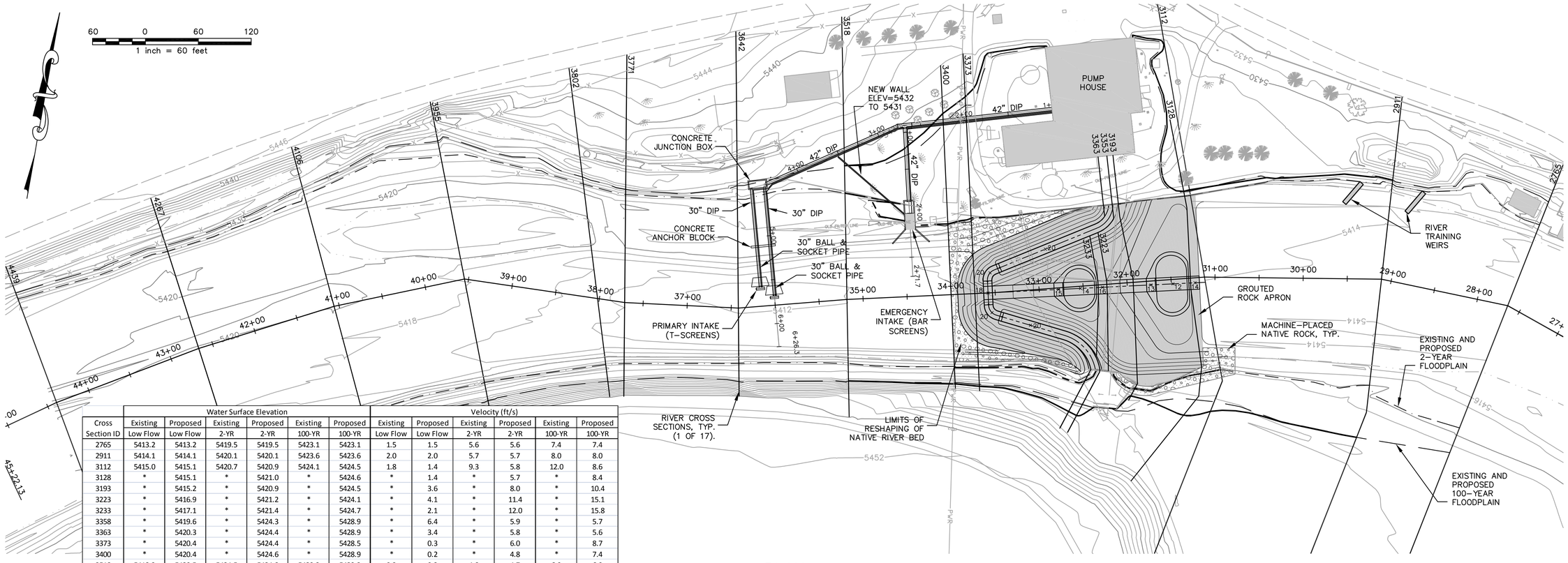
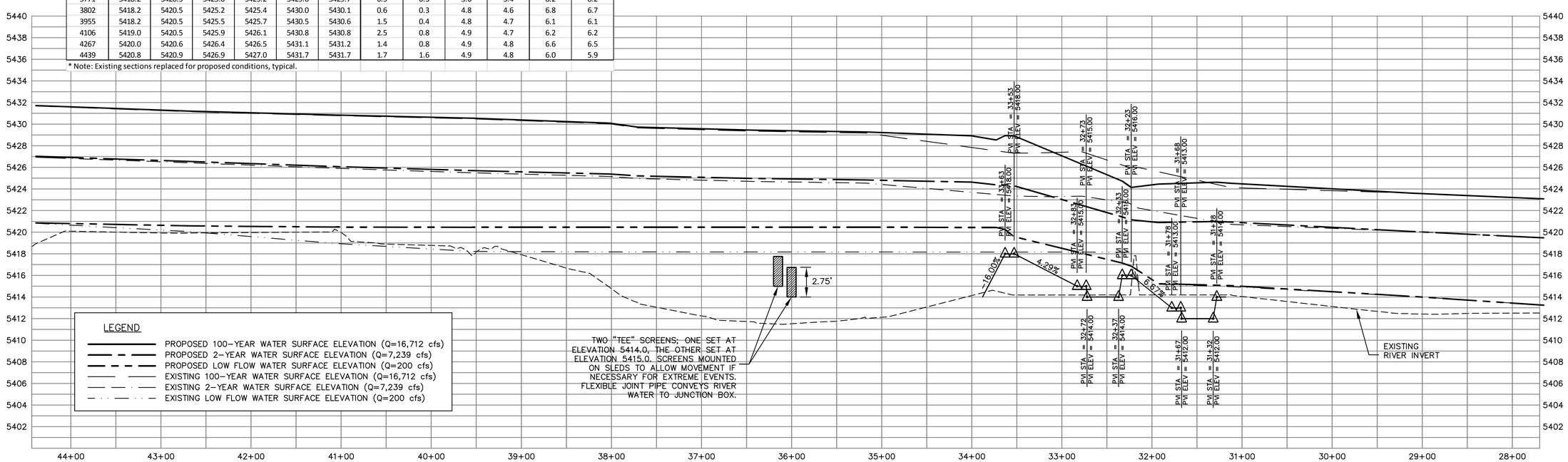


PLAN

Cross Section ID	Water Surface Elevation Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR	Velocity (ft/s) Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3128	*	5415.1	*	5421.0	*	5424.6	*	1.4	*	5.7	*	8.4
3193	*	5415.2	*	5420.9	*	5424.5	*	3.6	*	8.0	*	10.4
3223	*	5416.9	*	5421.2	*	5424.1	*	4.1	*	11.4	*	15.1
3233	*	5417.1	*	5421.4	*	5424.7	*	2.1	*	12.0	*	15.8
3358	*	5419.6	*	5424.3	*	5428.9	*	6.4	*	5.9	*	5.7
3363	*	5420.3	*	5424.4	*	5428.9	*	3.4	*	5.8	*	5.6
3373	*	5420.4	*	5424.4	*	5428.5	*	0.3	*	6.0	*	8.7
3400	*	5420.4	*	5424.6	*	5428.9	*	0.2	*	4.8	*	7.4
3518	5418.2	5420.5	5424.5	5424.8	5429.2	5429.3	0.3	0.2	4.8	4.7	6.9	6.9
3642	5418.2	5420.5	5424.7	5425.0	5429.3	5429.4	0.4	0.3	5.5	5.3	7.9	7.8
3771	5418.2	5420.5	5425.0	5425.2	5429.6	5429.7	0.5	0.3	5.6	5.4	8.2	8.2
3802	5418.2	5420.5	5425.2	5425.4	5430.0	5430.1	0.6	0.3	4.8	4.6	6.8	6.7
3955	5418.2	5420.5	5425.5	5425.7	5430.5	5430.6	1.5	0.4	4.8	4.7	6.1	6.1
4106	5419.0	5420.5	5425.9	5426.1	5430.8	5430.8	2.5	0.8	4.9	4.7	6.2	6.2
4267	5420.0	5420.6	5426.4	5426.5	5431.1	5431.2	1.4	0.8	4.9	4.8	6.6	6.5
4439	5420.8	5420.9	5426.9	5427.0	5431.7	5431.7	1.7	1.6	4.9	4.8	6.0	5.9

* Note: Existing sections replaced for proposed conditions, typical.



PROFILE

No.	Revision	By	Date

WARNING 1/2 0 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

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ALTERNATIVE 4 PLAN AND PROFILE

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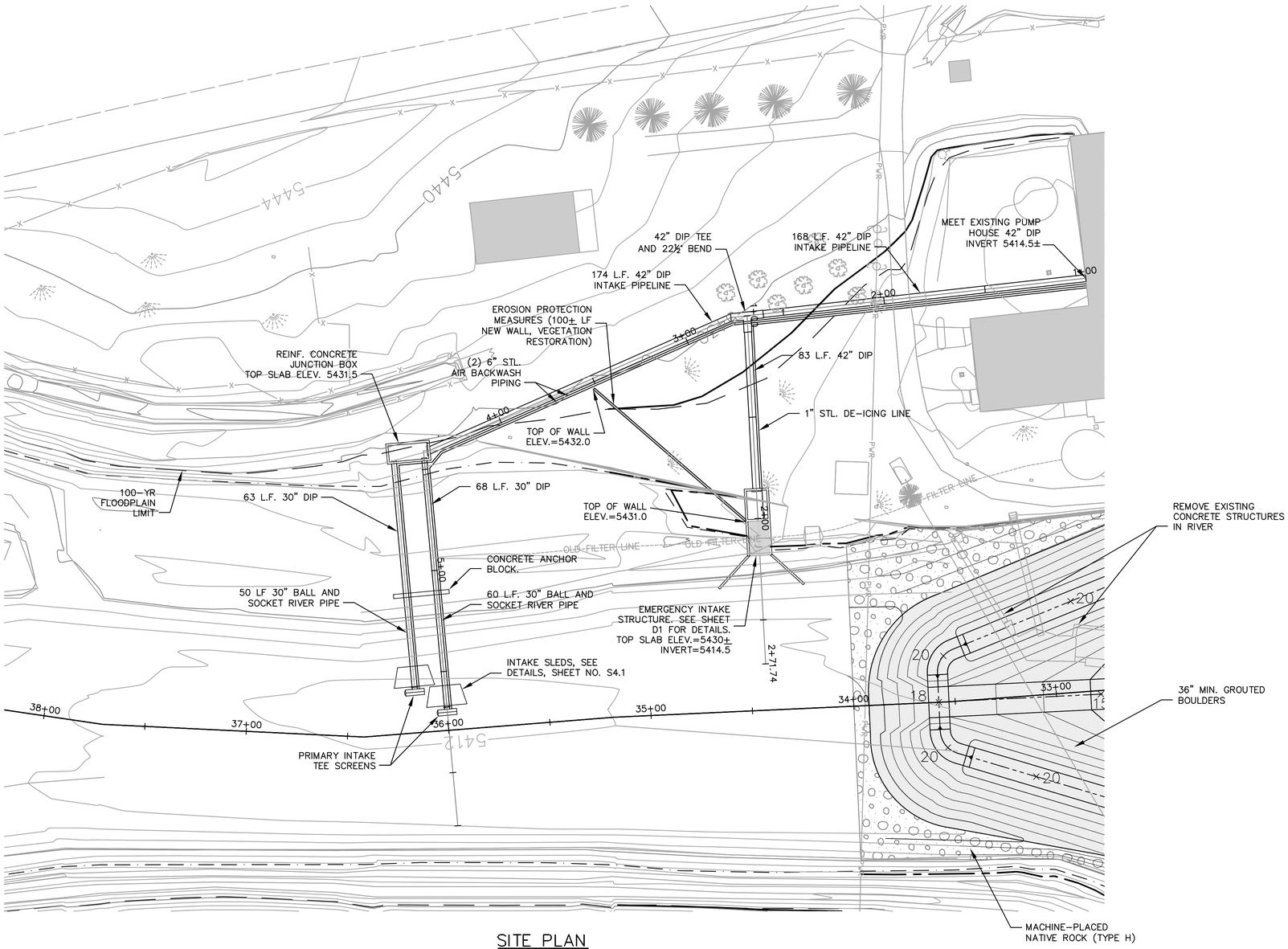
1 inch = 30 feet



SITE PLAN
1" = 30'-0"

No.	Revision	By	Date

WARNING
0 1/2 1
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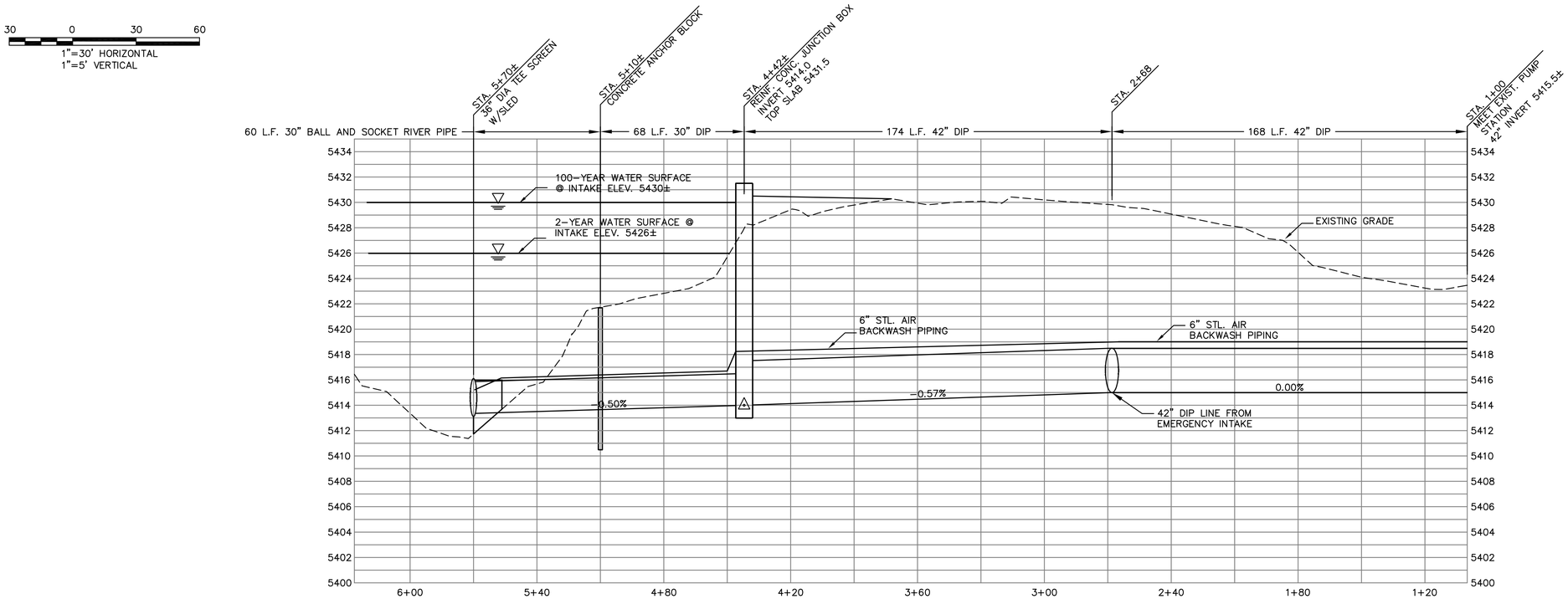
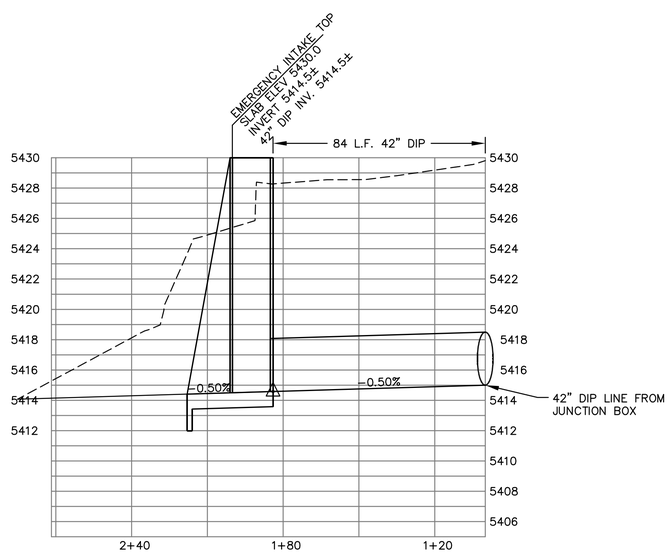


SCREEN PROFILE
1" = 30' HORIZONTAL
1" = 5' VERTICAL



BACKUP LINE PROFILE
1" = 30' HORIZONTAL
1" = 5' VERTICAL

No.	Revision	By	Date

WARNING
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ALTERNATIVE 4 PROFILES

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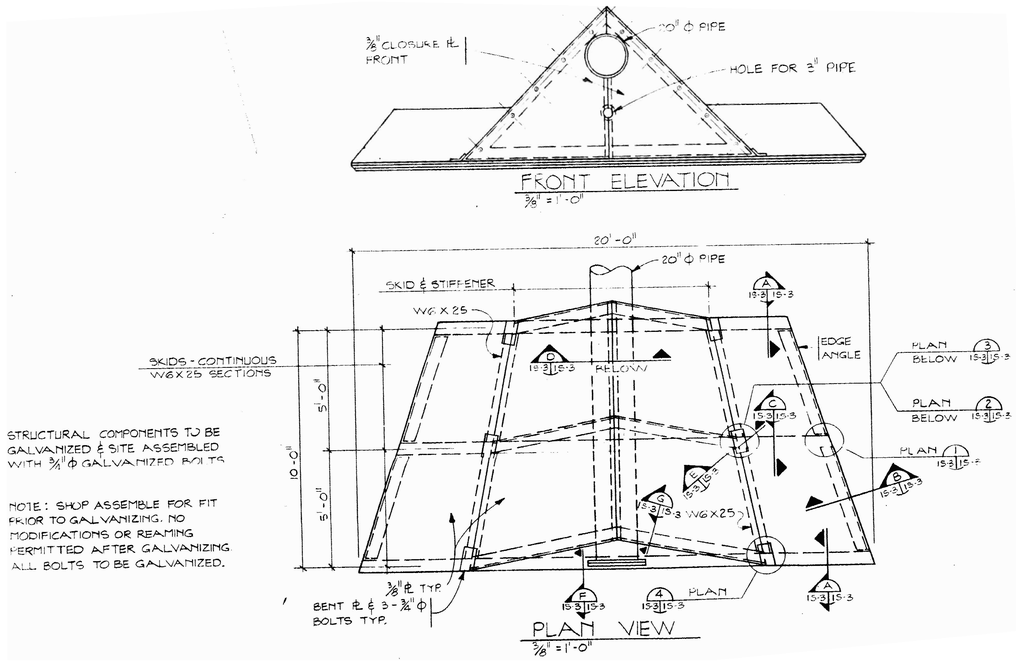

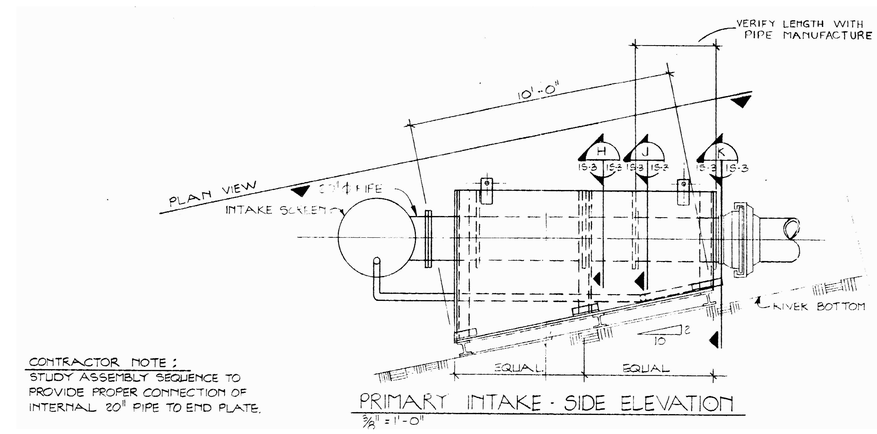

No.	Revision	By	Date

WARNING
0 1/2 1
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 4 SCREEN DETAILS

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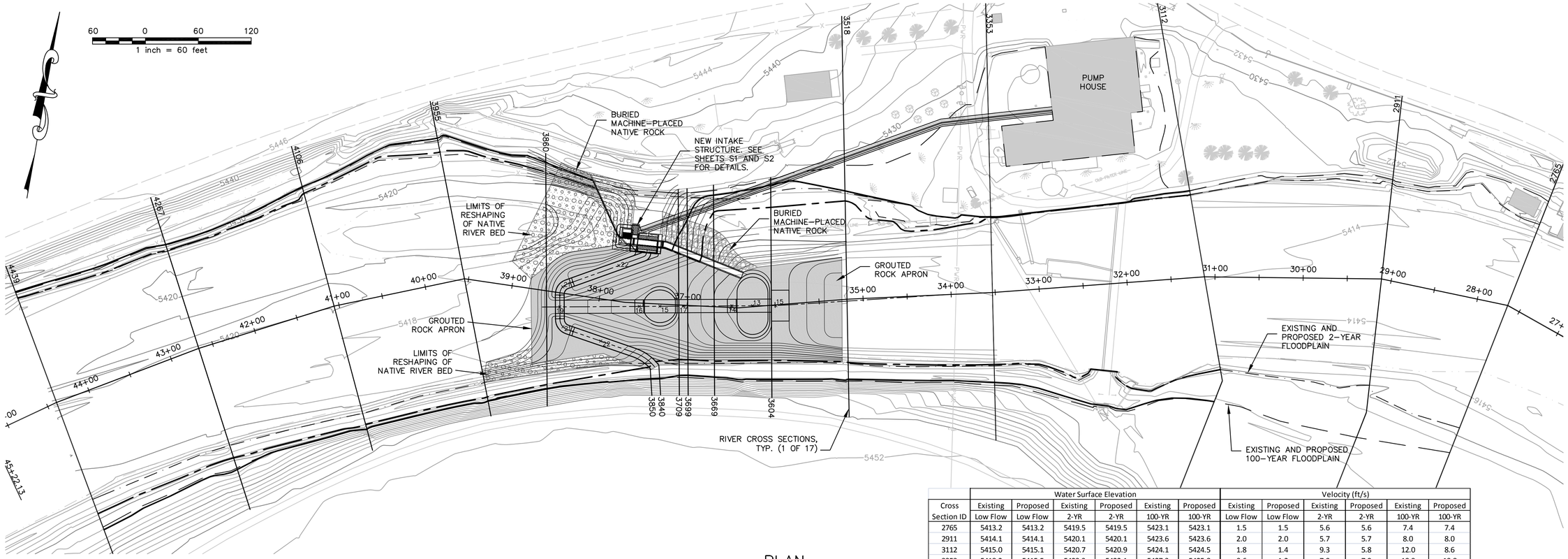
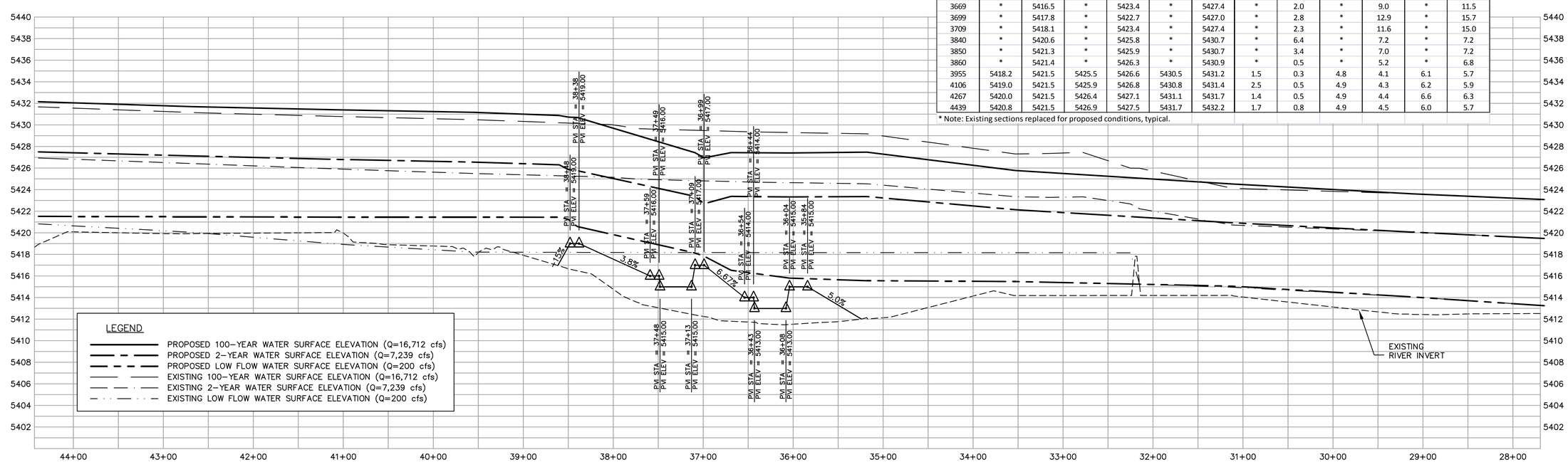


PLAN

Cross Section ID	Water Surface Elevation: Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR	Velocity (ft/s): Existing Low Flow	Proposed Low Flow	Existing 2-YR	Proposed 2-YR	Existing 100-YR	Proposed 100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3353	5418.2	5415.5	5423.3	5422.1	5427.3	5425.8	0.6	1.2	7.9	7.9	10.9	10.8
3518	5418.2	5415.6	5424.5	5423.4	5429.2	5427.5	0.3	0.6	4.8	5.6	6.9	8.1
3604	*	5415.8	*	5423.3	*	5427.4	*	4.3	*	7.6	*	10.1
3669	*	5416.5	*	5423.4	*	5427.4	*	2.0	*	9.0	*	11.5
3699	*	5417.8	*	5422.7	*	5427.0	*	2.8	*	12.9	*	15.7
3709	*	5418.1	*	5423.4	*	5427.4	*	2.3	*	11.6	*	15.0
3840	*	5420.6	*	5425.8	*	5430.7	*	6.4	*	7.2	*	7.2
3850	*	5421.3	*	5425.9	*	5430.7	*	3.4	*	7.0	*	7.2
3860	*	5421.4	*	5426.3	*	5430.9	*	0.5	*	5.2	*	6.8
3955	5418.2	5421.5	5425.5	5426.6	5430.5	5431.2	1.5	0.3	4.8	4.1	6.1	5.7
4106	5419.0	5421.5	5425.9	5426.8	5430.8	5431.4	2.5	0.5	4.9	4.3	6.2	5.9
4267	5420.0	5421.5	5426.4	5427.1	5431.1	5431.7	1.4	0.5	4.9	4.4	6.6	6.3
4439	5420.8	5421.5	5426.9	5427.5	5431.7	5432.2	1.7	0.8	4.9	4.5	6.0	5.7

* Note: Existing sections replaced for proposed conditions, typical.



PROFILE

No.	Revision	By	Date

WARNING
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 5 PLAN AND PROFILE

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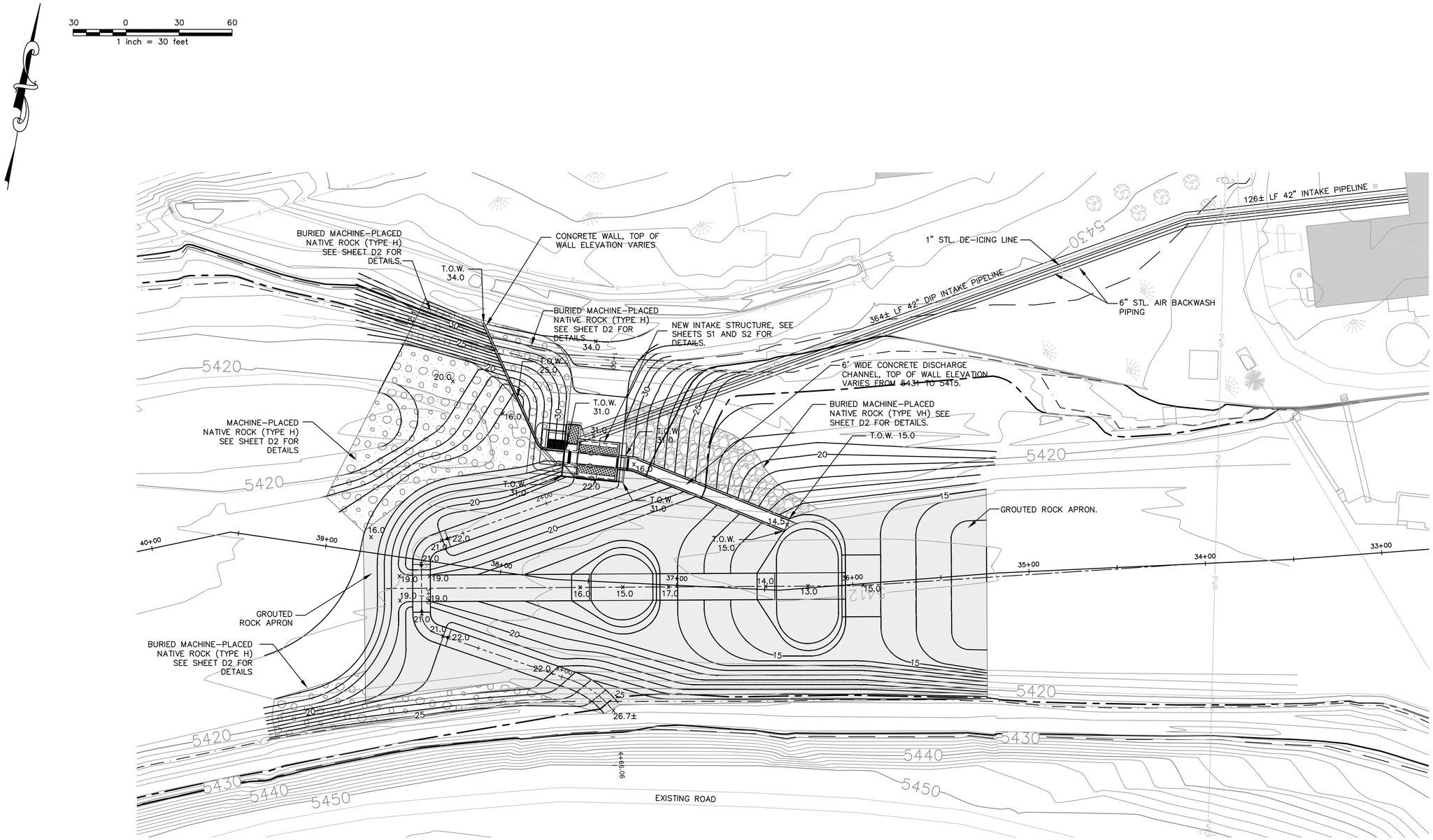

SITE PLAN
1" = 30'-0"

No.	Revision	By	Date

WARNING
0 1/2 1
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 5 SITE PLAN

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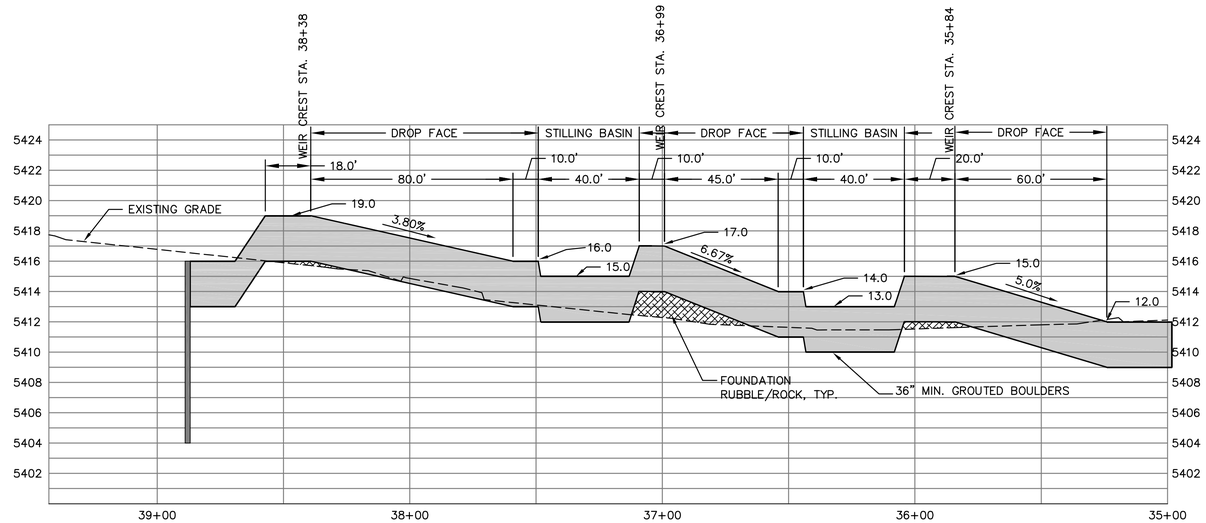
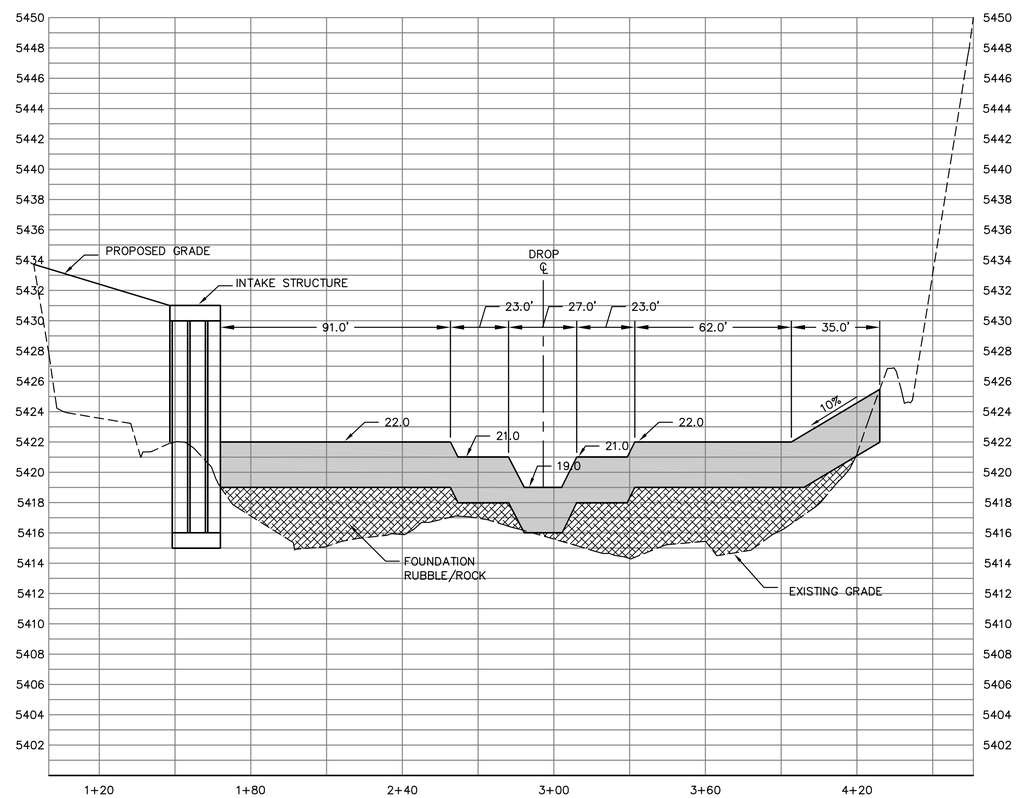
1"=30' HORIZONTAL
1"=5' VERTICAL



BOAT/FISH BYPASS PROFILE

1" = 30' HORIZONTAL
1" = 5' VERTICAL



WEIR CREST SECTION

1" = 30' HORIZONTAL
1" = 5' VERTICAL

No.	Revision	By	Date

WARNING
0 1/2 1
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 5 PROFILE AND SECTION

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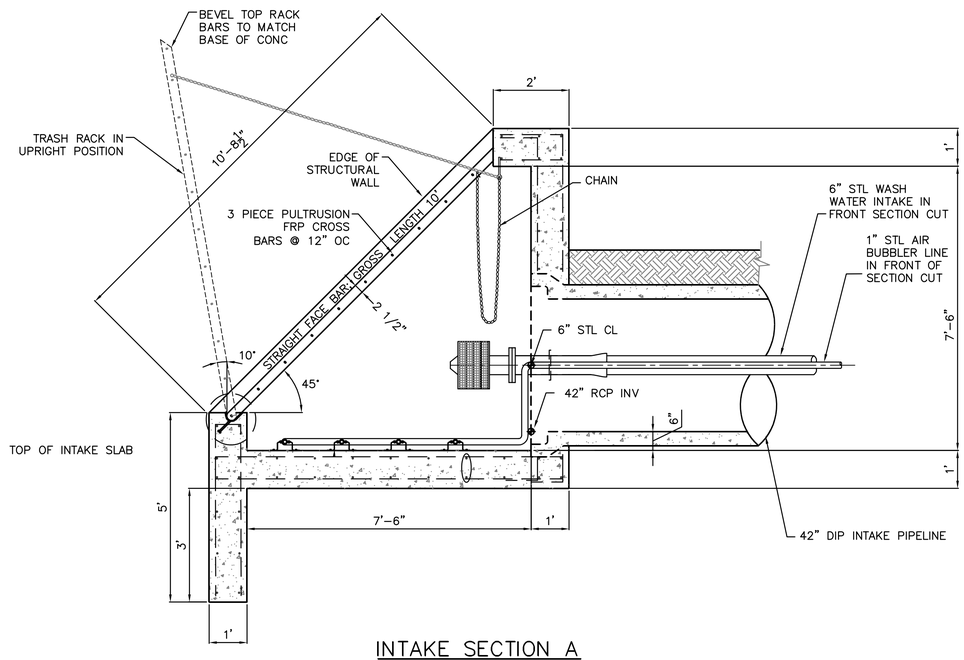
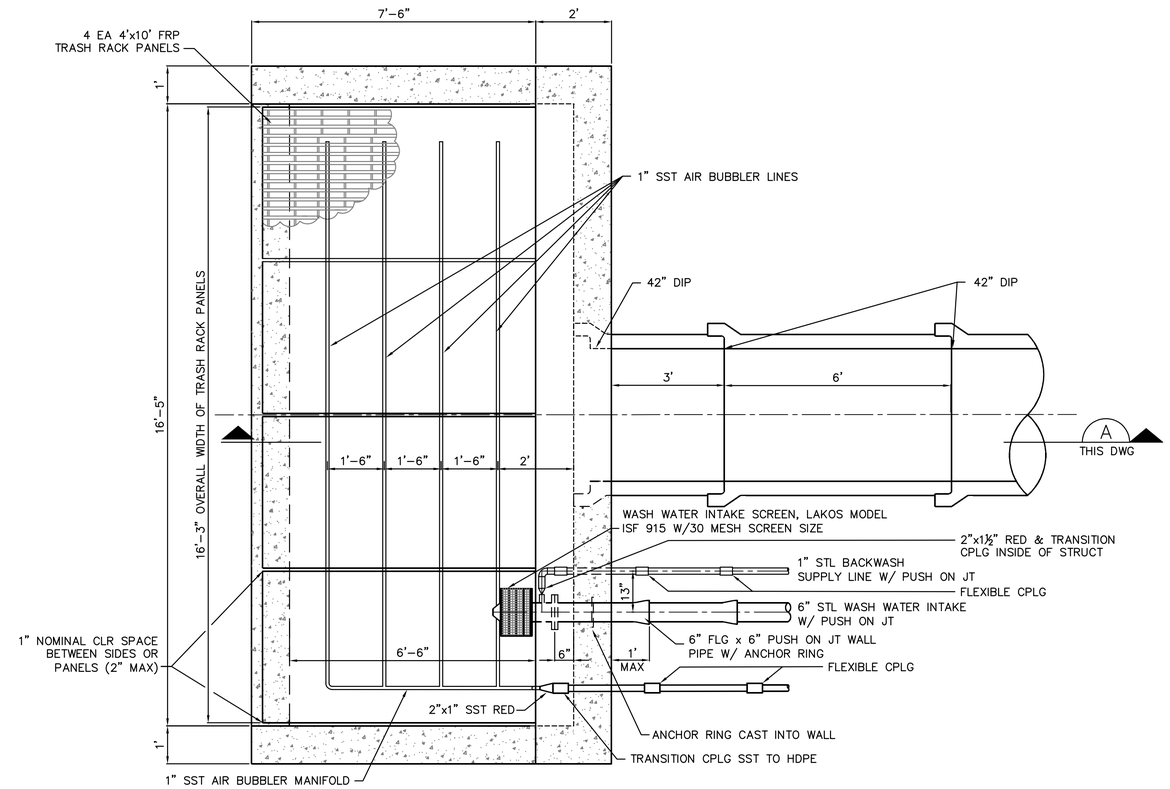


INTAKE SECTION A
1/2"=1'-0"



INTAKE STRUCTURE PLAN
1/2"=1'-0"

No.	Revision	By	Date

WARNING
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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

ALTERNATIVE 4 INTAKE STRUCTURE DETAILS

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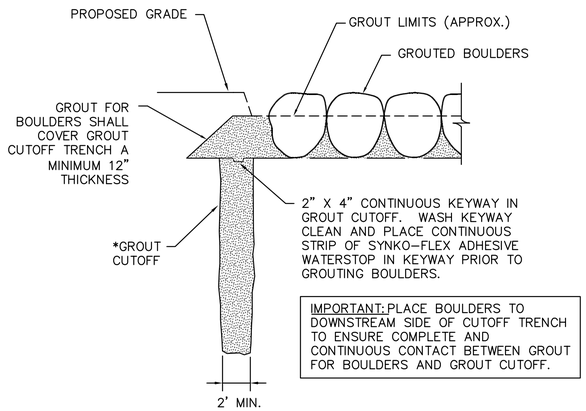
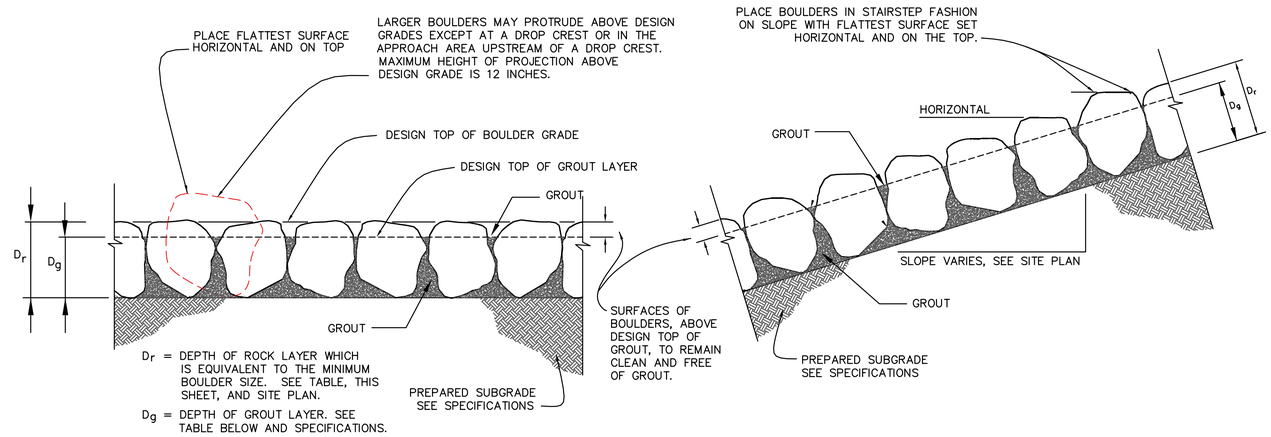


GROUT CUTOFF TRENCH DETAIL

NTS

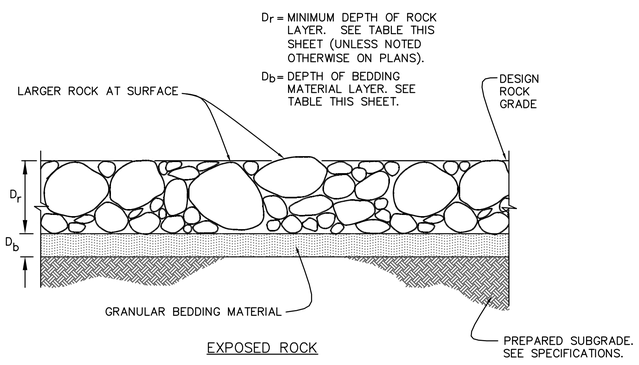


USED THIS PROJECT	D_r	D_g
	18	12
	24	18
	30	24
X	36	28
	42	32
ALL DIMENSIONS IN INCHES		

NOTES:
1. BEFORE GROUTING, CLEAN ALL DIRT AND MATERIALS FROM ROCK THAT COULD PREVENT THE GROUT FROM BONDING TO ROCK. FINAL PLACEMENT OF BOULDERS TO BE APPROVED BY THE ENGINEER PRIOR TO GROUTING.
2. PLACE GROUT BY INJECTION METHODS TO FILL VOIDS TO THE SPECIFIED GROUT DEPTH. CLEAN EXCESS GROUT FROM ALL EXPOSED SURFACES. REFER TO SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
3. THE CONTRACTOR SHALL CONTROL GROUT MIX AND PLACEMENT PROCEDURES TO ACHIEVE THE SPECIFIED THICKNESS AND GRADE OF THE GROUT LAYER.
4. UP TO 20% OF ROCK MAY PROTRUDE ABOVE DESIGN GRADE, EXCEPT AT THE DROP CREST AREA WHERE NO ROCK SHALL EXCEED D_r.

TYPICAL GROUTED BOULDER PLACEMENT

NTS



EXPOSED ROCK

USED THIS PROJECT	ROCK TYPE	D_{50}	D_r
	VL	6	11
	L	9	16
	M	12	21
X	H	18	32
X	VH	24	42
ALL DIMENSIONS IN INCHES			

NOTES:
1. EXPOSED ROCK DETAILS ARE APPLICABLE TO FLAT OR SLOPED AREAS. REFER TO THE SITE PLAN FOR ACTUAL LOCATION AND LIMITS OF EACH TYPE.
2. REFER TO SPECIFICATIONS FOR MATERIALS AND PLACEMENT REQUIREMENTS FOR ROCK AND GRANULAR BEDDING MATERIAL.
3. GENERAL PLACEMENT TECHNIQUES SHOULD RESULT IN LARGER ROCK AT THE SURFACE WITH ROCK SECURELY INTERLOCKED AT THE DESIGN THICKNESS AND GRADE. COMPACTION AND LEVELING SHOULD RESULT IN MINIMAL VOIDS AND PROJECTIONS ABOVE GRADE.

TYPICAL NATIVE ROCK PLACEMENT - EXPOSED INSTALLATIONS

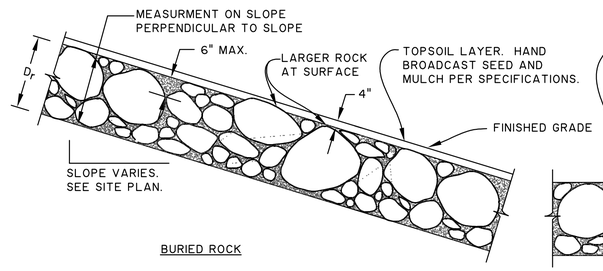
NTS

ROCK TYPE	D_b – MINIMUM BEDDING THICKNESS (INCHES)	
	FINE GRAINED SOILS TYPE I + TYPE II = TOTAL	COARSE GRAINED SOILS* TYPE II
VL, L	4 + 4 = 8	6
M	4 + 4 = 8	6
H	4 + 6 = 10	8
VH	4 + 6 = 10	8

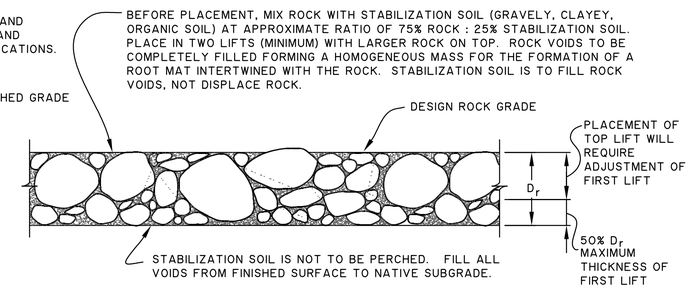
*50% OR MORE BY WEIGHT RETAINED ON THE #40 SIEVE.

AT THE CONTRACTOR'S OPTION, A 12-INCH LAYER OF TYPE II BEDDING MAY BE SUBSTITUTED FOR THE COMBINATION LAYER OF TYPE I AND TYPE II BEDDING OVER IN-SITU FINE GRAINED SOILS.

NOTE:
SEE PLANS AND SECTIONS FOR ROCK THICKNESS GREATER AT LAYDOWN BANKS, TOES, AND OTHER LOCATIONS.



BURIED ROCK



EXPOSED ROCK

D_r = DEPTH OF ROCK LAYER. SEE TABLE BELOW (UNLESS NOTED OTHERWISE ON PLANS.)

USED THIS PROJECT	ROCK TYPE	D_{50}	D_r
	VL	6	11
	L	9	16
	M	12	21
X	H	18	32
X	VH	24	42
ALL DIMENSIONS IN INCHES			

NOTES:
1. EXPOSED AND BURIED ROCK DETAILS ARE APPLICABLE TO FLAT OR SLOPED AREAS. REFER TO SITE PLAN FOR ACTUAL LOCATION AND LIMITS OF EACH TYPE.
2. REFER TO SPECIFICATIONS FOR MATERIALS AND PLACEMENT REQUIREMENTS FOR ROCK.
3. GENERAL PLACEMENT TECHNIQUES SHOULD RESULT IN LARGER ROCK AT THE SURFACE WITH ROCK SECURELY INTERLOCKED AT THE DESIGN THICKNESS AND GRADE. COMPACTION AND LEVELING SHOULD RESULT IN MINIMAL VOIDS AND PROJECTIONS ABOVE GRADE. TYPICAL FOR BOTH BURIED AND EXPOSED ROCK.
4. FOR BURIED ROCK: FINAL ROCK PLACEMENTTO BE COMPACTED BY FULL LOADING OF BACK HOE BUCKET AS APPROVED. ANY SOFT, YIELDING OR POCKETS OF SMALL ROCK WILL BE REWORKED. PLACE TOPSOIL SO NO MORE THAN 4 INCHES THICK OVER ROCK. COORDINATE ROCK PLACEMENT TO PROVIDE TREE OR SHRUB PLANTING PITS WHEN INDICATED ON PLANTING PLANS.

TYPICAL BURIED NATIVE ROCK PLACEMENT

NTS

No.	Revision	By	Date

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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

MACHINE-PLACED NATIVE ROCK AND GROUTED BOULDER DETAILS

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SECTION A-A

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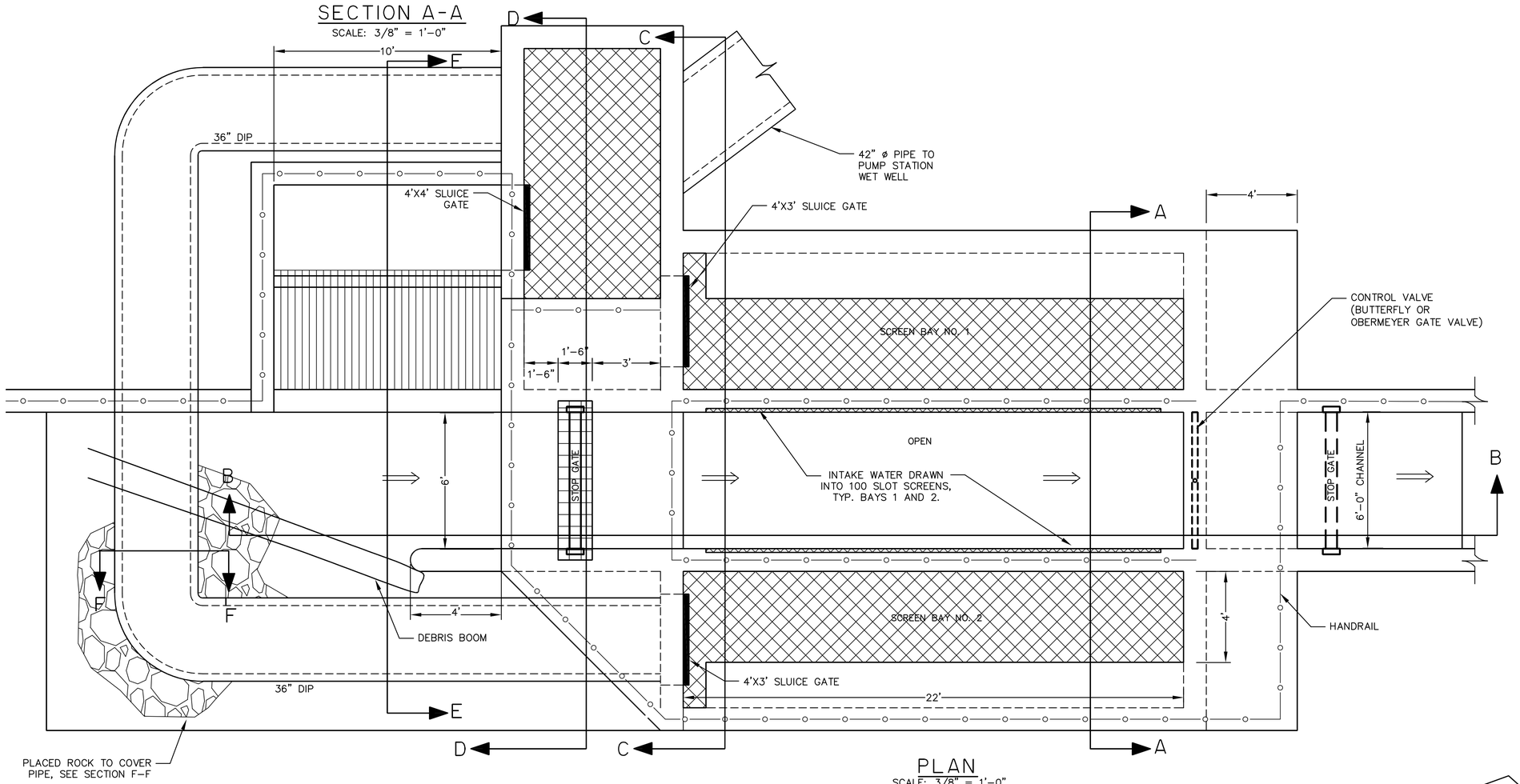

PLAN

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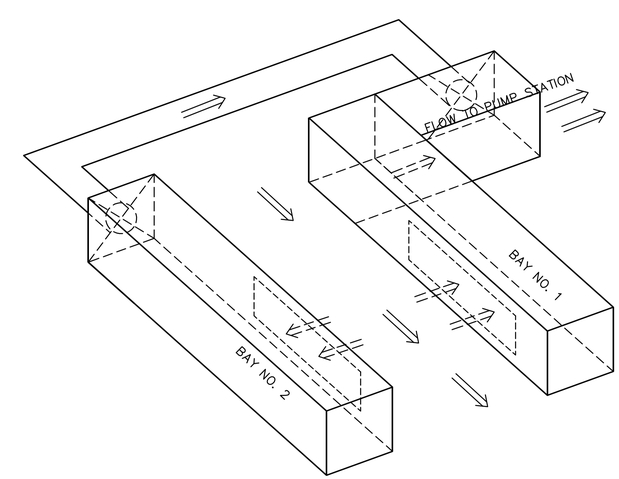

PERSPECTIVE I

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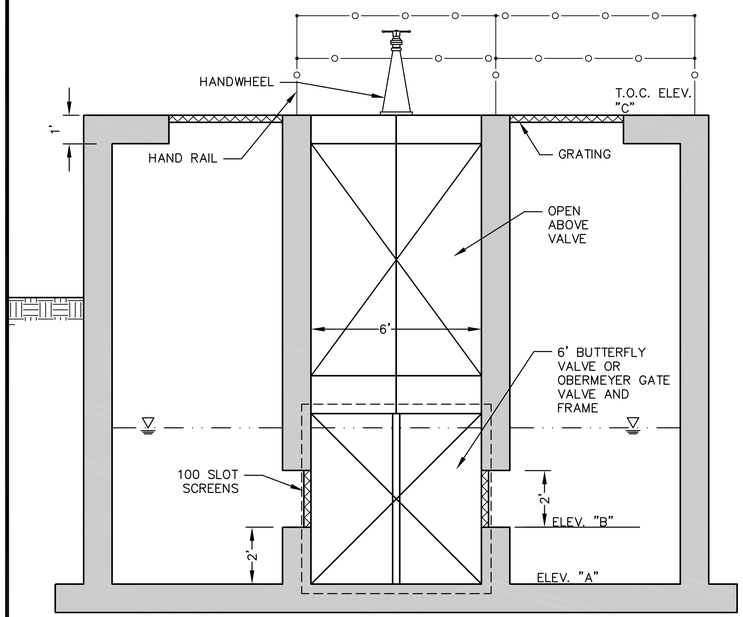

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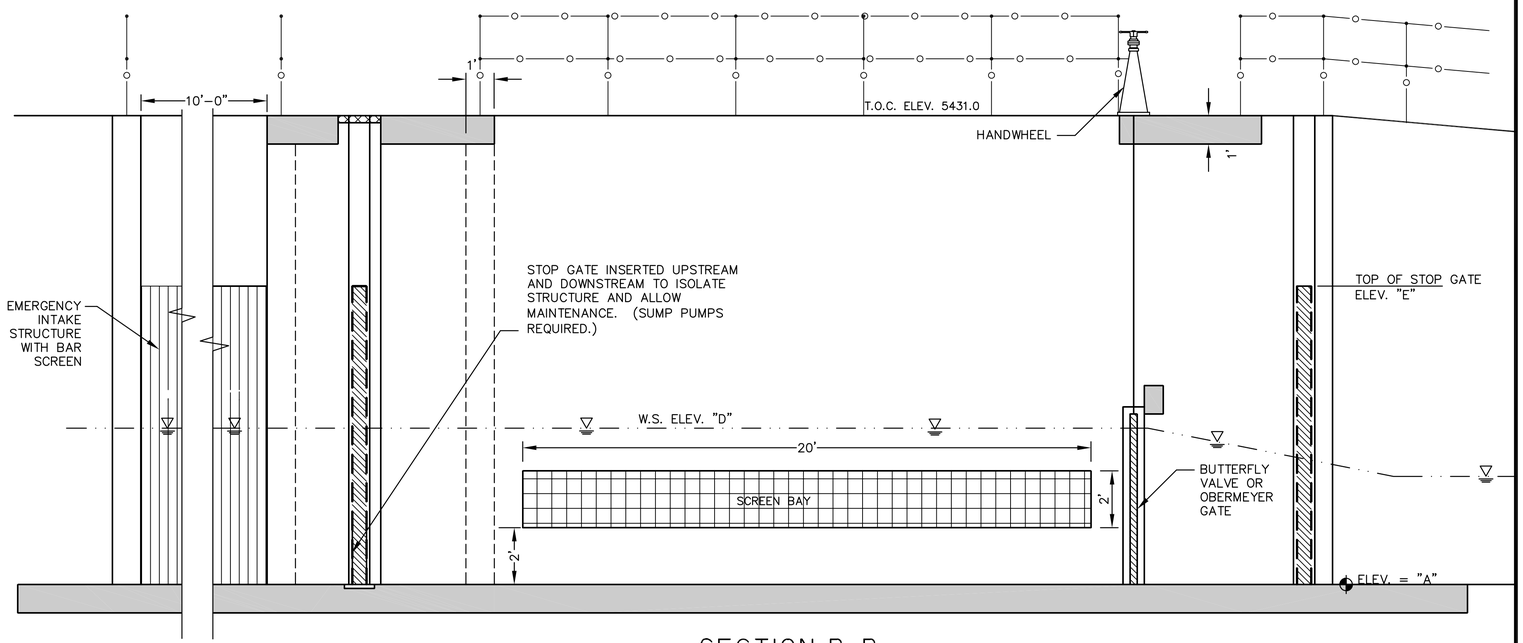

SECTION B-B

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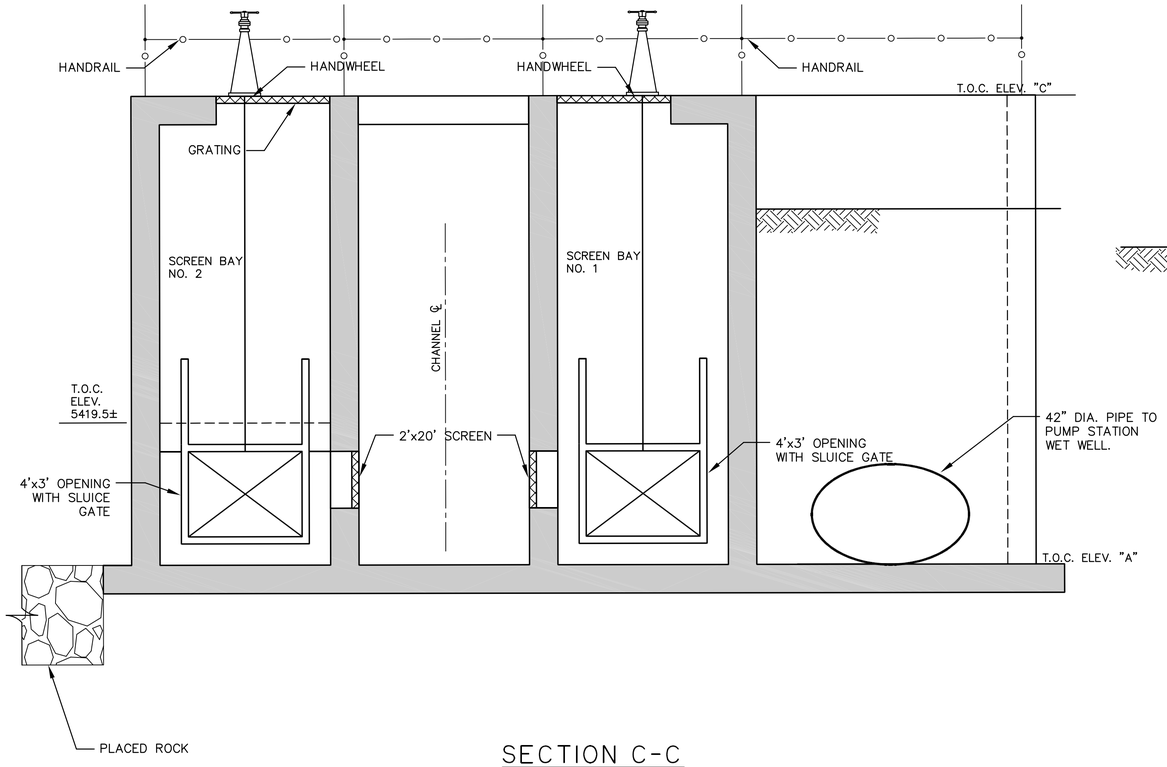

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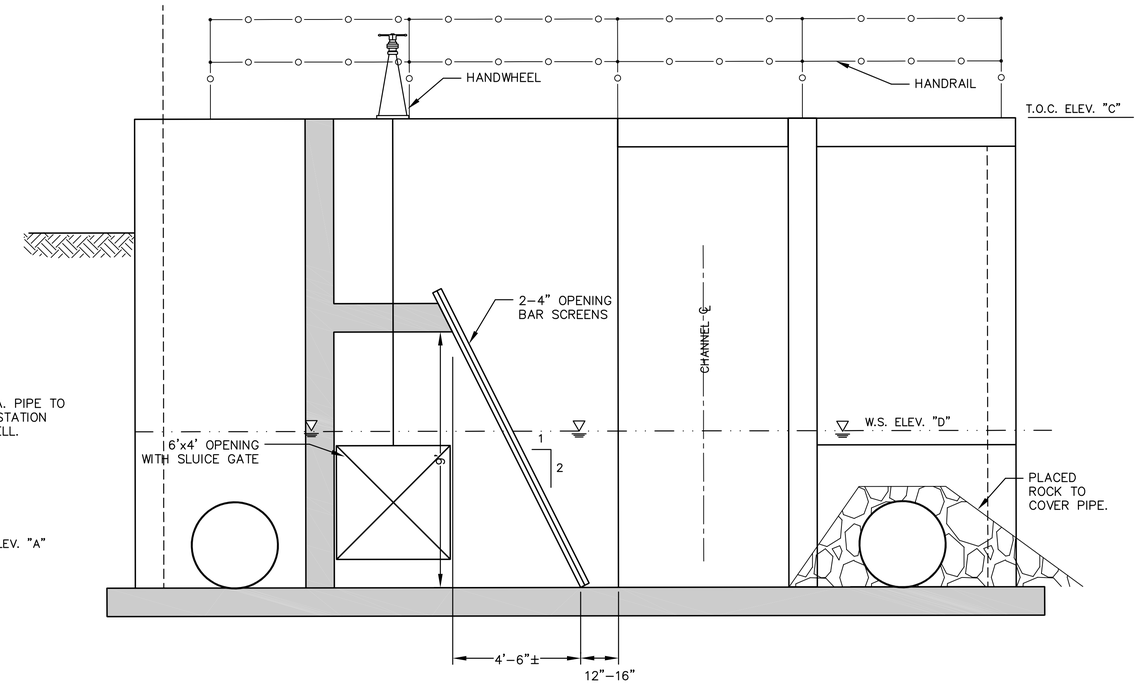

SECTION E-E

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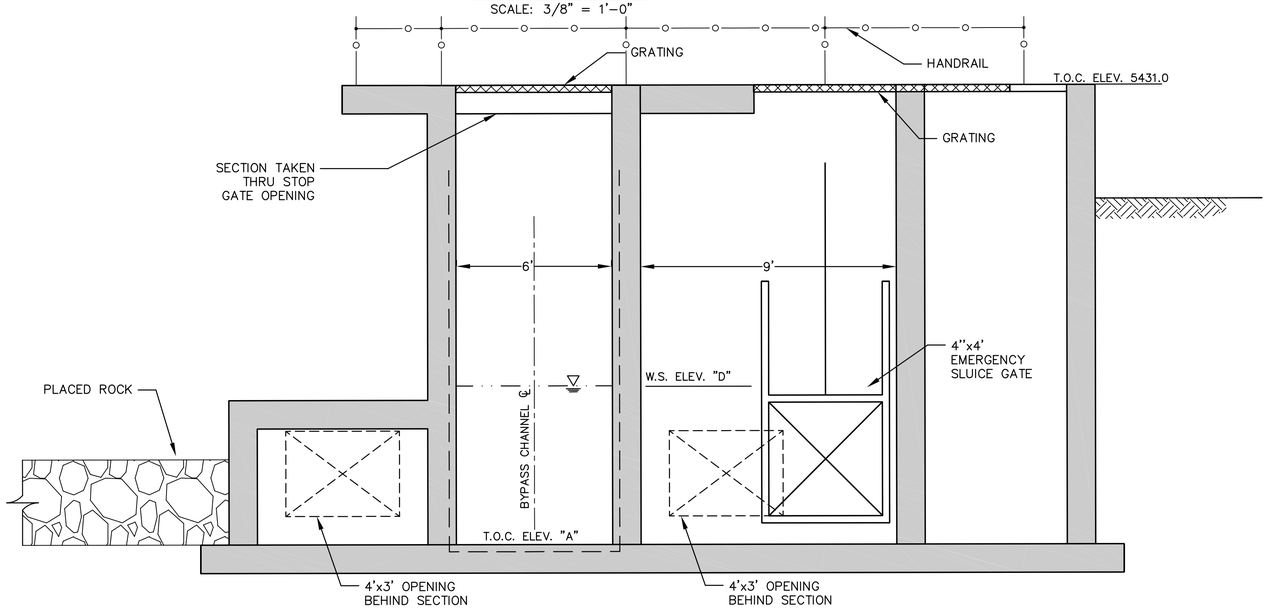

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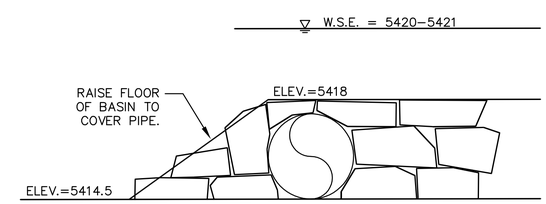

SECTION F-F

SCALE: 3/8" = 1'-0"

LOCATION	ELEVATION (ft) ALT 2	ALT 3	ALT 5	DESCRIPTION
A	5414.5	5414.5	5416.0	STRUCTURE INVERT
B	5416.5	5416.5	5418.0	BOTTOM SCREEN ELEVATION
C	5431.0	5428.0	5431.0	STRUCTURE ROOF/GRATING
D	5420.0	5419.6±	5421.0	LOW FLOW WATER SURFACE
E	5425.0	5425.0	5426.5	APPROXIMATE STOP LOG ELEVATION

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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

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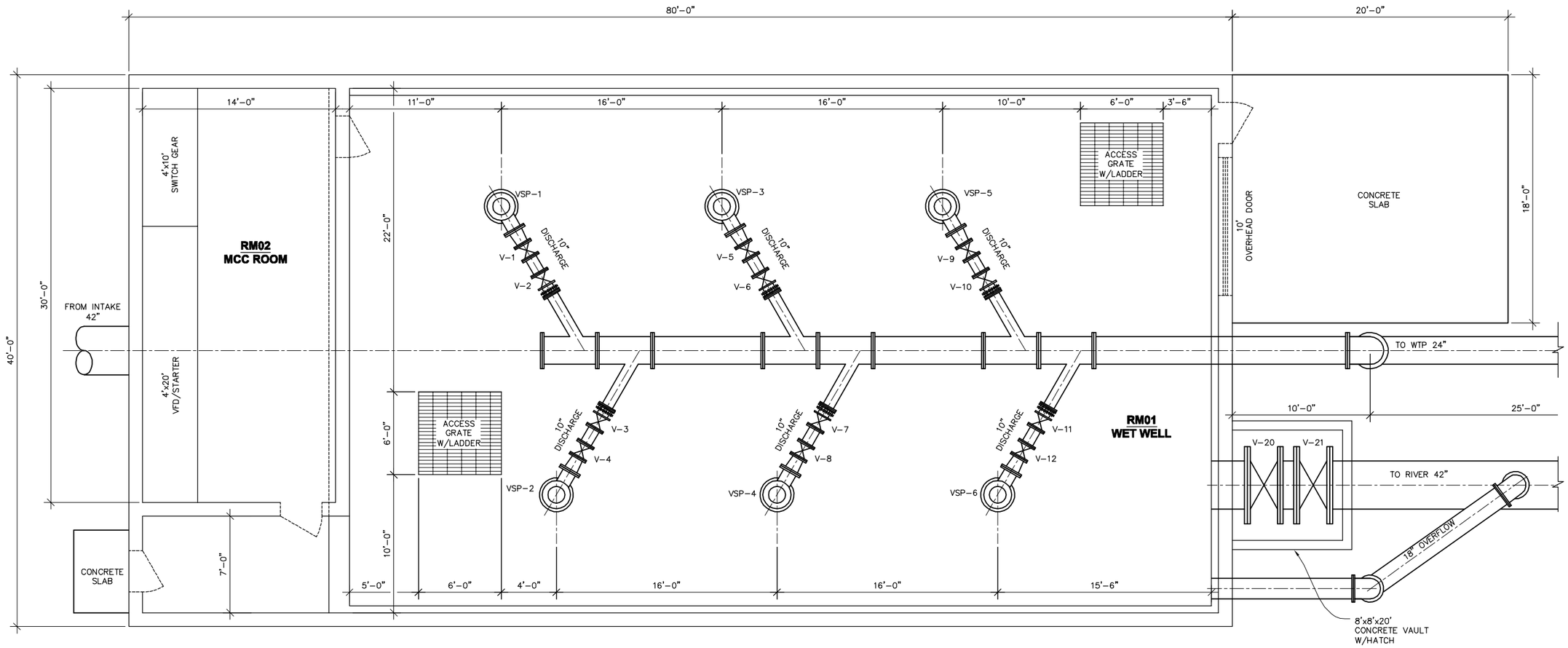

FOUNDATION PLAN VIEW

N

2 0 2 4 6 8 10
scale feet

VALVE SCHEDULE

VALVES	SIZE	DESCRIPTION	TYPE
V-1, V-4, V-5, V-8, V-9, V-12	10-INCH	PRESSURE PUMP CONTROL VALVE ON PUMP DISCHARGE	GOLDEN ANDERSON ECCENTRIC PLUG VALVE
V-2, V-3, V-6, V-7, V-10, V-11	10-INCH	ISOLATION VALVES ON PUMP DISCHARGE	GOLDEN ANDERSON ELECTRIC CHECK VALVE
V-14, V-15, V-16, V-17	10-INCH	ISOLATION VALVE	GOLDEN ANDERSON ECCENTRIC PLUG VALVE
V-18, V-19	10-INCH	SURGE ANTICIPATOR VALVES	GOLDEN ANDERSON SURGE ANTICIPATOR VALVE
V-20	42-INCH	ISOLATION VALVE	BUTTERFLY VALVE WITH ELECTRIC ACTUATOR CONTROLLED BY LEVEL TRANSDUCER
V-21	42-INCH	AUTOMATIC VALVE CONTROLLED BY LEVEL OF CLEARWELL	GOLDEN ANDERSON ECCENTRIC PLUG VALVE
V-22	24-INCH	ISOLATION VALVE	BUTTERFLY VALVE

PUMPS/STARTER/CONTROLS	DESCRIPTION
VSP-1, VSP-2, VSP-3, VSP-4, VSP-5, VSP-6	500 HP-2800 gpm @ 600 FEET VERTICAL TURBINES W/VARIABLE SPEED OF 700 TO 2800 gpm WITH NEW POWER SUPPLY/SWITCHGEAR STARTERS & VFD's

OBJECTIVE:

NEW PUMP STATION FOR THE BIG HOLE DIVERSION DAM

NOTES:

1. BUTTE-SILVER BOW WATER RIGHT IS 21.26 cfs (9,500 gpm)
2. ASSUME WSE FOR POOL IS ELEVATION 5419.6 FEET.
3. ASSUME INTAKE FLOWLINE ELEVATION 5414.50 FEET.
4. DISCHARGE TO APPROXIMATELY 58,000 FEET OF 36-INCH STEEL/DUCTILE PIPELINE WITH AN ELEVATION HEAD OF 550 FEET (±).
5. ASSUME 42 INCH INTAKE PIPING WITH A VELOCITY OF 1 FOOT PER SECOND WITH 220-FOOT OF LENGTH AND A 1/2-FOOT DROP TO CLEARWELL.

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BIG HOLE DIVERSION DAM REPLACEMENT PROJECT

CONCEPTUAL PUMP STATION

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Butte, MT 59701-2839
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dowlhkm.com

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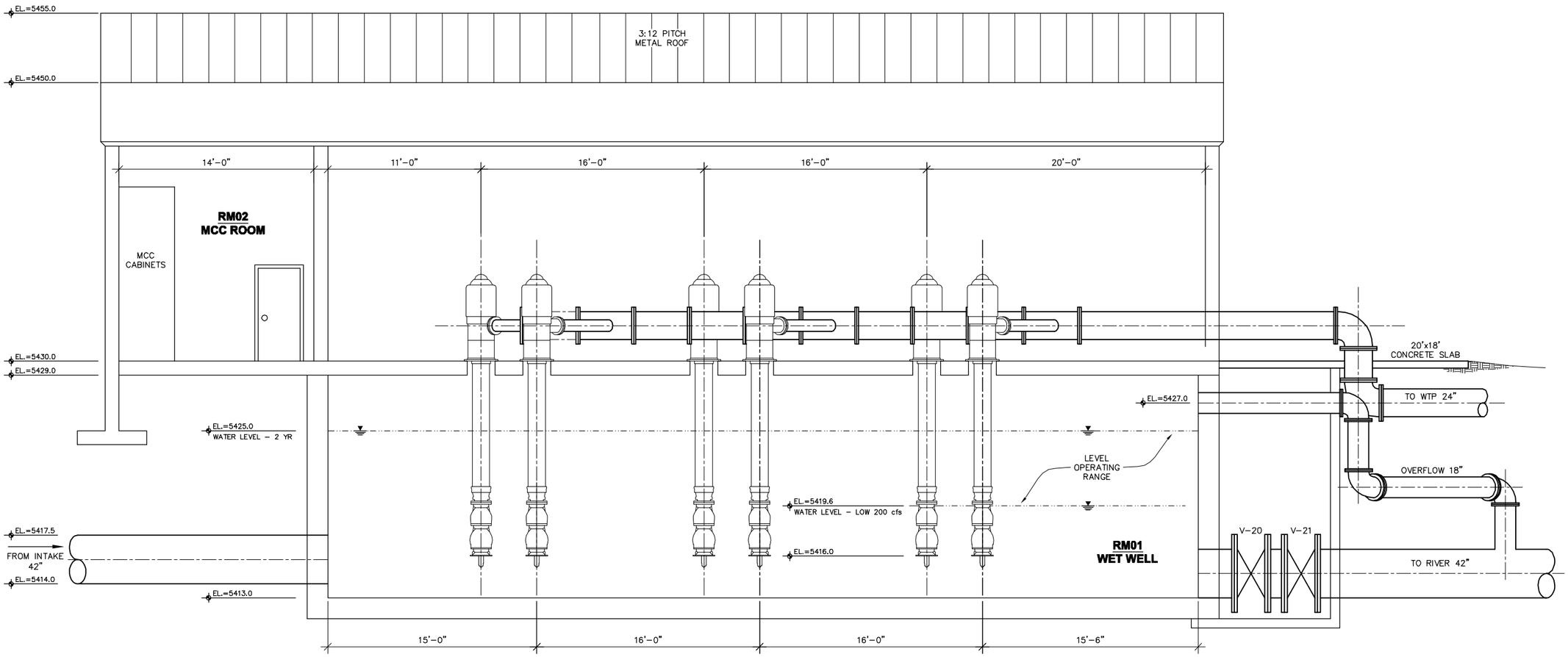

PROFILE - LOOKING NORTH

2 0 2 4 6 8 10
scale feet

NOTES:

1. NEED A TURBIDITY METER IN WET WELL
2. ULTRSONIC LEVEL CONTROL

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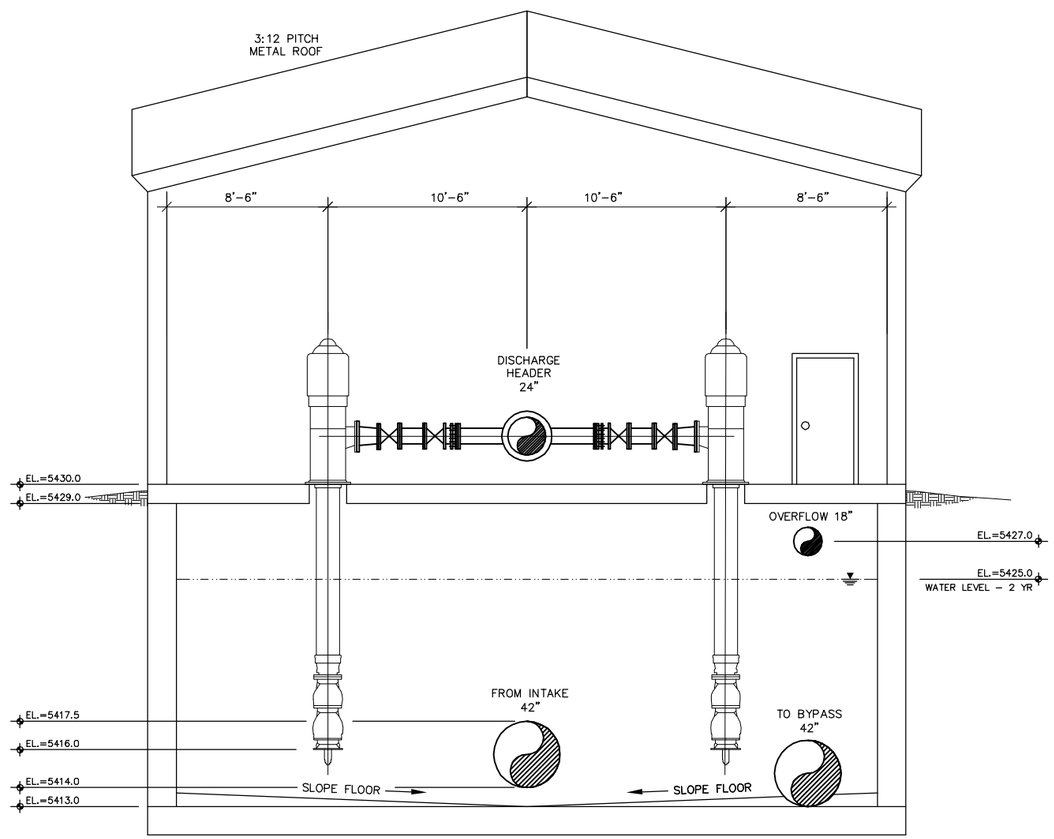

PROFILE - LOOKING EAST

2 0 2 4 6 8 10
scale feet

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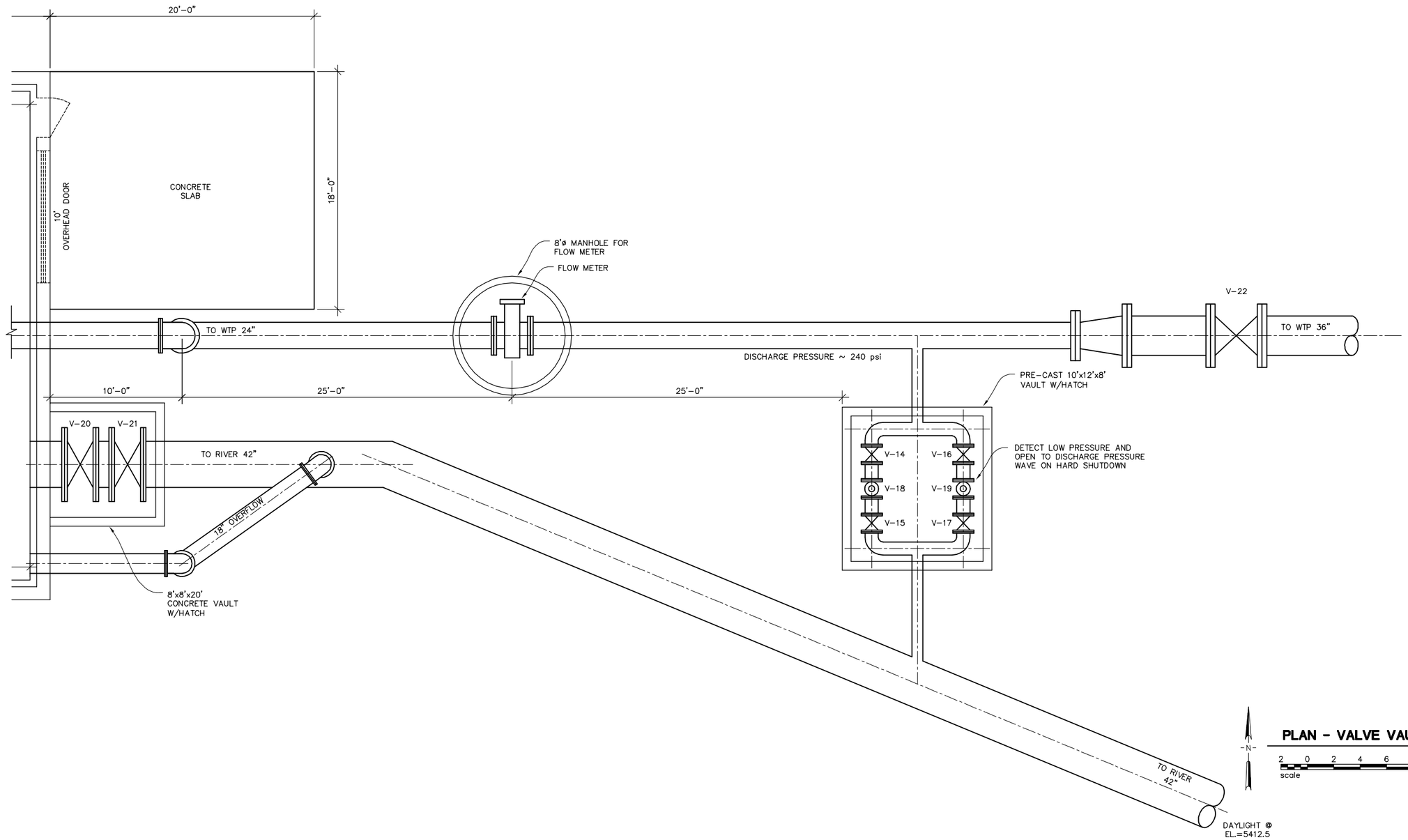

PLAN - VALVE VAULT

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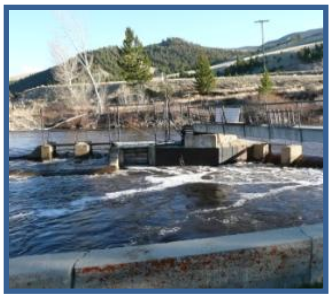

ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX D

ALTERNATIVES ANALYSIS REPORT

WHPacific

November 19, 2009

Mr. Dick Talley
DOWL HKM
130 North Main, Suite 100
Butte, Montana 59701-2839

Re: Alternatives Analysis Report, Big Hole River Diversion Dam

Dear Mr. Talley:
Please find attached the above referenced report for the Big Hole River Diversion Dam project. We have followed generally accepted hydraulic methods in producing conceptual design components for the alternatives shown in this report. The report contains detailed descriptions of the alternatives, their specific goals, features, descriptions, hydraulic performance, intake operations and other items.

We provide detailed analyses for three flow events; 1) the minimum design low flow of 200 cfs, 2) the 2-year event, and 3) the 100-year event. These flow values were selected to provide a representative picture of overall alternative performance over a broad range of conditions. Other flow values for other events have been modeled, but they are not presented in detail herein.

This report will be used along with documents prepared by historical and environmental specialists in support of an overall Environmental Analysis report for the project.

Please let us know if you have any questions regarding the material presented herein. We can be reached at (303) 458-5550.

Sincerely,
WHPacific, Inc.

MONTANA
BRIAN E. CHEVALIER
No. 19224
LICENSED
PROF. ENGINEER

Brian E. Chevalier, P.E.

Alternatives Analysis Report

Big Hole River Diversion Dam

Divide, Montana

Project No. 500956

November 2009

Prepared for:

DOWL HKM

Prepared by:

WHPacific

12596 West Bayaud Avenue, Suite 200
Lakewood, Colorado 80228

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Appendix B Drawings
Appendix C Manufacturer's Material
Appendix D HECRAS Output

Introduction

The Big Hole River diversion and intake structure has been providing municipal water to Butte Montana for several years, with the original dam structure dating back to the late 1800's. The structure has been upgraded and repaired several times over its history, and it now requires constant vigilance due to a probable piping condition near the south abutment. In addition, the facility inhibits fish passage, and it is a hazard for recreational boating and fishermen. Butte Silver Bow (BSB) has contracted with DOWL HKM to provide an engineering and feasibility analysis for upgrading the facility.

DOWL HKM has retained the services of WHPacific, Inc. to perform an engineering alternatives analysis of the site. The analysis includes an assessment of the existing conditions plus formulation of proposed alternatives. Five alternatives, including a do nothing alternative, are presented herein.

Background

Hydrology

Hydrology calculations have been competed by DOWL HKM. Calculations to determine flow peaks for various storm events are described separately.

Table 1 shows a summary of flow peaks for specific events.

Table 1. Major Event Flow Peaks

Event	Flow Value (cfs)
2-Year	7,239
5-Year	9,411
10-Year	11,029
50-Year	15,055
100-Year	16,712

The Big Hole River experiences a range of flow values during the course of a year, with typical high snowmelt runoff peaks during the spring and periods of low peak values in the late summer and winter. A design condition applicable to all alternatives is that BSB must be able to pull a proposed peak demand of 21.26 cubic feet per second (cfs) under all instream flow conditions, including periods of low flow and during icing conditions in extreme winter weather. A value of 200 cfs was selected as the minimum instream flow under which the intake and pumping system must remain operable. All alternatives herein will work under these low flow conditions, but system performance will have varying degrees of operability below 200 cfs. An assessment of each alternative's performance for flow peaks below 200 cfs is given in each section.

Boating Conditions

Numerous fishermen and recreational boaters report that the Big Hole River becomes unpassable for rafts and boats in nearly all years in the late summer. To get an approximation of the flow value for minimum boating conditions, the HECRAS model of existing conditions was examined for a range of flow values. We suggest that boating is feasible for a flow value where all cross sections have at least 1 foot of depth across a significant portion of the cross section. We estimate the minimum boating flow value in our study area is about 1000 cfs given the above conditions, however input from the recreational public suggests that this value is about 300 cfs given the improvements made to the draft requirements of rafts, kick boats and other devices employed by fishermen and boaters in recent years. Given this public input, we have assumed that boat passage in this stretch of the river is probable and will occur at flows as low as 300 cfs, below which, boat passage through the dam and intake is not a requirement.

For all alternatives that include boat and fish bypass channels, the boating portion of the bypass will be navigable for flow values of 300 cfs and greater.

Alternative Analysis

Specific topics are addressed for each alternative as they are applicable. These topics are:

- Alternative goals
- Alternative features
- Alternative description, including hydraulic performance, proposed reliability and maintenance, materials, and construction sequence.

Alternative One – Do Nothing

Goals

- Minimize cost by utilizing the existing facility
- Minimize impacts to existing pump house facility
- Minimize impacts to vegetation and wildlife habitat

Features

- No removal or improvement to existing dam
- No removal or replacement of water supply pipes
- No safety improvements

Description

Alternative One is a "Do Nothing" alternative and its purpose is to provide a comparison point for the other alternatives. A drawing of the existing site is shown on Sheet No. 1 in Appendix B. Alternative One has been in place for nearly a century, and BSB desires complete new features to remove concerns regarding public safety, employee safety, maintenance and repair, and operations. BSB has secured a portion of the required funding for improvements.

As with all improvements projects, there is some benefit to keeping the existing facility in place. Obviously, less capital funds are used, however maintenance costs are higher than proposed allternatives. Keeping the existing facility in place will have the least impact on the pump house, streambanks, and stream conditions, however, opportunities to improve on existing conditions are lost. Our goal with other alternatives presented herein is to identify the best features of the existing system and continue their use or improve upon them with other alternatives.

Hydraulic Performance

The existing structure was initially constructed in 1899, and modified over the years. See the Big Hole Diversion Dam Historic and Cultural Resources Report (Historical Research Associates) for further information. The most significant feature of the existing dam is the ogee cross section shape, which has been shown to create a dangerous keeper wave condition at this site. Figure 1 shows this wave under spring runoff conditions.

A HECRAS hydraulic model of the existing conditions and dam structure is included in Appendix D. Water surface elevations and cross section velocities for the 200 cfs flow, and 2-year and 100-year events are shown on the characteristics tables for existing conditions and for each alternative on the drawings. The highest velocity noted for the study reach is 12 ft/sec for the 100-year event at Section 3112, which is located approximately 90 feet downstream of the existing dam. The remainder of the velocities range from 6 to 8 ft/sec. The existing cobble and armored stream bottom generally would withstand velocities of this magnitude with little significant damage.

Figure 1. Spring 2009 runoff event at existing dam showing the keeper wave.

Expected Structure Life

We understand BSB periodically places large rock at the downstream toe of the dam in several locations, one of which is about 20 feet north of the south abutment. The conditions suggest that the structure is being undercut by a significant seepage hole, where water is piping and removing the substrate below the existing dam. Left on its own, this condition would worsen and complete failure of a section could occur at any time. Currently, a new scour hole is developing under the dam immediately left of the river centerline and will require repair and/or rehabilitation in the immediate future to preclude failure of the dam. Improvement alternatives presented herein should be strongly considered given the existing age, condition and known potential for failure.

Summary of Alternative Characteristics

Table 2 below shows a summary of Alternative One characteristics. The table includes hydraulics, intake, maintenance and operational comments and can be compared to values found in other alternative characteristic tables to follow.

Table 2. Alternative One Characteristics

Items	Assessment	Comments
Hydraulics		
Boatable Features	No	Dangerous condition with keeper wave. Reports of numerous injuries and rescues.
Fish Passage	No	Biological Resources Report indicates species distribution is probably influenced by the existing dam.
Maximum Water Surface Increase From Existing (100-Year) (ft)	N/A	Proposed conditions do not change existing floodplain characteristics.
Maximum Intake Velocity (ft/sec)	N/A	Using existing structure and sediment basin.
Minimum Intake Velocity (ft/sec)	N/A	Using existing structure and sediment basin.
Pool Elevation at 200 cfs (ft)	5418.2	Approximated by weir calculation over main dam and downstream walls of sediment basin
Floodplain - 100-Year		
Water Elevation at Pump House (ft)	5427.3	Section 3353
Flooding Depth at Pump House (ft)	0.8	Pump House floor elevation = 5426.5
Maximum Velocity (100-year) (ft/sec)	12.0	No apparent erosion issues visible, therefore natural armoring appears adequate.
Maximum Velocity Section	3112	
Maintenance		
Reduced Frazzle Ice Issues	No	
Ice Reduction	No	
Debris Handling	No	
Sediment Flushing	No	
Materials		
Dam or Embankment	Concrete	
Other Issues		
Point of Diversion Change	No	
New Dam/Boat Bypass Structure	No	
New Intake	No	
New Pump Station	No	

Alternative Two – Replace in Kind

Goals

- Replace the existing facility with a new dam and intake system
- Locate the improvements in close proximity to the existing facility
- Minimize costs by using existing facility components as much as possible
- Do not include boating or fish passage features to minimize costs
- Incorporate improved operations and safety features for staff
- Design for the maximum water right of 21.26 cfs (all subsequent alternatives)

Features

- New dam structure upstream of existing dam, at elevation 5418.8, for a length of 147'
- Concrete dam with a stepped face on the downstream side
- Upstream grout trench approximately 8 feet deep
- New primary and emergency intake on the north bank
- New slotted screen on primary intake to block excessive sediment and debris
- Air backwash screen cleaning
- New pipe system to deliver raw water to the pump house
- Floating boom to redirect floating debris from the intake

Description

Alternative Two is to "Replace in Kind" and is shown on Sheets No. 2 and 3 in Appendix B. Alternative Two recognizes the need for improvements, yet it is designed to minimize improvement costs. One aspect of cost reduction is to not incorporate boat bypass and fish passage into the new facility. The improvements deliver water to the raw water system downstream in a similar manner to the existing facility, i.e., the new instream dam checks up water to allow the screened intake to intercept water. The new intake screen replaces the existing settling basin, and the screens block excessive sediment from the downstream raw water delivery system. New piping conveys water directly to the pumps without a settling basin.

This alternative improves safety conditions and operational effort for BSB staff, but the proposed dam would have minimal improvements for general public safety. A modification to the existing dam section would be to gradually step the downstream face of the new dam, which would reduce the possibility of the "keeper wave" that shows up under existing conditions. A typical dam section is shown on Sheet No. 4 in Appendix B. The keeper wave condition is described in the Alternative One Section.

Alternative Two would have some impact on the existing streambanks and instream backwater pool. A new penetration of the existing pump house is required, and connections will be needed

from the delivery pipe to the existing pumps. All instream components of the existing dam are to be removed, except for the existing abutment along the south bank.

Hydraulic Performance

Dam and Instream Conditions

The HECRAS analysis for this alternative is shown in Appendix D. A comparison of proposed and existing water surface elevations and velocities is shown on Sheet Number 2. Upstream of the new dam crest, the proposed water surface elevations are 1.3 ft, 1.0, and 0.8 feet higher than existing conditions (measured at Section 3518) for the 200 cfs flow, the 2-year event and the 100-year event respectively. At Section 4439, which is about 920 feet upstream, these differences diminish to about 0.0, 0.4, and 0.4 feet respectively. Overall the impact of the increased water surface is minimal. Furthermore, with wall improvements shown on Sheet Number 3, the existing pump station can be protected from flooding for the 100-year event, an improvement over existing conditions. The wall's primary purpose will be to provide erosion protection for the proposed intake structure. The wall could be combined with benches or terraces that will promote wetland and upland plant species depending on mitigation needs. It is anticipated that if this alternative is desired, the proposed dam height could be increased in order to further improve pump performance without a significant impact to the surrounding site.

Velocities for this alternative under low flow and flood events are similar, with the exception of velocities of at least 15 ft/sec at the dam face during the 100-year event. The downstream toe of the dam will be protected by placing concrete rubble from the demolition of the existing dam and sediment basin.

Intake Structure

The intake site plan is shown on Sheet No. 3 in Appendix B, and preliminary structure details are shown on Sheet Numbers S1 and S2 in Appendix B.

Referring to the site plan, the proposed intake structure will be located along the north shoreline, approximately 150 feet upstream of the existing abutment wall of the existing dam/sediment basin. Approximately 63 l.f. of the existing abutment wall will be removed to allow for the intake structure installation. Raw water will be intercepted through screens and conveyed to 42- inch pipe.

Referring to the detail sheet, the structure will have several key components, which include:

- A butterfly gate or Obermeyer Gate to regulate flow on the downstream side of the structure
- Two bays of 20 foot long by 2 foot high 100 slot screens along the main channel

- Two collection bays that will transfer water to the 42 inch pipe.

Butterfly Gate Valve or Obermeyer Gate Valve

A design consideration with intake structures is to encourage high instream or bypass velocities, yet minimize low velocities moving through the screens in order to reduce collection of debris and sediment along the screen faces. The butterfly valve or Obermeyer gate valve provides an excellent solution for this consideration. In the case of a butterfly valve, when the gate is opened, water will pass through vertical slots that are adjacent to the downstream end of the screens. Therefore velocity vectors will be oriented parallel to the two screen bays. Near the gate opening this desirable condition performs best, and it lessens along the length of the screens as the distance increases from the gate opening. Opening and closing the butterfly will set the flow rate through the main channel, and also help regulate the entire upstream water surface pool One draw back of the butterfly valve is the stem which extends through the water and will be a source for slush ice collection and deposition during extreme cold weather operations.

An Obermeyer gate is essentially an inflatable dam that would be mounted in the floor of the intake chute and would pneumatically raise and lower via a bladder system. When the bladder is deflated, the flowline of the chute would be clear and allow for unrestricted passage of water passed the screens. As the bladder is inflated, the gate would rise creating an upstream water surface elevation increase. The gate elevation could be varied dependent upon instream flows such that adequate volume and velocity of water could pass through the intake chute to enable adequate diversion, clearing of screens and passage of ice and debris over the top of the gate, yet could be adjusted to enable flows over the new dam. The position of the crest of the gate will control flow through both the intake channel and the main channel and also help to regulate the entire upstream water surface pool.

The final gate selection will occur in the final design phase of this project after meetings with BSB staff and operators. Drawings sheets shown herein show a butterfly valve for the intake control.

Screens

The structure will utilize two bays of 100 slot screens (0.10 square inch opening size). The screen size is set to have a maximum flow through velocity of 0.5 ft/sec. The actual screen open area factor to total screen area percentage is 57.5%. Preliminary design efforts have sized each screen bay as 2 feet high by 20 feet long for a total screen area of 40 sq. ft. and an open area of 23 sq.ft.

The open area of the slotted screens totals to 40 sq. ft. At the design flow rate of 21.26 cfs, the velocity through the screens is 0.5 ft/sec.

The screens will be cleaned periodically via an air backwash system (not shown on the drawings). This air backwash system can be constructed to automatically purge on timed intervals or other operational criteria as to be determined in the final design should this alternative be selected as the Preferred Alternative.

Intake Hydraulics and Pool

Shown on Figure A2.1 in Appendix A is a rating curve showing a combination of instream flow, flow through the intake structure, and flow over the main dam. It is important to note that the intake butterfly gate valve is assumed to be in the full open position, or, in the case of the Obermeyer Gate, in the full down or deflated position. Either of these valve considerations will provide operational flexibility to BSB to enable maximum system performance during variable river flows, weather conditions and raw water demands. The full open position of the butterfly gate or full deflated position of the Obermeyer gate will send a maximum flow through the structure at all times; whereas, full closed position on the butterfly or full up position or inflated position on the Obermeyer will send a maximum flow over the new dam.

HECRAS was used to calculate the values shown in Figure A2.1. Surveyed sections downstream of the intake structure in the main stem of the river were used to determine a backwater profile. The overall instream flow will influence the backwater conditions of the gate.

As can be seen in the figure, unrestricted flow through the intake structure sets the water surface pool elevation at about elevation 5419.0. Another analysis was performed with the flow through the intake structured restricted by approximately 50%. The results of that analysis show that the upstream pool elevation is 5419.1 as shown on Figure A2.2. With the intake structure fully obstructed; i.e. valve closed or gate fully inflated, the water pool elevation upstream is 5419.5.

Intake Operations

The ability to modulate the flow through the intake structure via the butterfly valve or the Obermeyer gate will have several operational advantages. In the case of the butterfly valve, as the gate is slowly opened, water is drawn to the openings where the intake screens are located. Velocities will be greatest at the gate edges, near the screens which will assist with screen clearing and cleansing. Additionally the operational flexibility of the butterfly valve will enable flow balancing between the intake structure and the main stem channel to optimize intake efficiency. The main advantage of the butterfly valve will be the increased velocity profiles along the edges for screen clearing whilst the main disadvantage will be the potential for icing of the valve stem that is located in the center of the flow channel. This can be mitigated with the

addition of air bubblers in and around the valve stem and by maintaining flow velocities through the channel sufficient to carry the ice past the structure.

In the case of the Obermeyer gate, the bladder can be periodically deflated to enable full flushing flows through the intake structure to assist in sediment removal, screen cleaning and cleansing and ice removal. The ability to raise and lower the crest position will create a variable weir height which will enable flow balancing between the intake structure and the main stem channel as noted above in the description of the butterfly valve operation. The main advantage of the Obermeyer gate is its ability to pass ice due to having no obstructions in the flow channel and can be raised and lowered from the bottom to enable flushing and passage of any obstructions. The main disadvantage is that during normal operations, a dead pool will be maintained upstream in the screen section due to the raised position of the bladder and gate. This dead pool will not facilitate velocity vectors parallel to the face of the screens and may result in more than acceptable incidences of screen plugging. This can be offset with periodic air backflushing in concert with lowering of the gate and bladder deflation to enable a flushing of any buildup.

Manufacturer's cut sheets for the butterfly valve and the Obermeyer gate are provided in Appendix C.

Intake Performance Expectations

The overall system performance will have the following advantages over existing conditions:

- **Increased ability to flush the intake works.** Current operations essentially rely on high instream flows to flush sediment from the sediment bay. Accumulated sediment does not appear to be a significant issue at the site, but the new structure has the ability to operate under several flow through scenarios, plus the addition of a strong flush by opening butterfly gate wide open or by deflating the Obermeyer gate.

- **Reduced Ice Buildup.** Air bubblers at the butterfly gate will reduce ice buildup, and in addition, water will always be moving through the intake system. The position of the Obermeyer gate will also aid in reduced ice buildup as it will maintain an unrestricted flow through the chute with velocities between 2 and 6 cfs. This is a similar situation to the first raceway cell of the existing system, where water very rarely freezes due to constant flow. Slower velocities in the existing sediment basin, along the river face of the raceway, at the dam face and in and around the pier promote freezing. The intake screens will not be exposed to air even at very low instream flows. Operators will have the alternative to modulate either the butterfly valve or the Obermeyer gate to maintain an operable upstream water surface, optimal flows and velocities for ice and sediment

removal through the intake channel and to maintain and balance flows between the intake and over the main channel dam crest.

- **Reduced Frazzle Ice Issues.** Water will always be moving past the submerged intake screens and these screens will not be exposed to cold air conditions which promote ice buildup. For additional backup, air bubblers can be installed around the perimeters of the screen and in the intake collection box to reduce ice buildup. Final designs will consider this alternative should it be desired or deemed to be advantageous.

- **Improved Debris Handling.** The new dam will result in most instream debris eventually passing over the main dam, similar to existing conditions. However, operators will have a new, safer access point to the dam. Since the new dam will not have a notch (as in Alternatives Three, Four and Five), debris could accumulate at any point along the dam face. Debris near the debris boom could be hooked by a long rake and pulled over to the dam face from the intake platform, then pulled over the dam from the south side of the platform.

- **Increased Operator Safety.** Handrails will be installed along the intake platform to increase operator safety. There will be no need to go out on the dam face to clear ice as under existing conditions. Air bubblers will reduce ice buildup and frazzle ice conditions within the intake structure.

Materials of Construction

The dam crest section will consist of concrete, cast-in-place, with a stepped downstream face as shown on the drawings. The overall dam height will be about 6 feet high in the middle of the channel (see Sheet No. 4). However, near the dam abutments, the existing grade rises up to nearly the proposed dam crest. The design anticipates that the entire dam section would be cut into existing grades and backfilled as needed at the dam abutments to approximate the existing channel shape.

The dam will require an upstream grout toe trench that is approximately 8 feet deep, based on the maximum hydraulic difference of about 4 feet that occurs for most major events. The downstream toe of the dam would be protected with a 20 foot wide, 2 foot thick layer of concrete rubble resulting from demolition of the existing dam and sediment basin. A layer of native angular rock would be needed near the intake structure, and adjacent to the south abutment wall for protection against erosion and scour and to promote stream bank stability.

Constructability

The expected construction sequence for the project would be as follows:

1. Install the intake discharge line into the existing pump house and make connections, but close gates and valves until operational.

2. Construct a temporary coffer dam around the new intake area that would extend from the north bank above the proposed dam site as far south as practical, (at least to mid stream) allowing for construction of the intake, northern half of toe trench, and northern half of the proposed dam. BSB would continue to operate existing intake to collect water supply.

3. After completion of the intake and north dam, the north coffer dam would be removed and relocated to the south side to force water to the north side of the river and through the new intake channel. Once the river was diverted from the south side back to the north side, construction of the southern portion of the new dam would be completed. BSB would continue to operate the existing intake during this period to collect water supply.

4. Once the southern half of the new dam is completed, the new intake would be commissioned and the valves in the pump house opened to enable flow to the pump suction header. After satisfactory commissioning, the existing dam and intake structures would be breached and removed. The rubble salvaged from this removal would be placed downstream of the new dam in sections. This would be enabled by providing for full flow through the new intake chute and through the use of sandbags to block flow over the new structure in segments to allow concrete rubble placement..

Summary of Alternative Characteristics

Table 3 below shows a summary of items reviewed above. The table includes hydraulics, intake, maintenance and operational comments.

Table 3. Alternative Two Characteristics

Items	Assessment	Comments
Hydraulics		
Boatable Features	No	Stepped dam will reduce keeper wave formation, but structure will not be designed for boating.
Fish Passage	No	Biological Resources Report indicates species distribution is probably influenced by the existing dam. Same conditions could be expected from this structure.
Maximum Water Surface Increase From Existing (100-Year) (ft)	2	Measured at new dam crest.
Maximum Intake Velocity (ft/sec)		
Minimum Intake Velocity (ft/sec)		
Pool Elevation at 200 cfs (ft)	5419.5	HEC-RAS calculations with inline weir. Gate fully closed.
Floodplain - 100-Year		
Water Elevation at Pump House (ft)	5425.8	Section 3353
Flooding Depth at Pump House (ft)	N/A	Pump House floor elevation = 5426.5
Maximum Velocity (100-year) (ft/sec)	15.1	At dam crest.
Maximum Velocity Section	3378	
Maintenance		
Reduced Frazzle Ice Issues	Yes	Screens are not exposed to air.
Ice Reduction	Yes	Water moving through intake.
Debris Handling	Yes	Debris boom will collect surface debris.
Sediment Flushing	Yes	Gate will allow for various flushing scenarios, stop gates used for dry cleaning.
Materials		
Dam or Embankment	Concrete	
Other Issues		
Point of Diversion Change	Yes	Approximately 100 feet upstream.
New Dam/Boat Bypass Structure	No	
New Intake	No	
New Pump Station	No	

Alternative Three – New Rock Weir Dam, Intake and Pump Station

Goals

- Remove existing dam and features
- Utilize the same or nearly identical point of diversion
- Incorporate boat and fish passage
- Provide primary and secondary intake systems
- Provide new pump station and components
- Locate the improvements within the historical footprint
- Incorporate improved operations and safety features for staff
- Design for the maximum water right of 21.26 cfs (all subsequent alternatives)

Features

- New pump facility with new variable speed pumps
- New pump wetwell to improve pump performance
- Boat and fish passage capability in the main stream
- Removal of the existing dam section
- New rock weir dam structure with boat and fish passage channel and rest pools
- New primary and emergency intake on the north bank
- New slotted screen on primary intake to block excessive sediment and debris
- Air backwash screen cleaning
- New pipe system to deliver raw water to the pump house
- Floating boom to redirect floating debris from the intake

Description

Alternative Three is referred to as "New Rock Weir Dam, Intake and Pump Station". This alternative calls for the construction of a new pump station building to the east of the existing pump station building. The new pump house would include four new variable speed pumps with new pump starter and control drives atop a buried concrete wet well to improve system delivery performance and reliability. It is understood that bedrock conditions were encountered during the pump installation in 1995, and this prevented the pumps from being installed at the desired elevations. As a result, available suction head during low river flow conditions and/or icing conditions is limited due to the elevation of the pump suction bowls and can create pump cavitation at desired flow rates. As a result, BSB's ability to fully operate the pumps at higher flow rates during low water levels in the river is restricted. Additionally, the water delivery components consisting of the instream pier, conveyance box located beneath the sedimentation basin, the existing cistern and the raw water delivery pipeline from the cistern to the suction header is in aged and deteriorated condition. The new pump house would result in lowering the

pump suction bowls to improve the available suction head and alleviate the cavitation restrictions, and in addition remove all aged and deteriorated water delivery components from the existing pump house site.

Sheet No. 5 in Appendix B shows the components of Alternative Three. The primary components are the new dam and boat and fish passage structure, primary and secondary intake structure, and new pump station.

One aspect of this alternative is that the point of diversion remains unchanged, hence not requiring an application for a change in the point of diversion and accompanying concerns.

Alternative Three includes primary and secondary intake systems. The primary intake would include screens to keep most sediment and fines in the main channel. The secondary intake generally would include coarser screens or bar screens to allow for water delivery during periods of maintenance on the primary screens and intake or if an emergency problem with the primary intake arose. It would generally be used for a short period of time to allow for repairs or maintenance of the primary intake. The raw water conveyance system would deliver water directly to the new pump station.

A benefit to this alternative's design is that the wetwell and new pump elevations would be set based on the new instream water surface to allow for sufficient suction head thereby eliminating any cavitation concerns and optimizing pump performance. The water surface would be controlled both by the intake structure as noted in description of Alternative Two and by including a notched rock "spillway" in the proposed rock drop structure, replacing the function of the existing dam but allowing boat and fish passage. The profile of the new drop structure would include small gradual steps to make up elevation down the rock drop face. The shape and elevations of the downstream channel and drops would be optimized to provide the desired upstream water surface and enable boat and fish passage.

Hydraulic Performance

Dam and Instream Conditions

The HECRAS analysis for Alternative Three is shown in Appendix D. A comparison of proposed and existing water surface elevations and velocities is shown on Sheet Number 5. As shown in Table 4 below, upstream of the new dam crest the proposed water surface elevations range from 0.5 feet to 2.2 feet higher than existing conditions for the events listed in the table. At the upstream study limit for this project (near Section 44+39) those differences are negligible as shown in the table.

Table 4. Alternative Three Hydraulics Comparison

Cross Section Location	Difference In Water Surface (ft)		
	200 cfs	2-Year (7,239 cfs)	100-Year (16,712 cfs)
35+18	2.2	0.6	0.5
44+39	0.1	0.2	0.2

Velocities for this alternative under low flow and flood events are similar, with the exception of velocities of at least 15 ft/sec within the grouted rock structure pools during the 100-year flows.

The velocities shown on Sheet No. 5 are calculated using the HECRAS normal depth subcritial solutions. This solution does not allow the water surface to cross below critical depth, and therefore the solution does not indicate velocities that could exceed critical velocity. This type of solution is used to establish floodplain elevations and delineations because it shows the most conservative or highest water surface.

For cases where actual velocities and depths are required, HECRAS provides a supercritical profile alternative and a combination of supercritical and subcritical profiles called a mixed flow alternative. The analysis used this alternative to more closely model actual velocities on the boat bypass chutes. The analysis included using additional cross sections on the drop faces and pools that are not shown on Sheet No. 5.

Figure 2 shows the resulting velocities using a mixed flow calculation at four key sections on the boat bypass structure. The sections are:

1. Section 31+68, at the lowest pool – Red line
2. Section 31+93, at the lower drop face – Blue line
3. Section 32+23, at the lower drop crest – Purple line
4. Section 32+55, at the upper pool – Green line
5. Section 32+83, at the upper drop face – Orange line

Figure 2. Velocity characteristics in the Alternative Three Fish/Boat Passage Channel

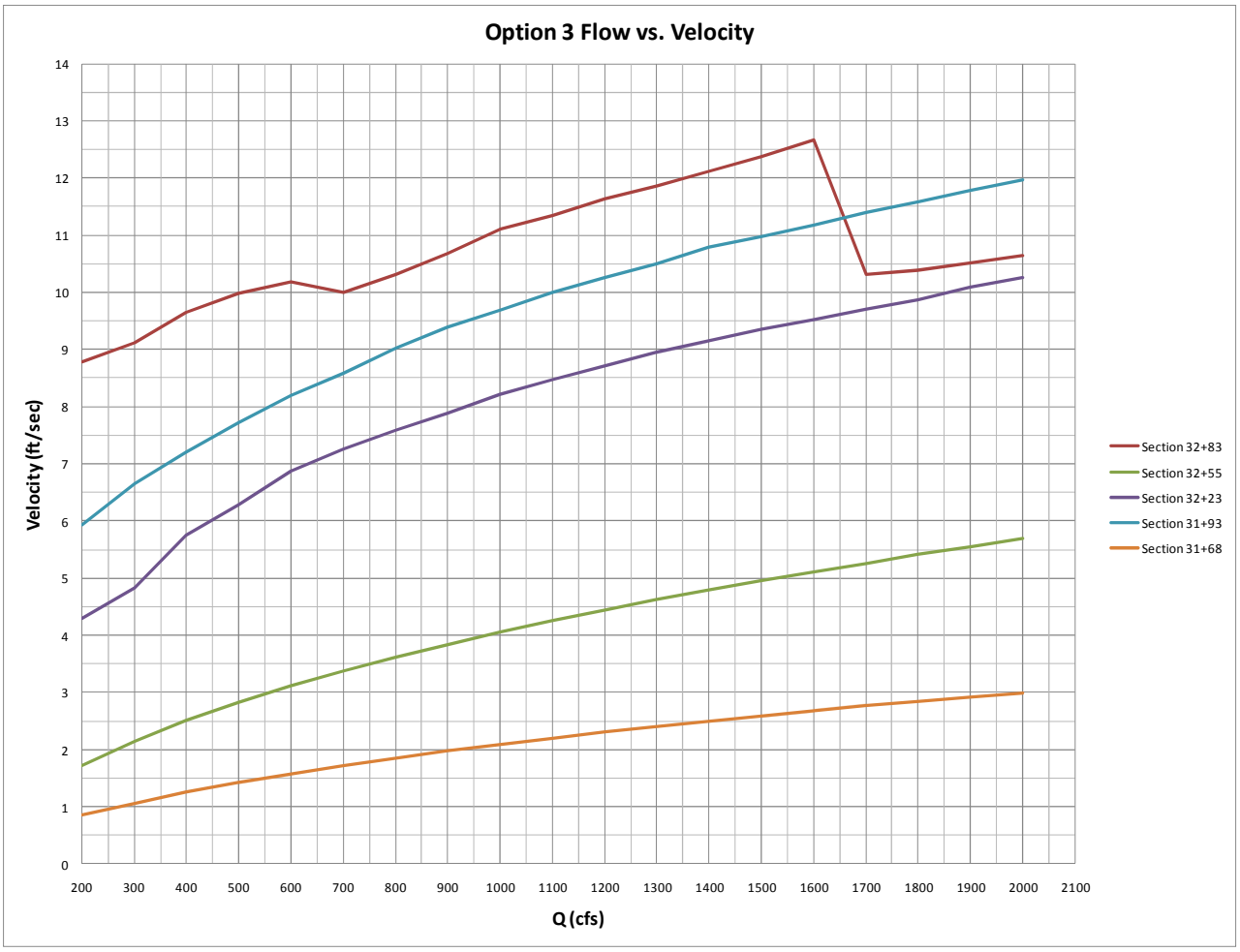


Figure 2 shows that the highest velocity expected for the range of flows analyzed is about 12.5 ft/sec. This velocity occurs at Section 32+83, which is on the upper drop face and at river flows of 1,600 cfs. This velocity should be expected under these conditions over a distance of about 45 feet (downstream of this section).

It is understood that "ideal" fish passage occurs when velocities remain below 6 feet per second. As can be seen in Figure 2, these velocities are easily achieved over the range of flows analyzed with exceptions of the crest of the upper drop, the upper drop pool and the crest of the lower drop. Continued evolution of the design may result in a wider opening in the boat and fish channel to reduce the velocities in these sections further should this option be selected as the Preferred Alternative. With a wider opening, the cross sectional area will be increased resulting in a lower velocity for the same flow rate. It also bears noting that these velocities are represented at a single cross section and are not representative of velocities along the entire flow path.

Site Grading

Shown on Sheet No.s 5 and 6 of Appendix B is erosion protection grading that starts at the existing north abutment wall and continues to the northwest through an open area just west of the existing pump house. The components of the erosion protection grading will probably consist of a small vertical wall combined with buried rock and planted wetlands and upland species. The intent of the grading is to protect future extreme events from impacting the proposed features, including the intake structure. The grading and final components will be determined during final design.

The final design anticipates that the grading could be set high enough to protect the existing pump house from flooding during the 100-year event. Final grades and elevations have not been determined at this time. As noted previously, the existing conditions and structures result in the existing pump station to be located within the 100-year flood plain. As shown on Sheet No.'s 5 and 6, as a result of Alternative Three, the 100-year event will continue to inundate the existing pump station. Our intent during final design will be to refine the erosion protection grading at this location so that the pump station may be protected from flooding during the 100-year event. In addition, disturbed area mitigation could occur here, where the proposed grades could be benched or sloped as needed to allow for wetland and upland vegetation planting.

Intake Structure

The intake site plan is shown on Sheet No. 6 in Appendix B.

Referring to the site plan, the proposed intake structure will be located along the north abutment wall of the existing dam/sediment basin. Approximately 45 l.f. of the existing abutment wall will be removed to allow for the intake structure installation. Raw water will be intercepted through screens and conveyed via a conduit to a transition structure. A 42- inch pipe will convey flow from the transition structure to the pump station.

Note that the intake structure has the same horizontal dimensions as the structure shown for Alternative Two. Intake characteristics are described in detail in the subsections of Alternative Two and are not repeated here. The exception is the discussion surrounding the control valve (butterfly or Obermeyer) and the ability to modulate flows. In this Alternative Three, the control valves will enable BSB to balance flows between the intake structure and the boat/fish passage channel. All other benefits of this intake as outlined in the discussion of Alternative Two remain constant with Alternative Three.

Additionally, an alternate intake structure will be assessed in final design that is similar in nature to the one shown on Sheet No. 6, however it would have a set of screens mounted in a stacked fashion on a single wall rather than on opposing walls. The advantage of this alternate system maybe reduced construction costs and less structural requirements. This minor deviation in the

intake design will be determined during final design once the preferred alternative is chosen. This alternate intake design will still engage a flow chute with a control valve (butterfly or Obermeyer gate) on the downstream section to enable flow control as discussed previously.

Intake Hydraulics and Pool

Shown on Figure A3.1 in Appendix A is a rating curve showing a combination of instream flow, flow through the intake structure, and flow over the boat and fish passage structure.

As for the analysis for Alternative Two, the first analysis assumes unrestricted flow through the intake structure; i.e. the intake butterfly gate valve is assumed to be in the full open position or the Obermeyer gate is in the full down position. Figure A3.1 shows that at the design low flow event of 200 cfs, approximately 154 cfs will pass through the intake structure and 45.6 cfs will flow over the boat and fish passage channel at Elevation 5418.4. As flows increase, the maximum intake flow approaches about 400 cfs as elevation increases.

Assuming the flow through the intake structure is 50% restricted; i.e. the butterfly gate is ½ open or the Obermeyer gate is half inflated, Figure A3.1 shows the water surface pool is now 5419.4. Lastly, assuming fully restricted flow; i.e. the butterfly gate fully closed or the Obermeyer gate in fully inflated position, the water pool elevation is about 5420.4.

Operators will have control over the pool elevations at all instream flow values, but this control is probably most effective at very low flows in the river. For instance, for flows less than 200 cfs, operators could close the intake system butterfly valve completely to maintain the highest water pool possible and maximum flow through the boat and fish channel.

Given that the proposed dam configuration will result in an upstream water surface elevation of 5418.4 at 200 cfs at zero restricted flow through the intake structure and can be increased to 5420.4 at fully restricted flow, it is possible to maintain the existing available suction head on the existing pumps in the existing pump station. This alternative allows for a staged construction of the dam/intake now and a new pump station in the future given the current budget constraints. With an available water surface elevation of 5418.4 to 5420.4, the available suction head will be equal to or slightly better than the existing condition. This will allow the potential to construct the intake piping with a wye leg such that piping can be extended to and penetrate the east side of the existing pump station building and connect to the existing pump suction header. With the installed wye, BSB can continue with the future buildout of the new pump station and lower the pumps to improve performance and efficiency once funding is available.

System Hydraulics

Velocities

Table 5 shows anticipated velocities through select system components at various flow rates. The table shows that velocities will be low through the collection system, therefore total head loss from the structure water surface pool to the pump station will be minimized.

Table 5. Alternate Three Component Velocities

Flow Rate		Velocity (ft/sec)	
(cfs)	(gpm)	Screens	42 –in Pipe
2	898	0.1	0.2
5	2245	0.2	0.5
10	4490	0.4	1.0
15	6735	0.7	1.6
20	8980	0.9	2.1
22	9878	1.0	2.3

Materials of Construction

The boat bypass structure will consist of grouted rock, which will be composed of local quarried rock with grout placed in the rock voids. Typical grouted rock details are shown on Sheet No. D2 in Appendix B.

A significant portion of the new structure will be placed above the existing river substrate. The design concept will be to place large rock and grout with a low slump in this base zone. It will be referred to as “core rock”. The function of the core rock is to form an impermeable base upon which to build the remaining structure. It will also provide mass and irregular surfaces to lock the structure to the existing river base.

The rock will be 2 to 3 foot diameter rock with grout in the rock voids. It may be constructed with two types of grout (Type I – flowable grout for the structure core depending on the height of the structure, and Type II – lower slump grout for the outer layers).

Rock and grout provide an extremely durable material to withstand the hydraulic forces, erosion and scour potential and freeze thaw damage. Good construction techniques include building the structure in stages such that grout penetrates all voids. Good water control is also critical to avoid pockets of trapped water.

Conceptual drawings of the new pump house are shown on Sheet No.'s P1 through P4 in Appendix B.

Constructability

The expected construction sequence for the project would be as follows:

1. Install the new intake discharge line up and through the wye with isolation valves. One leg of the wye will be extended into the existing pump house and connected to the existing suction header, but with closed valves until operational. The other leg will be extended to the location of the new pump station in the future as funding for the construction of the new pump station becomes available.

2. Construct a temporary coffer dam around the proposed intake area that extends to the proposed dam site as far south as practical, allowing for demolition of the existing sedimentation basin and northern portions of the existing dam and raceway, construction of the new intake structure, connection to piping, and north part of the proposed dam. The existing upstream weir would be breached to provide water flow into the pier and BSB will continue to operate existing intake to collect raw water supply.

3. After completion of the intake and north dam, construct coffer dams or other temporary measures to redirect water to the north side of the site through the new intake system. The new intake system will be commissioned and flow will be provided to the pumps via the new intake piping system. The remaining sections of the pier, raceway and existing dam will be demolished and removed and the southern portion of the new dam will be constructed

Summary of Alternative Characteristics

Table 6 below shows a summary of items reviewed above. The table includes hydraulics, intake, maintenance and operational comments.

Table 6. Alternate Three Characteristics

Items	Assessment	Comments
Hydraulics		
Boatable Features	Yes	New boat passage, navigable at low flows.
Fish Passage	Yes	See test for supercritical velocity discussion.
Maximum Water Surface Increase From Existing (100-Year) (ft)	1.6	Section 33+53
Maximum Intake Velocity (ft/sec)		
Minimum Intake Velocity (ft/sec)		
Pool Elevation at 200 cfs (ft)	5420.4	Gate fully closed.
Floodplain - 100-Year		
Water Elevation at Pump House (ft)	5428.5	Section 33+73
Flooding Depth at Pump House (ft)	2	Pump House floor elevation = 5426.5
Maximum Velocity (100-year) (ft/sec)	15.8	
Maximum Velocity Section	3233	
Maintenance		
Reduced Frazzle Ice Issues	Yes	Screens are not exposed to air.
Ice Reduction	Yes	Water moving through intake.
Debris Handling	Yes	Debris boom will collect surface debris.
Sediment Flushing	Yes	Gate will allow for various flushing scenarios, stop gates used for dry cleaning.
Materials		
Dam or Embankment	Grouted Rock	
Other Issues		
Point of Diversion Change	No	Relatively same location.
New Dam/Boat Bypass Structure	Yes	
New Intake	Yes	
New Pump Station	Yes	

Alternative Four – New Rock Weir Dam with Upstream Submerged Intake

Goals

- Remove existing dam and features
- Replace the existing facility with a new dam and intake system
- Incorporate boat and fish passage
- Provide primary and secondary intake systems
- Make use of the natural pool upstream of the existing dam for location of a new intake
- Incorporate improved operations and safety features for staff
- Design for the maximum water right of 21.26 cfs (all subsequent alternatives)

Features

- Removed existing dam or stilling basin
- New rock weir dam structure with boat and fish passage channel and rest pools
- River intake screens placed in the natural pool
- Improved debris, ice and frazzle ice handling
- New pipe connection to existing pump house
- Use of existing pump system
- Removal of the existing dam section
- Boat and fish passage capability in the main stream
- New primary and emergency intake on the north bank
- New slotted screen on primary intake to block excessive sediment and debris
- Air backwash screen cleaning
- New pipe system to deliver raw water to the pump house
- Floating boom to redirect floating debris from the intake

Discussion

Alternate Four evolved from a close examination of an approximately 6 foot deep pool (measured from an extended existing dam crest to the pool bottom). It appears that this pool has formed naturally, and it is a favorite spot for local fishermen, indicating that it has been in place long enough to get a reputation. The river naturally narrows here, so we anticipate that previous extreme events created the depression. Furthermore, it does not appear to be aggrading.

The design concept is to construct new rock weir dam with a boat and fish passage channel near the current dam site to maintain a stable water surface. River Tee screens would be placed in the natural pool along with a secondary backup. River pipe would convey water from the screens to a proposed junction box, which conveys water to the existing pump station. River pipe can be moved in several directions yet still hold together to convey flow. Although it

is recognized that hydraulic forces may tend to exert forces resulting in movement of the pipe and the intake skids, the screens will be located upstream. As importantly, it is understood that a new dam structure will create an upstream water surface pool under all stream flow events, and therefore localizing the maximum stream velocities at the surface. This will minimize stresses imparted on the pipe, screen and skids located in the more calm water in the bottom of the pool. The drawings that show the concepts, profiles, and details are shown on Sheet No.'s 8, 9, 10 and S4.1 in Appendix B.

The point of diversion would be approximately 300 feet upstream from the current diversion point under existing conditions.

Alternative Four also includes a secondary intake structure located on the north bank approximately half way between the screened intakes and the new dam.. This secondary intake would include coarser screens or bar screens to allow for water delivery if there was a problem with the primary intake. It would be used for a short period of time to allow for repairs or maintenance of the primary intake. Both intakes would deliver raw water directly to the existing pump station with increased and sufficient head to resolve the existing pump cavitation concerns.

Hydraulic Performance

Main Channel

The HECRAS water surface profiles for Alternative Three are applicable to this Alternative Four because the boat bypass structure that controls the instream hydraulics is the same for both alternatives. Refer to the Alternative Three discussion regarding the proposed increase in water surface elevations between existing and proposed conditions. Also refer to the Alternative Three sections for a discussion regarding supercritical velocities within the boat bypass and fish passage structure.

Our analysis examined the instream velocities in the Big Hole River for Section 36+42, which is near the proposed intake screens. Average section velocities are 0.3, 5.2, and 7.5 ft/sec for the 200 cfs flow, the 2-year event, and the 100-year event respectively. Note that these are average stream velocities at this section, and that actual velocities will vary across the section due to surface irregularities. Typically, a stronger jet of water will be located just below the water surface near the center of the cross section. We believe that water will be moving slightly slower near the screen elevations where the screens are relatively close to the stream bottom, so the actual velocities at the screens will be less than the values shown above.

As shown on Sheet No. S4.1 in Appendix B, the screens will be mounted on a movable sled, custom fit to rest on the bottom or side of the natural pool bottom. Based upon our analysis and experience with similar installations, the pipe, screens and sleds will remain in place for events up to the 100-year event. During the 100-year event, some minor movement may occur, but the screens could function in a relocated position or moved back depending on the circumstances.

Discussion contained in Alternative Three regarding the boat and fish passage channel and anticipated flow and velocity profiles will be very similar for Alternative Four and are graphically represented in Figure 2. The details of this discussion are not repeated in the analysis of Alternative Four but are referenced for comparison.

It is also noted that discussion in Alternative Three regarding the 100-year flood plain limits is germane to Alternative Four as well given the dam footprint, crest profile and boat and fish passage channel are nearly identical. Again, upstream streambank stabilization is proposed along the north bank to protect the north abutment of the dam and this element would offer the increased benefit of flood protection to the existing pump house.

Intake Screens

Intake screens are shown on Sheet No. 9 and a profile of the main intake screen is shown on Sheet Nuo. 10 in Appendix B. Cut sheets for the screens are shown in the Appendix C. Typical practice in these conditions is to install the screens at least one half of the screen diameter above the river bottom. We propose to use two screens set at different elevations as shown on the drawings.

The screens are sized by determining the maximum flow rate desired, and then matching that rate to predetermined sizes set by the manufacturer. Typically the desired velocity through the screens is approximately 0.5 ft/sec..

Intake Hydraulics and Pool

As discussed above, the river screens will be located in a natural pool, and the water surface at the screens will be established by the bypass structure downstream and local hydraulic conditions.

Shown on Figure A4.1 in Appendix A is a rating curve showing a combination for this alternative. There are no gate settings for this alternative as the water surface is established by the boat bypass structure downstream.

Figure A4.1 in Appendix A shows that at the design low flow event of 200 cfs, the water elevation available to the existing pump system is 5420.4. As flows increase, the available suction head will increase according to the figure.

Note that the above calculations do not include the maximum pumping rate in the calculation. The maximum rate of 21.26 cfs will only slightly affect the pool elevation shown in the figure.

An item of concern is the long term reliability of the this pool and whether future river flow conditions may result in this pool filling up and reducing its effectiveness as a location for the intake screens. This concern is extremely difficult to assess its probability or impacts.

System Hydraulics

Velocities

Table 7 shows anticipated velocities through select system components at various flow rates. The table shows that velocities will be low through the collection system; therefore total head loss from the structure water surface pool to the pump station will be minimal.

Table 7. Alternative Four Velocity Values

Flow Rate		Velocity (ft/sec)		
(cfs)	(gpm)	Intake Screens	Junction Box	42 –in Pipe
2	898	0.1	0.1	0.2
5	2245	0.2	0.2	0.5
10	4490	0.4	0.4	1.0
15	6735	0.7	0.6	1.6
20	8980	0.9	0.8	2.1
22	9878	1.0	0.9	2.3

Materials of Construction

The boat bypass and fish passage structure will consist of grouted rock, and its lines and grades will nearly identical to the grades shown for Alternative Three. Please refer to that section for a discussion of its materials.

The screens shown on the drawings are sized according to manufacturer's product sheets provided by Hendrick Screen Company. The product sheets are shown in Appendix C.

Constructability

The expected construction sequence for the project would be as follows:

1. Install the intake discharge line into the existing pump house and make connections, but close valves until operational.

2. Install the screens and mounting sleds via a crane and/or barge system and connect to the new intake discharge line.
3. Construct a temporary coffer dam around the south portion of the existing dam up to the existing raceway and remove the south portion of the existing dam. Continue to draw water from the existing intake system via the upstream weir. Install rock and grouted rock for the dam and new bypass structure starting from the south and extend to the south edge of the existing raceway.

4. Construct a temporary coffer dam around the north part of the existing structure. Once coffer dam is in place and the ability to check the water surface elevation up to elevation 5418 is achieved, commission the new intake screen system. Once system is commissioned and operable, remove the sedimentation basin, pier, and raceway.

5. Construct the north portion of the dam structure and connect to the south dam half and boat/fish passage channel.

Summary of Alternative Characteristics

Table 8 below shows a summary of items reviewed above. The table includes hydraulics, intake, maintenance and operational comments.

Table 8. Alternative Four Characteristics

Items	Assessment	Comments
Hydraulics		
Boatable Features	Yes	New boat passage, navigable at low flows.
Fish Passage	Yes	See test for supercritical velocity discussion.
Maximum Water Surface Increase From Existing (100-Year) (ft)	1.6	Section 33+53
Maximum Intake Velocity (ft/sec)	N/A	
Minimum Intake Velocity (ft/sec)	N/A	
Pool Elevation at 200 cfs (ft)	5420.4	Gate fully closed.
Floodplain - 100-Year		
Water Elevation at Pump House (ft)	5428.5	Section 3373
Flooding Depth at Pump House (ft)	2	Pump House floor elevation = 5426.5
Maximum Velocity (100-year) (ft/sec)	15.8	
Maximum Velocity Section	3233	
Maintenance		
Reduced Frazzle Ice Issues	Yes	Screens are not exposed to air.
Ice Reduction	Yes	
Debris Handling	Yes	
Sediment Flushing	Yes	
Materials		
Dam or Embankment	Grouted Rock	
Other Issues		
Point of Diversion Change	Yes	Approximately 300 feet upstream.
New Dam/Boat Bypass Structure	Yes	
New Intake	Yes	River screens at natural pool.
New Pump Station	No	

Alternative Five – New Upstream Rock Weir Dam with New Intake

Goals

- Remove existing dam and features
- Incorporate boat and fish passage
- Provide primary and secondary intake systems
- Move the intake facilities upstream to take advantage of higher elevations
- Incorporate improved operations and safety features for staff
- Design for the maximum water right of 21.26 cfs (all subsequent alternatives)

Features

- Removed existing dam or stilling basin
- New rock weir dam structure with boat and fish passage channel and rest pools
- Improved debris, ice and frazzle ice handling
- New pipe connection to existing pump house
- Use of existing pump system
- New primary and secondary intakes at higher elevations than the existing facility
- Improved debris, ice and frazzle ice handling
- New primary and emergency intake on the north bank
- New slotted screen on primary intake to block excessive sediment and debris
- Air backwash screen cleaning
- Floating boom to redirect floating debris from the intake

Discussion

Sheet No. 11 in Appendix B shows the components of Alternative Five. The primary components are the new dam and boat/fish bypass structure and primary and secondary intake structure. The point of diversion for this alternative is approximately 450 feet upstream of the existing location. The plan calls for approximately 500 feet of 42 inch DIP to deliver raw water to the existing pump station.

Alternative Five includes primary and secondary intake systems. The primary intake would include screens to keep most sediment and fines in the main channel. The secondary intake would include coarser screens or bar screens to allow for water delivery if there was a problem with the primary intake. It would be used for a short period of time to allow for repairs or maintenance of the primary intake. The raw water conveyance system would deliver water directly to the existing pump station.

The water surface would be set by the new boat and fish passage structure that includes a notched rock “spillway” replacing the function of the existing dam but allowing boat and fish passage. The profile of the new drop structure includes gradual steps to make up elevation

down the rock drop face. The shape and elevations drops are optimized to provide the desired upstream water surface and enable boat and fish passage.

The design has other benefits, such as allowing floatable objects and sediment to pass through the main channel relatively uninhibited. This will allow for increased intake efficiency and less maintenance concerns.

Hydraulic Performance

Dam and Instream Conditions

The HECRAS analysis for this Alternative Five is shown in Appendix D. A comparison of proposed and existing water surface elevations and velocities is shown on Sheet Number 11. As shown in Table 9 below, upstream of the new dam crest, the proposed water surface elevations range from 0.5 feet to 2.2 feet higher than existing conditions for the events listed in the table. At the upstream study limit for this project (near Section 44+39) those differences are negligible as shown in the table.

Table 9. Alternative Five Hydraulics Comparison

Cross Section Location	Difference In Water Surface (ft)		
	200 cfs	2-Year 7,239 cfs	100-Year 16,712 cfs
35+18	2.2	0.6	0.5
44+39	0.1	0.2	0.2

Velocities for this alternative under low flow and flood events are similar, with the exception of velocities of at least 15 ft/sec within the grouted rock structure pools at the 100-year flows.

The velocities shown on Sheet No. 11 in Appendix B are calculated using the HECRAS normal depth subcritical solutions. This solution does not allow the water surface to cross below critical depth, and therefore the solution does not indicate velocities that could exceed critical velocity. This type of solution is used to establish floodplain elevations and delineations because it shows the most conservative or highest water surface.

It is noted that with the relocation of the new dam and intake upstream and the removal of the existing structures downstream, the revised 100-year flood plain limits will no longer inundate the existing pump station as currently exists as a result of the existing structure.

For cases where actual velocities and depths are required, HECRAS provides a supercritical profile alternative and a combination of supercritical and subcritical profiles called a mixed flow

alternative. We used this alternative to more closely model actual velocities on the boat bypass chutes. The analysis included using additional cross sections on the drop faces and pools that are not shown on Sheet No. 11 in Appendix B.

Figure 3 shows the resulting velocities using a mixed flow calculation at five key sections on the boat bypass structure. The sections are:

1. Section 36+44, at the lowest pool – Orange line
2. Section 36+75, at the lower drop face – Green line
3. Section 36+99, at the lower crest – Purple line
4. Section 37+41, upper drop pool – Blue line
5. Section 37+59, at the upper drop crest – Red line

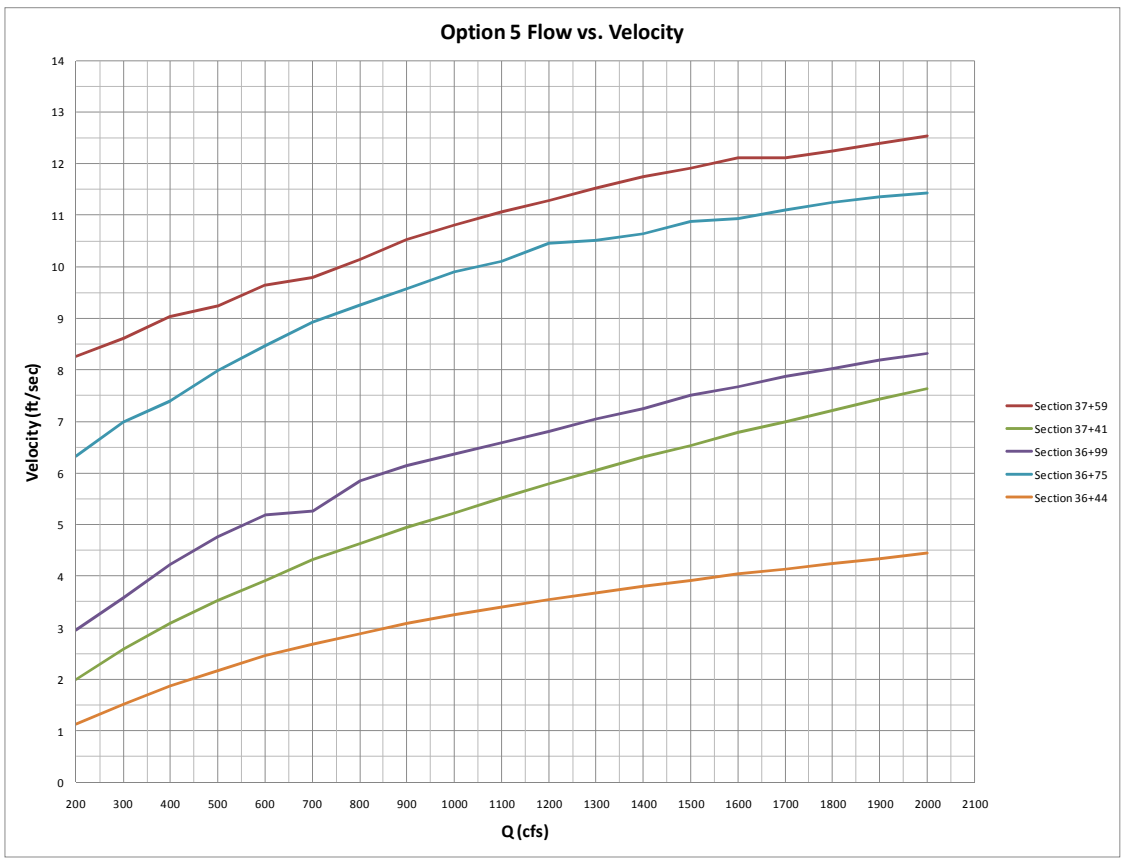


Figure 3. Velocity characteristics at the Alternative Five Boat and Fish Passage Structure

Figure 3 shows that the highest velocity expected for the range of flows analyzed is about 12.5 ft/sec at the upper drop crest at river flow of 2,000 cfs.

As noted in the discussion of Alternative Three, it is understood that “ideal” fish passage occurs when velocities remain below 6 feet per second. As can be seen in Figure 2, these velocities

are easily achieved over the range of flows analyzed with exceptions of the crest of the upper drop, the upper drop pool and the crest of the lower drop. Continued evolution of the design may result in a wider opening in the boat and fish channel to reduce the velocities in these sections further should this option be selected as the Preferred Alternative. With a wider opening, the cross sectional area will be increased resulting in a lower velocity for the same flow rate. It also bears noting that these velocities are represented at a single cross section and are not representative of velocities along the entire flow path.

Intake Structure

The intake site plan is shown on Sheet No. 12, and preliminary structure details are shown on Sheet Numbers S1 and S2 in Appendix B.

Referring to the site plan, the proposed intake structure will be located at a bend in the river at about Station 37+50. Raw water will be intercepted through screens. Approximately 500 feet of 42- inch pipe will convey flow from the transition structure to the west wall of the existing pump station.

Note that the intake structure has the same horizontal dimensions as the structure shown for Alternative Two. Intake characteristics are described in detail in the subsections of Alternative Two and are not repeated here. The exception is the discussion surrounding the control valve (butterfly or Obermeyer) and the ability to modulate flows. In this Alternative Five, the control valves will enable BSB to balance flows between the intake structure and the boat/fish passage channel. All other benefits of this intake as outlined in the discussion of Alternative Two remain constant with Alternative Five.

Intake Hydraulics and Pool

Shown on Figure A5.1 in Appendix A is a rating curve showing a combination of instream flow, flow through the intake structure, and flow over the boat and fish passage structure. As for the analysis for Alternative Two, the first analysis assumes unrestricted flow through the intake structure; i.e. the intake butterfly gate valve is assumed to be in the full open position or the Obermeyer gate is in the full down position. Figure A5.1 in Appendix A shows that at the design low flow event of 200 cfs, approximately 143 cfs will pass through the intake structure and 57 cfs will flow over the boat bypass at Elevation 5419.6. As flows increase, the maximum intake flow approaches about 400 cfs as elevation increases.

Assuming the flow through the intake structure is 50% restricted; i.e. the butterfly gate is ½ open or the Obermeyer gate is half inflated, Figure A5.2 in Appendix A shows the water surface pool is now 5420.5.

Lastly, assuming fully restricted flow; i.e. the butterfly gate fully closed or the Obermeyer gate in fully inflated position, the water pool elevation is about 5421.4.

Operators will have control over the pool elevations at all instream flow values, but this control is probably most effective at very low flows in the river. For instance, for flows less than 200 cfs, operators could close the intake system butterfly valve completely to maintain the highest water pool possible and maximum flow through the boat and fish channel.

System Hydraulics

Velocities

Table 10 shows anticipated velocities through select system components at various flow rates. The table shows that velocities will be low through the collection system, therefore total head loss from the structure water surface pool to the pump station will be low.

Table 10. Velocities through Alternative Five intake structure.

Flow Rate		Velocity (ft/sec)	
(cfs)	(gpm)	Screens	42 –in Pipe
2	898	0.1	0.2
5	2245	0.2	0.5
10	4490	0.4	1.0
15	6735	0.7	1.6
20	8980	0.9	2.1
22	9878	1.0	2.3

Materials of Construction

The boat bypass structure will consist of grouted rock, which will be composed of local quarried rock with grout placed in the rock voids. Typical grouted rock details are shown on Sheet Number D2 in Appendix B.

A significant portion of the new structure will be placed above the existing river substrate. The design concept will be to place large rock and grout with a low slump in this base zone. It will be referred to as “core rock”. The function of the core rock is to form an impermeable base upon which to build the remaining structure. It will also provide mass and irregular surfaces to lock the structure to the existing river base.

The rock will be 2 to 3 foot diameter rock with grout in the rock voids. It may be constructed with two types of grout (Type I – flowable grout for the structure core depending on the height of the structure, and Type II – lower slump grout for the outer layers).

Constructability

The expected construction sequence for the project would be as follows:

1. Install the intake discharge line into the existing pump house and make connections, but close valves until operational.

2. Construct a temporary coffer dam around the proposed intake area, diverting the flow to the south, allowing for construction of the intake, and north part of the proposed dam and boat/fish channel. Continue to operate existing intake to collect water supply.

3. After completion of the intake and north portion of the boat bypass structure, construct coffer dams or other temporary measures to divert water to the north side of the site and construct the southern portion of the new dam.

4. Commission the proposed intake.

5. Breach the existing dam and demolish the existing structure.

Summary of Alternative Characteristics

Table 11 below shows a summary of items reviewed above. The table includes hydraulics, intake, maintenance and operational comments.

Table 11. Alternative Five Characteristics

Items	Assessment	Comments
Hydraulics		
Boatable Features	Yes	New boat passage, navigable at low flows.
Fish Passage	Yes	See test for supercritical velocity discussion.
Maximum Water Surface Increase From Existing (100-Year) (ft)	0.7	Section 33+60
Maximum Intake Velocity (ft/sec)	N/A	
Minimum Intake Velocity (ft/sec)	N/A	
Pool Elevation at 200 cfs (ft)	5421.4	Gate fully closed.
Floodplain - 100-Year		
Water Elevation at Pump House (ft)	5425.8	Section 3353
Flooding Depth at Pump House (ft)	N/A	Pump House floor elevation = 5426.5
Maximum Velocity (100-year) (ft/sec)	15.7	
Maximum Velocity Section	3699	
Maintenance		
Reduced Frazzle Ice Issues	Yes	Screens are not exposed to air.
Ice Reduction	Yes	Water moving through intake.
Debris Handling	Yes	Debris boom will collect surface debris.
Sediment Flushing	Yes	Gate will allow for various flushing scenarios, stop gates used for dry cleaning.
Materials		
Dam or Embankment	Grouted Rock	
Other Issues		
Point of Diversion Change	Yes	Approximately 450 feet upstream.
New Dam/Boat Bypass Structure	Yes	
New Intake	Yes	
New Pump Station	No	

Appendix A
Rating Curves

FIGURE A2.1
Option 2 Rating Curve 6' x 6' Gate Full Open

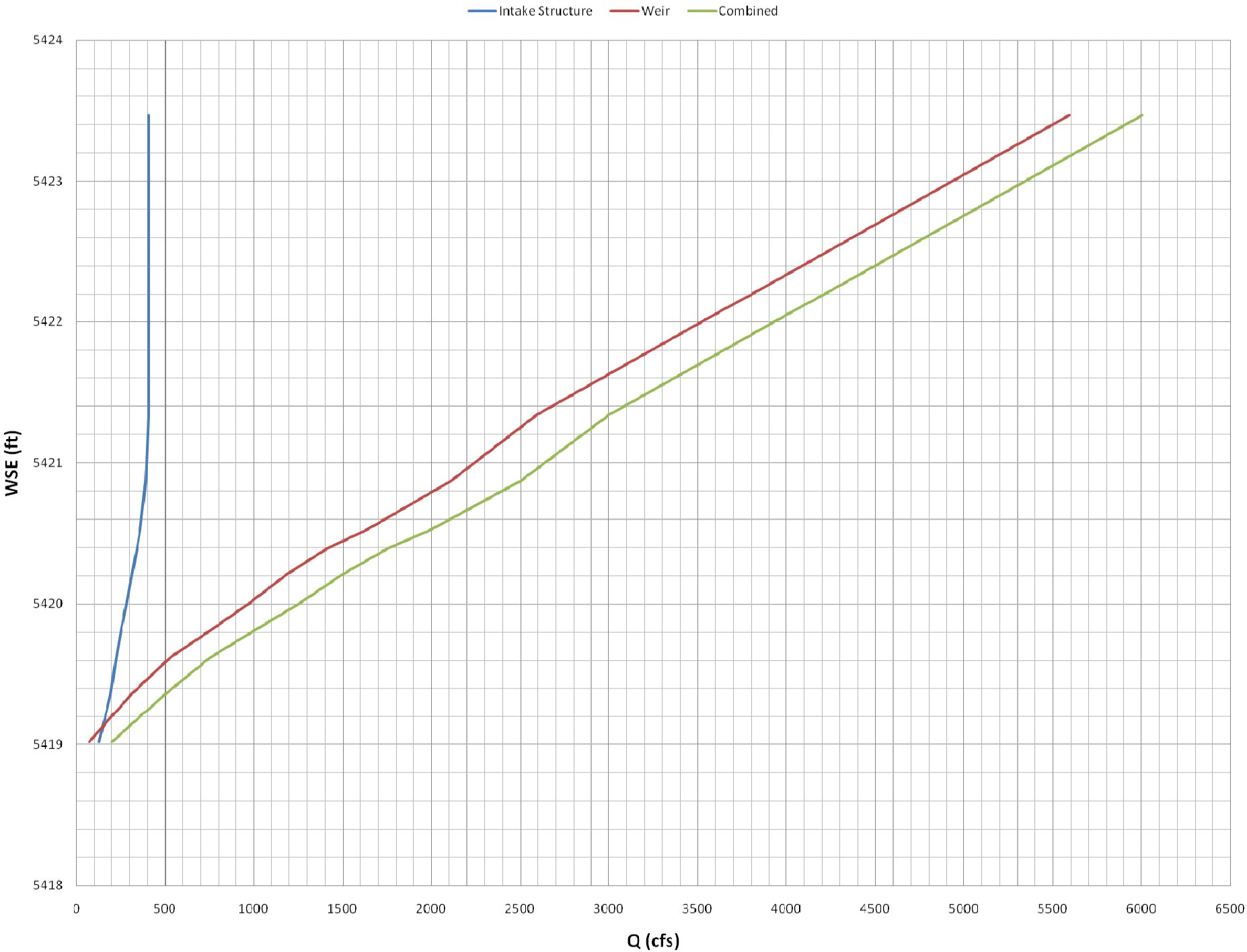


FIGURE A2.2
Option 2 Rating Curve 6' x 6' Gate Half Open

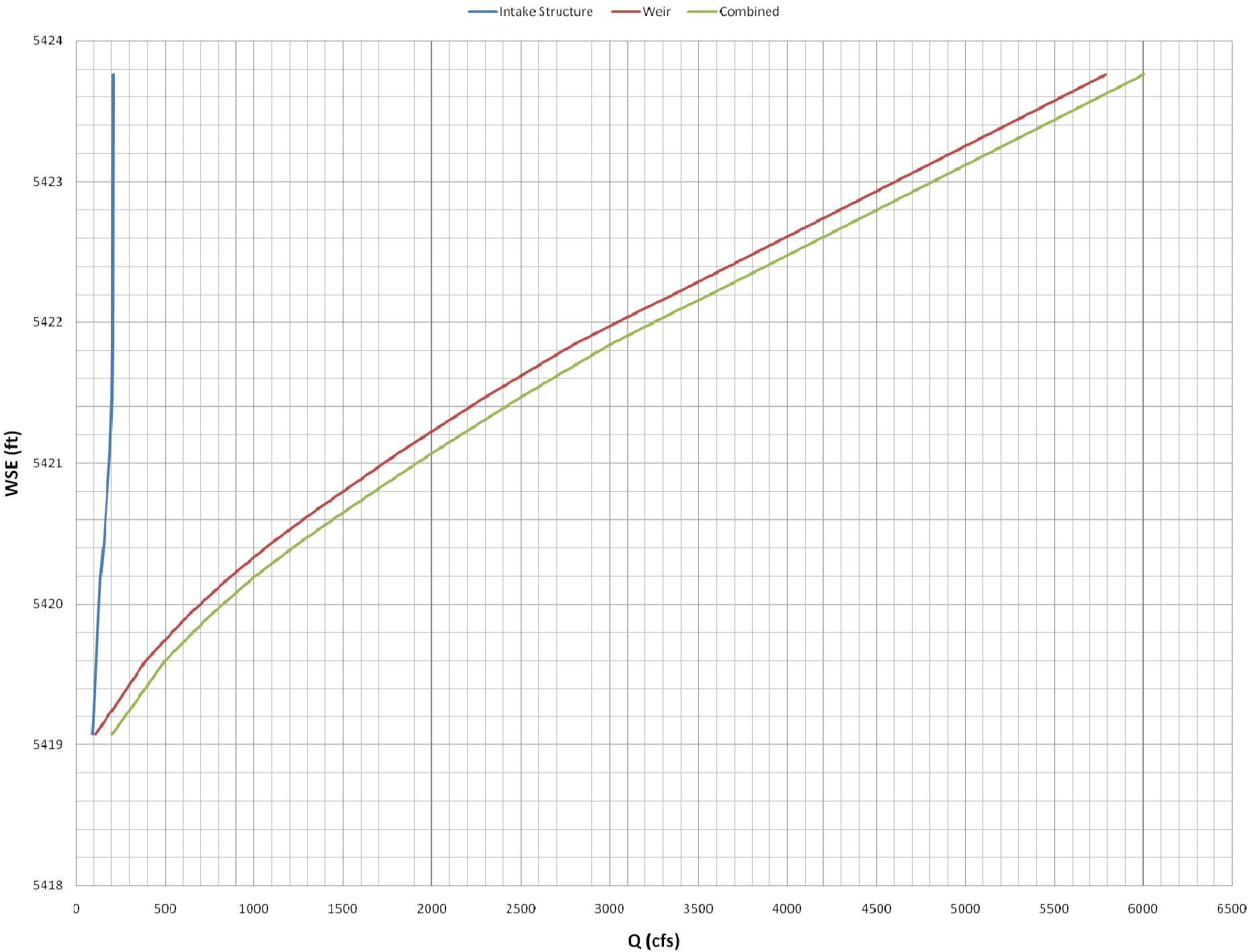


FIGURE A3.1
Option 3 Rating Curve 6' x 6' Gate Full Open

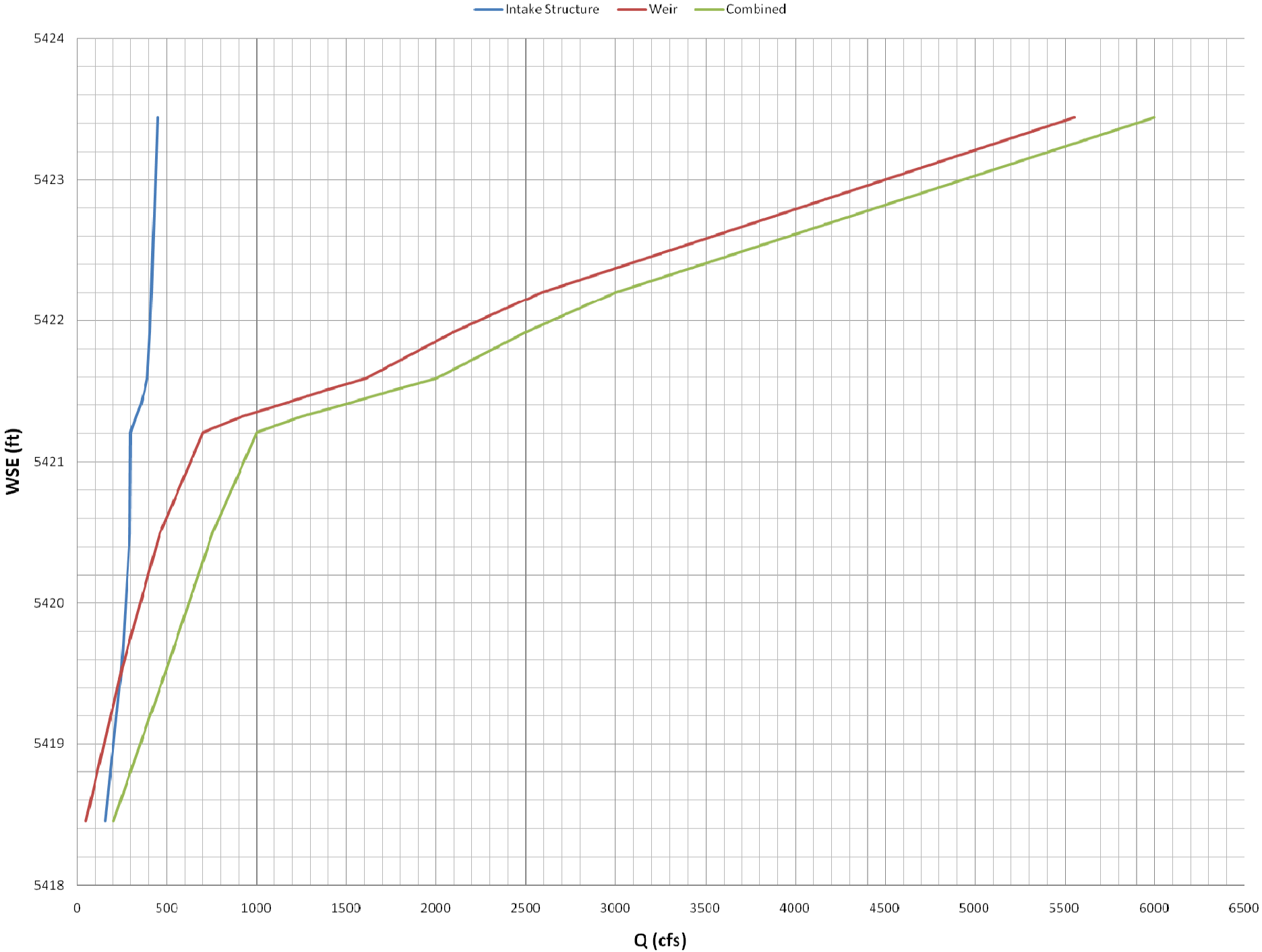


FIGURE A3.2
Option 3 Rating Curve 6' x 6' Gate Half Open

FIGURE A5.1
Option 5 Rating Curve 6' x 6' Gate Full Open

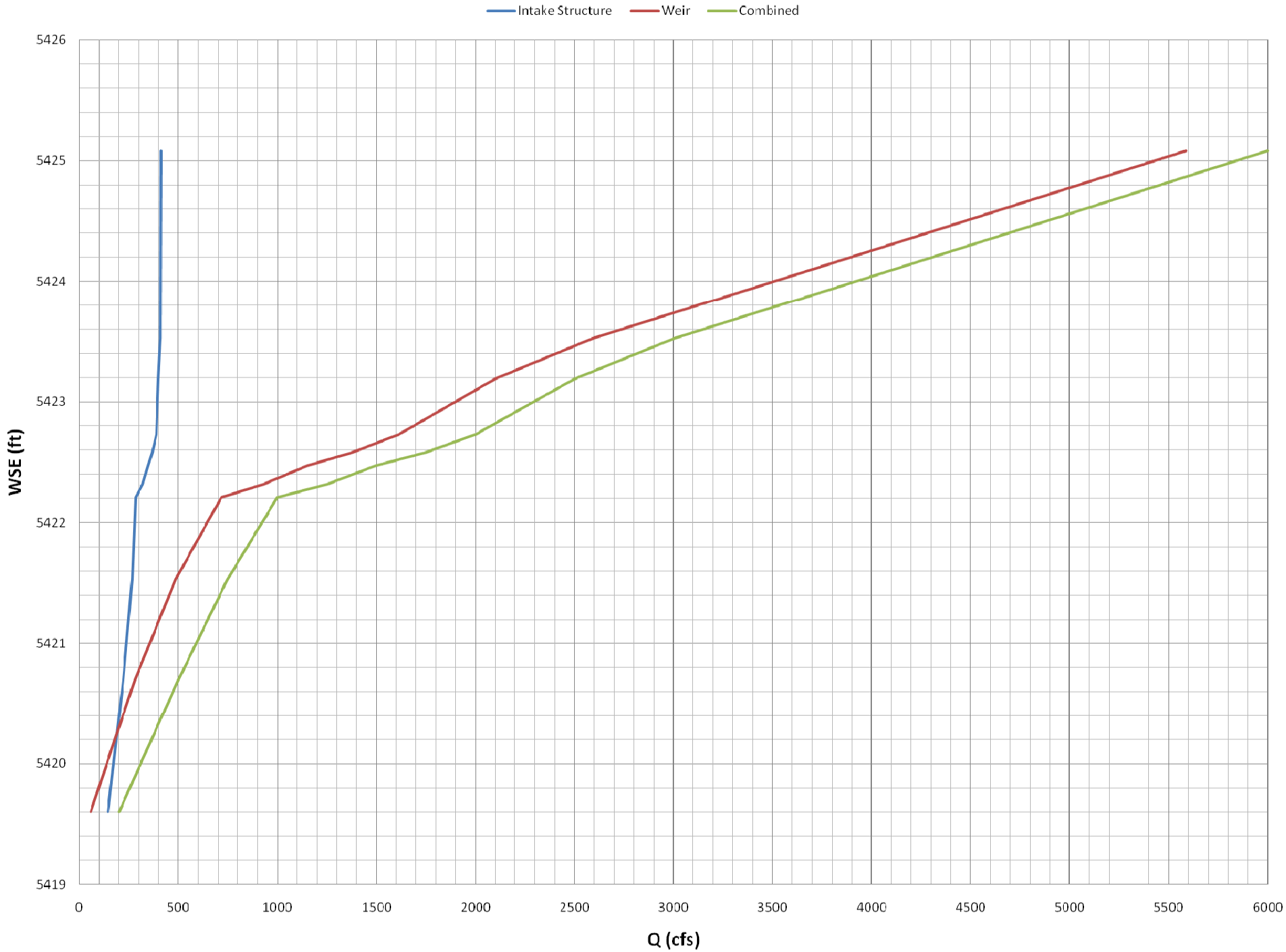
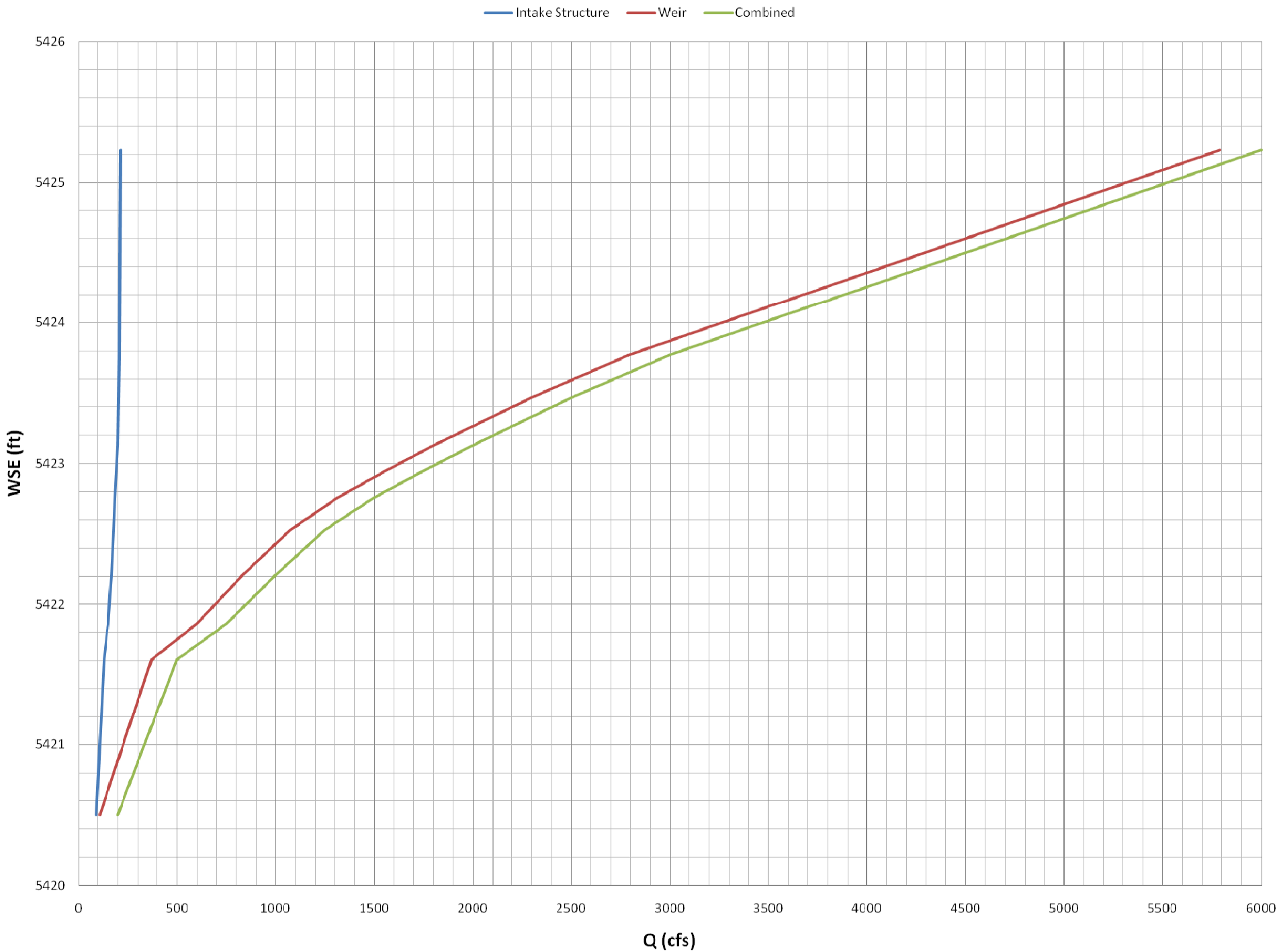


FIGURE A5.2
Option 5 Rating Curve 6' x 6' Gate Half Open



Appendix B
Drawings

Appendix B

The following drawings are included in this section for reference. Note that the original drawing scales were prepared for 22 x 34 format sheets, scalable to 11 x 17 sheets by half. Please note that these 8.5 x 11 sheets are not scalable.

	Sheet Number	Title
1	1	Alternative 1 Plan and Profile
2	2	Alternative 2 Plan and Profile
3	3	Alternative 2 Site Plan
4	4	Alternative 2 Profile and Section
5	5	Alternative 3 Plan and Profile
6	6	Alternative 3 Site Plan
7	7	Alternative 3 Profile and Section
8	8	Alternative 4 Plan and Profile
9	9	Alternative 4 Site Plan
10	10	Alternative 4 Profiles
11	S4.1	Alternative 4 Screen Details
12	11	Alternative 5 Plan and Profile
13	12	Alternative 5 Site Plan
14	13	Alternative 5 Profile and Section
15	D1	Intake Structure Details
16	D2	Rock and Grouted Boulder Details
17	S1	Intake Details
18	S2	Intake Details
19	S3	Intake Details
20	P1	Pump Station Plan View
21	P2	Pump Station Profile View
22	P3	Pump Station Details
24	P4	Pump Station Details

Appendix C
Manufacturer's Material

9856
1,57

Intake Screen Selection

1. Determine how much water in **gallons-per minute** your system must produce. This will tell you the diameter of the screen.
2. Make adjustments in screen size according to the slot opening size you'll be using. The smaller the slot, the bigger the screen will have to be. We've developed "Adjustment Factors" for selected slot sizes to take this effect into account. (See Chart A)
3. Multiply your system's capacity in gallons-per-minute by the Adjustment Factor for the slot size you've chosen. This will give you a number we call the "Selector Guide."

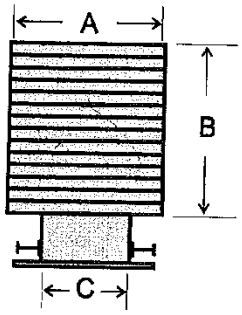
Selector Guide No. = GPM X Adjustment Factor

4. Now see Chart B (Screen Selection). Find the model with a Selector Guide Number closest to -but not lower than -the one you've just computed. This is the model you need based on your chosen capacity and slot size. (Note that you can choose either a single drum-type screen or a two-screen Tee arrangement.)

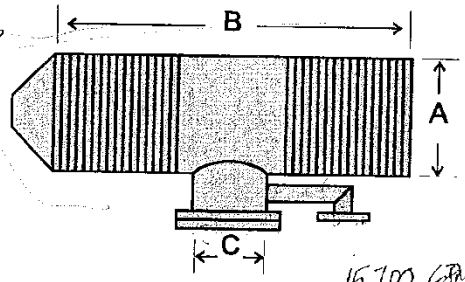
CHART A - ADJUSTMENT FACTORS

Slot	Adjustment Factor	Slot	Adjustment Factor	Slot	Adjustment Factor
.020	4.17	.090	1.64	.250	1.40
.030	3.09	.100	1.57	.280	1.34
.040	2.54	.130	1.44	.300	1.31
.050	2.21	.150	1.36	.350	1.26
.060	2.00	.180	1.29	.400	1.21
.070	1.84	.200	1.51	.450	1.19
.080	1.73	.230	1.44		

11,300



224 GPM
448 gpm/cts
22
896
896
9856



GPM

15,700 GPM

CHART B - SCREEN SELECTION

DRUM SCREEN ASSEMBLIES

Selector Guide No.	A (Inches)	B (Inches)	C (Inches)	Min. Depth D (Feet)	Air B/W Inlet Diam.
450-S	12	14	6	2.00	1.0
800-S	16	18	8	2.67	1.5
1010-S	18	20	10	3.00	1.5
1380-S	21	23	12	3.50	1.5
1800-S	24	26	12	4.00	2.0
2290-S	27	29	14	4.50	2.0
2820-S	30	32	16	5.00	2.0
3420-S	33	35	18	5.50	3.0
4070-S	36	38	18	6.00	3.0
5540-S	42	48	24	7.00	4.0
7230-S	48	55	24	8.00	4.0
9160-S	54	62	30	9.00	6.0
11300-S	60	68	30	10.00	6.0
13680-S	66	76	36	11.00	-
16280-S	72	82	36	12.00	-
19110-S	78	89	42	13.00	-
22160-S	84	96	42	14.00	-

TEE-SCREEN ASSEMBLIES

Selector Guide No.	A (Inches)	B (Inches)	C (Inches)	Min. Depth D (Feet)	Air B/W Inlet Diam.
900-T	12	39	10	2.00	1.0
1600-T	16	51	12	2.67	1.5
2030-T	18	57	14	3.00	1.5
2770-T	21	66	16	3.50	2.0
3610-T	24	75	18	4.00	2.0
4580-T	27	84	20	4.50	2.0
5650-T	30	93	24	5.00	3.0
6840-T	33	102	24	5.50	3.0
8140-T	36	111	30	6.00	3.0
11080-T	42	139	30	7.00	4.0
14470-T	48	159	36	8.00	4.0
18320-T	54	179	36	9.00	6.0
22610-T	60	199	42	10.00	6.0
27360-T	66	218	48	11.00	-
32570-T	72	237	48	12.00	-
38220-T	78	256	54	13.00	-
44330-T	84	275	60	14.00	-

1 @

HENDRICK SCREEN CO. P.O. BOX 22075 OWENSBORO, KY 42304 PHONE (270) 685-5138 FAX (270) 685-1729
website: http://www.hendrickscreenco.com email: sales @ hendrickscreenco.com

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3 @ 5650 = 16950

Appendix D
HECRAS Output

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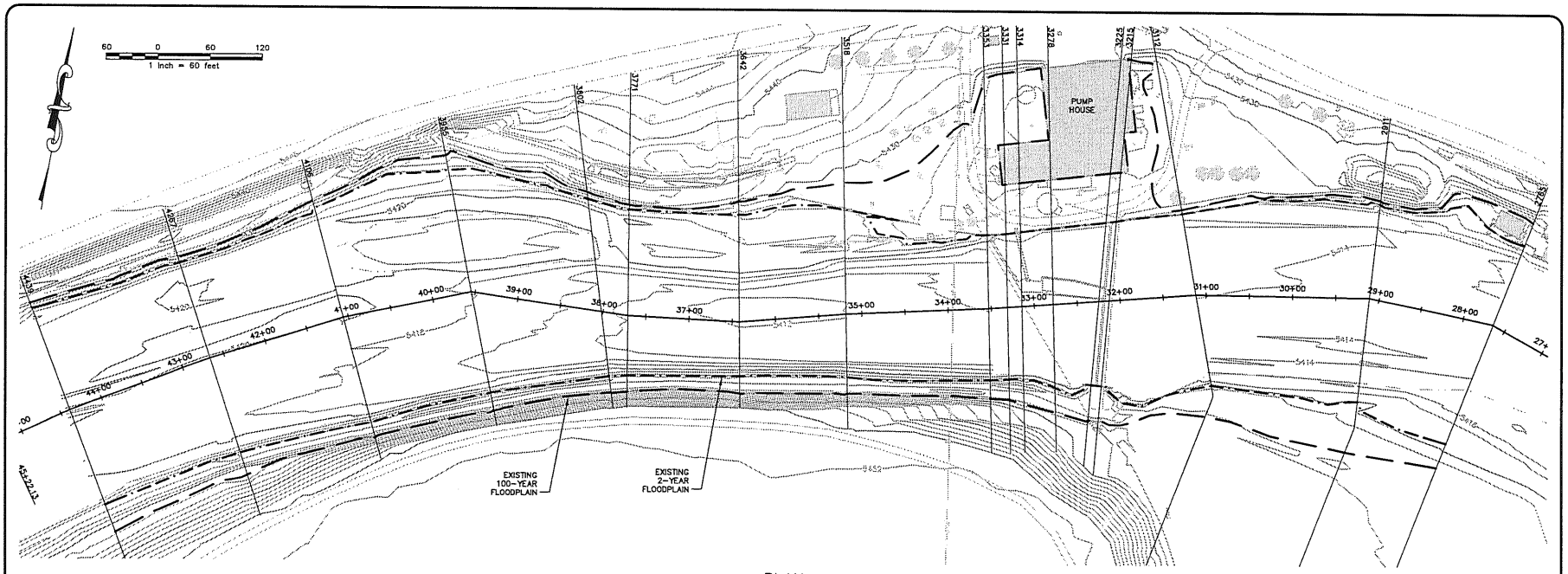
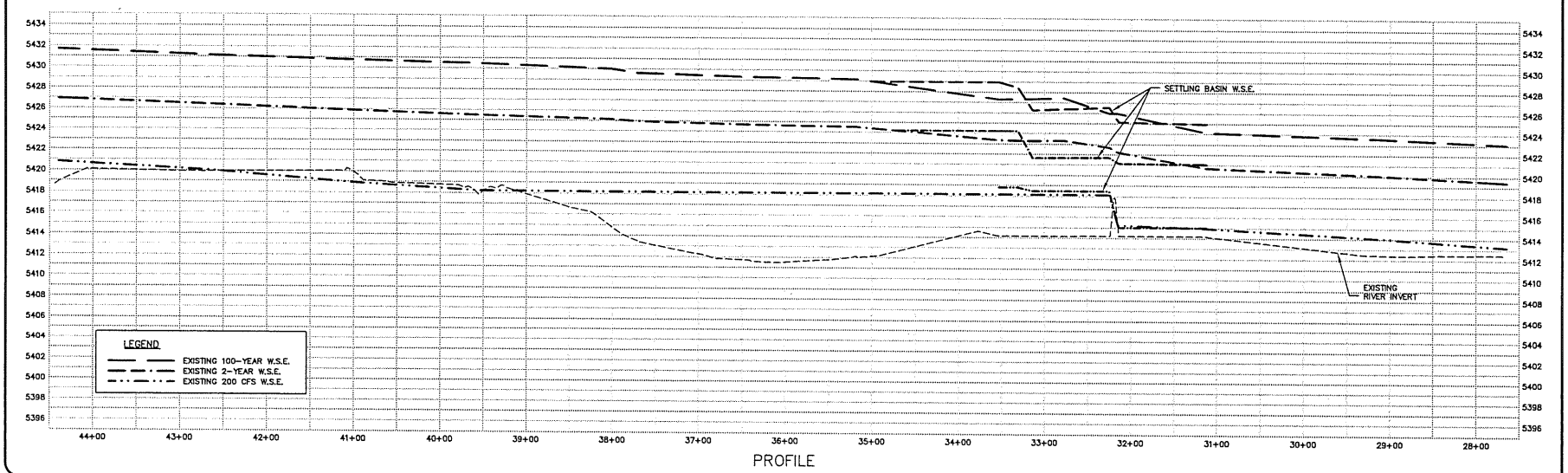


PLAN



PROFILE

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No.	Revision	By	Date

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

BIG HOLE RIVER DIVERSION DAM
REPLACEMENT PROJECT

OPTION 1 PLAN AND PROFILE

WHPacific
1326 W Park Ave, Ste 200
Helena, MT 59601
406-443-5150 (P) 406-443-5151 (F)
www.whpacific.com

DOWL HKM
130 N. Main St.
Suite 100
PO Box 3588
Butte, MT 59701-2839
406-723-5431 (P)
406-723-8328 (Fax)
dowlhkm.com

Sheet No.
1

Big Hole River
Existing Flows (From Dowl HKM)
Steady Flow Data - Translated-Flows-Split-Flow

	River	Reach	RS	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	200-YR	500-YR	8/17/2009	Low Flow
1	Big Hole	Upstream Chl	-100	7239	9411	11029	13308	15055	16712	18305	20431	657	200
2	Big Hole	Settling Basin	-1187.02	1449	2134	2641	3381	3956	4507	5040	5756	0.01	0.01
3	Big Hole	Settling Basin	-1208	1449	2134	2641	3381	3956	4507	5040	5756	0.01	0.01
4	Big Hole	Diversion	-1187.02	5760	7306	8388	9927	11098	12205	13265	14675	657	200
5	Big Hole	Diversion	-1224.78	5760	7306	8388	9927	11098	12205	13265	14675	657	200
6	Big Hole	Diversion	-1314.25	5760	7306	8388	9927	11098	12205	13265	14675	657	200
7	Big Hole	Downstream Chl	-1627.9	7239	9411	11029	13308	15055	16712	18305	20431	657	200

Existing

Project: Big-Hole
Plan: Plan 03 (.p03)

Geometry: Big Hole-Existing-Split-Flow (.g03)
Flow: Translated-Flows-Split-Flow (.f01)

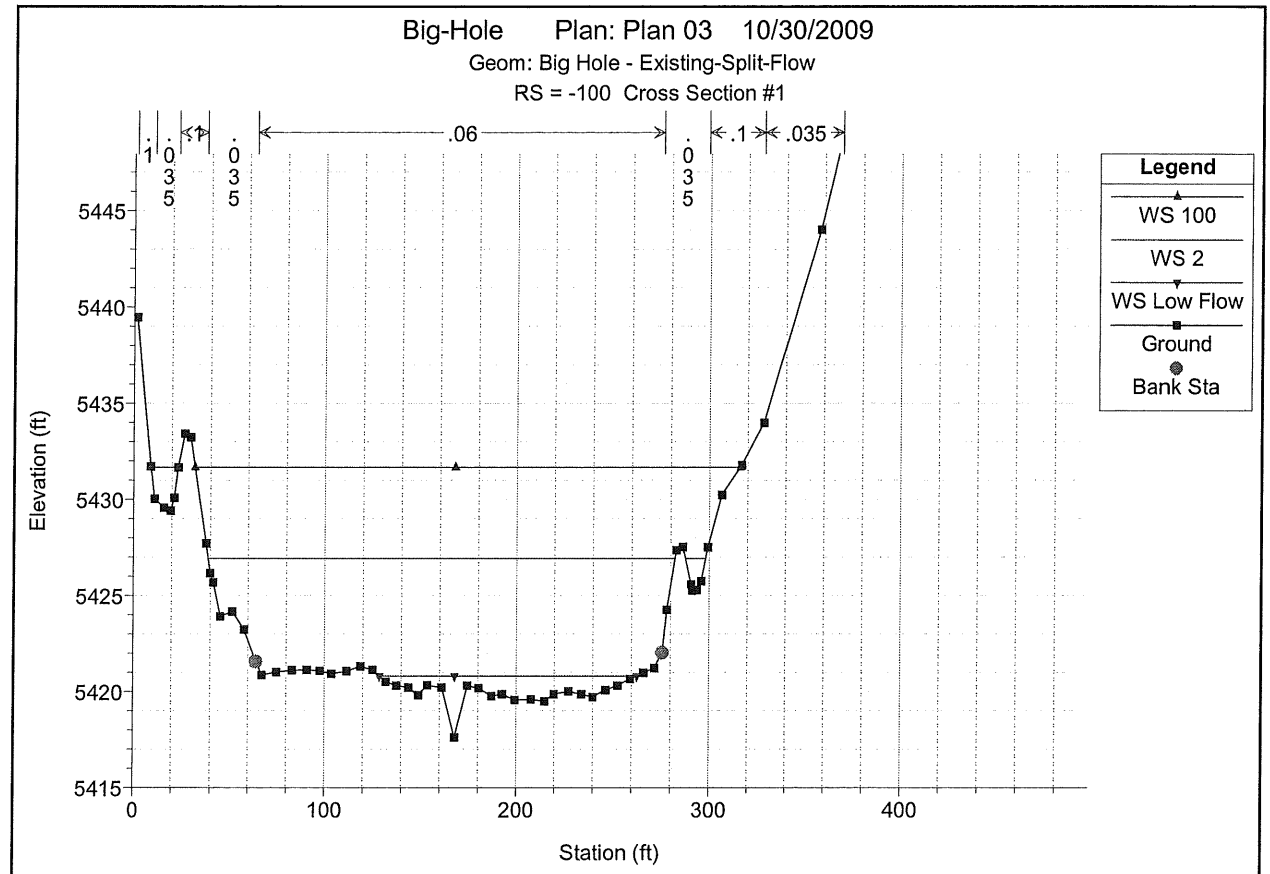
HEC-RAS Plan: n-0.06

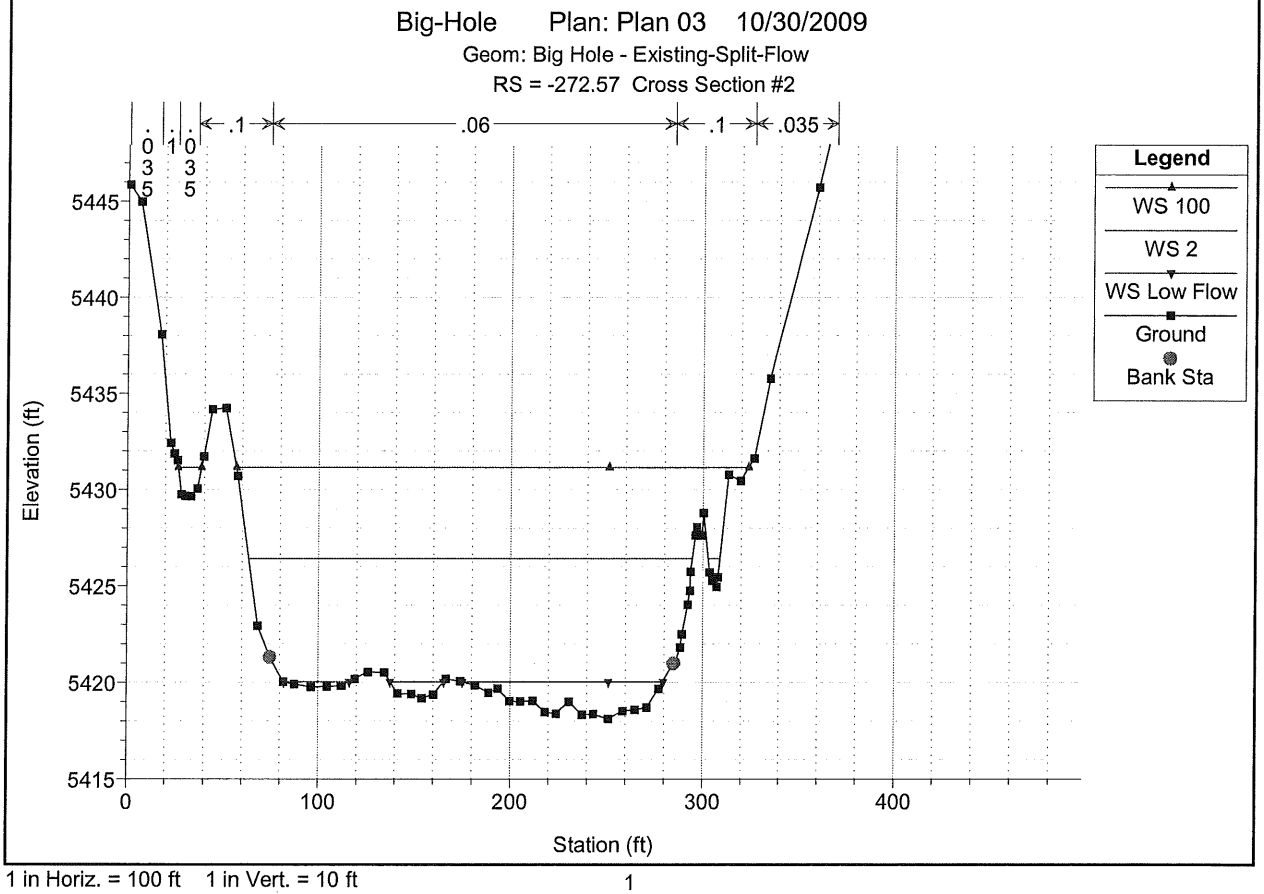
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	-100	7239.00	5417.62	5426.93	5423.65	5427.30	0.003172	4.88	1494.64	253.92	0.34
Upstream Chl	-100	16712.00	5417.62	5431.67	5426.09	5432.23	0.002295	5.96	2792.82	298.75	0.31
Upstream Chl	-100	200.00	5417.62	5420.82	5420.22	5420.86	0.005147	1.65	121.13	134.06	0.31
Upstream Chl	-272.57	7239.00	5418.11	5426.41		5426.77	0.002907	4.86	1539.57	236.93	0.32
Upstream Chl	-272.57	16712.00	5418.11	5431.14		5431.79	0.002663	6.57	2735.57	279.03	0.34
Upstream Chl	-272.57	200.00	5418.11	5420.04		5420.07	0.004110	1.42	140.93	166.38	0.27
Upstream Chl	-433.34	7239.00	5417.51	5425.91		5426.27	0.003326	4.87	1534.04	264.00	0.34
Upstream Chl	-433.34	16712.00	5417.51	5430.78		5431.36	0.002511	6.19	2886.67	292.50	0.33
Upstream Chl	-433.34	200.00	5417.51	5418.95		5419.04	0.011334	2.47	81.05	89.29	0.46
Upstream Chl	-584.47	7239.00	5415.73	5425.49		5425.85	0.002394	4.81	1577.04	270.15	0.33
Upstream Chl	-584.47	16712.00	5415.73	5430.48		5431.03	0.001771	6.10	3034.72	315.64	0.32
Upstream Chl	-584.47	200.00	5415.73	5418.21		5418.24	0.002990	1.45	137.63	123.37	0.24
Upstream Chl	-737.06	7239.00	5413.99	5425.15		5425.50	0.002198	4.77	1583.50	206.68	0.29
Upstream Chl	-737.06	16712.00	5413.99	5430.02		5430.70	0.002588	6.75	2663.24	237.82	0.33
Upstream Chl	-737.06	200.00	5413.99	5418.17		5418.17	0.000138	0.59	341.47	118.53	0.06
Upstream Chl	-768.17	7239.00	5413.06	5424.96		5425.41	0.002283	5.55	1499.83	197.34	0.30
Upstream Chl	-768.17	16712.00	5413.06	5429.64		5430.58	0.003035	8.22	2481.67	222.81	0.37
Upstream Chl	-768.17	200.00	5413.06	5418.17		5418.17	0.000067	0.48	417.91	113.64	0.04
Upstream Chl	-897.23	7239.00	5411.07	5424.69		5425.14	0.001948	5.50	1449.45	188.99	0.29
Upstream Chl	-897.23	16712.00	5411.07	5429.34		5430.19	0.002533	7.86	2419.64	223.43	0.34
Upstream Chl	-897.23	200.00	5411.07	5418.16		5418.17	0.000027	0.38	530.37	103.55	0.03
Upstream Chl	-1020.84	7239.00	5411.97	5424.54		5424.89	0.001568	4.84	1581.64	199.34	0.26
Upstream Chl	-1020.84	16712.00	5411.97	5429.17		5429.87	0.002014	6.91	2566.84	244.21	0.31
Upstream Chl	-1020.84	200.00	5411.97	5418.16		5418.16	0.000021	0.33	615.33	125.10	0.03
Settling Basin	-1187.02	1111.63	5413.00	5424.22		5424.32	0.001318	2.52	435.39	87.01	0.19
Settling Basin	-1187.02	4705.30	5413.00	5428.95		5429.12	0.001111	3.39	1423.17	269.53	0.19
Settling Basin	-1187.02	0.00	5413.00	5418.81		5418.81	0.000000	0.00	71.91	70.22	0.00
Settling Basin	-1208	1111.63	5412.86	5424.22	5416.68	5424.30	0.000034	2.27	498.19	69.02	0.13
Settling Basin	-1208	4705.30	5412.86	5428.46	5421.41	5429.01	0.000150	6.07	911.76	124.78	0.30
Settling Basin	-1208	0.00	5412.86	5418.81	5412.89	5418.81	0.000000	0.00	197.34	44.44	0.00
Settling Basin	-1209.65	Inl Struct									
Settling Basin	-1224.78	1111.63	5412.86	5421.65		5421.81	0.000099	3.20	347.02	54.80	0.22
Settling Basin	-1224.78	4705.30	5412.86	5426.26		5427.14	0.000303	7.61	645.20	87.53	0.41
Settling Basin	-1224.78	0.00	5412.86	5418.49		5418.49	0.000000	0.00	182.98	43.02	0.00
Settling Basin	-1261.12	1111.63	5412.86	5421.69		5421.77	0.000040	2.33	476.39	56.35	0.14
Settling Basin	-1261.12	4705.30	5412.86	5426.38		5427.01	0.000190	6.34	742.72	61.24	0.31
Settling Basin	-1261.12	0.00	5412.86	5418.49		5418.49	0.000000	0.00	297.90	53.03	0.00
Settling Basin	-1314.25	1111.63	5412.86	5421.71	5414.84	5421.76	0.000020	1.78	628.80	73.10	0.11
Settling Basin	-1314.25	4705.30	5412.86	5426.56	5418.04	5426.92	0.000086	4.81	999.90	128.48	0.23
Settling Basin	-1314.25	0.00	5412.86	5418.49	5412.88	5418.49	0.000000	0.00	394.52	70.31	0.00
Settling Basin	-1319.32	Inl Struct									
Settling Basin	-1325.49	1111.63	5414.19	5421.15		5421.24	0.000903	2.34	474.89	77.05	0.17
Settling Basin	-1325.49	4705.30	5414.19	5425.15		5425.71	0.003262	6.02	784.31	77.67	0.33
Settling Basin	-1325.49	0.00	5414.19	5415.09		5415.09	0.000000	0.00	16.92	52.14	0.00
Settling Basin	-1427.17	1111.63	5413.21	5421.09		5421.15	0.000573	1.89	589.43	94.24	0.13
Settling Basin	-1427.17	4705.30	5413.21	5424.98		5425.36	0.002159	4.94	963.08	100.97	0.27
Settling Basin	-1427.17	0.00	5413.21	5415.09		5415.09	0.000000	0.00	33.85	68.34	0.00
Diversion	-1187.02	6097.38	5413.00	5423.34		5424.31	0.005921	7.92	779.17	85.71	0.45
Diversion	-1187.02	12006.70	5413.00	5427.30		5429.12	0.007469	10.90	1154.95	103.08	0.52
Diversion	-1187.02	200.00	5413.00	5418.15		5418.15	0.000079	0.57	349.96	78.99	0.05
Diversion	-1224.78	6097.38	5413.00	5423.28		5423.98	0.004292	6.75	914.67	103.14	0.39
Diversion	-1224.78	12006.70	5413.00	5427.35		5428.60	0.005044	9.08	1377.21	124.59	0.44
Diversion	-1224.78	200.00	5413.00	5418.15		5418.15	0.000060	0.49	407.03	94.63	0.04

10/30/09

HEC-RAS Plan: n-0.06 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Diversion	-1225	Lat Struct									
Diversion	-1261.12	6097.38	5413.00	5423.33		5423.90	0.000205	6.19	1049.64	125.27	0.36
Diversion	-1261.12	12006.70	5413.00	5427.45		5428.46	0.000223	8.29	1623.88	151.99	0.40
Diversion	-1261.12	200.00	5413.00	5418.15		5418.15	0.000003	0.47	438.63	105.39	0.04
Diversion	-1314.25	6097.38	5413.00	5422.67	5419.94	5423.72	0.003026	5.38	972.05	115.00	0.32
Diversion	-1314.25	12006.70	5413.00	5425.99	5422.40	5428.10	0.004029	7.54	1356.02	119.50	0.38
Diversion	-1314.25	200.00	5413.00	5418.14	5413.98	5418.15	0.000037	0.38	456.13	112.27	0.03
Diversion	-1319.32	Inl Struct									
Diversion	-1324.49	6097.38	5413.21	5422.22		5422.94	0.005037	6.96	903.45	113.77	0.44
Diversion	-1324.49	12006.70	5413.21	5425.98		5427.29	0.005449	9.38	1334.51	116.97	0.48
Diversion	-1324.49	200.00	5413.21	5415.24		5415.28	0.002169	1.56	130.52	84.24	0.22
Diversion	-1427.17	6097.38	5413.21	5420.72		5422.02	0.011619	9.25	678.50	105.11	0.62
Diversion	-1427.17	12006.70	5413.21	5424.12		5426.25	0.011906	11.95	1079.00	143.36	0.65
Diversion	-1427.17	200.00	5413.21	5414.95		5415.00	0.003575	1.78	112.35	84.20	0.27
Downstream Chl	-1627.90	7239.00	5412.42	5420.06		5420.55	0.004374	5.65	1330.21	232.34	0.39
Downstream Chl	-1627.90	16712.00	5412.42	5423.61		5424.54	0.004842	7.97	2290.89	380.05	0.44
Downstream Chl	-1627.90	200.00	5412.42	5414.05		5414.11	0.008865	1.96	101.86	131.65	0.39
Downstream Chl	-1774.21	7239.00	5411.40	5419.47	5416.55	5419.94	0.003905	5.62	1327.89	244.82	0.38
Downstream Chl	-1774.21	16712.00	5411.40	5423.08	5419.21	5423.87	0.003906	7.43	2369.70	402.87	0.40
Downstream Chl	-1774.21	200.00	5411.40	5413.24	5412.59	5413.28	0.003905	1.53	130.34	131.67	0.27





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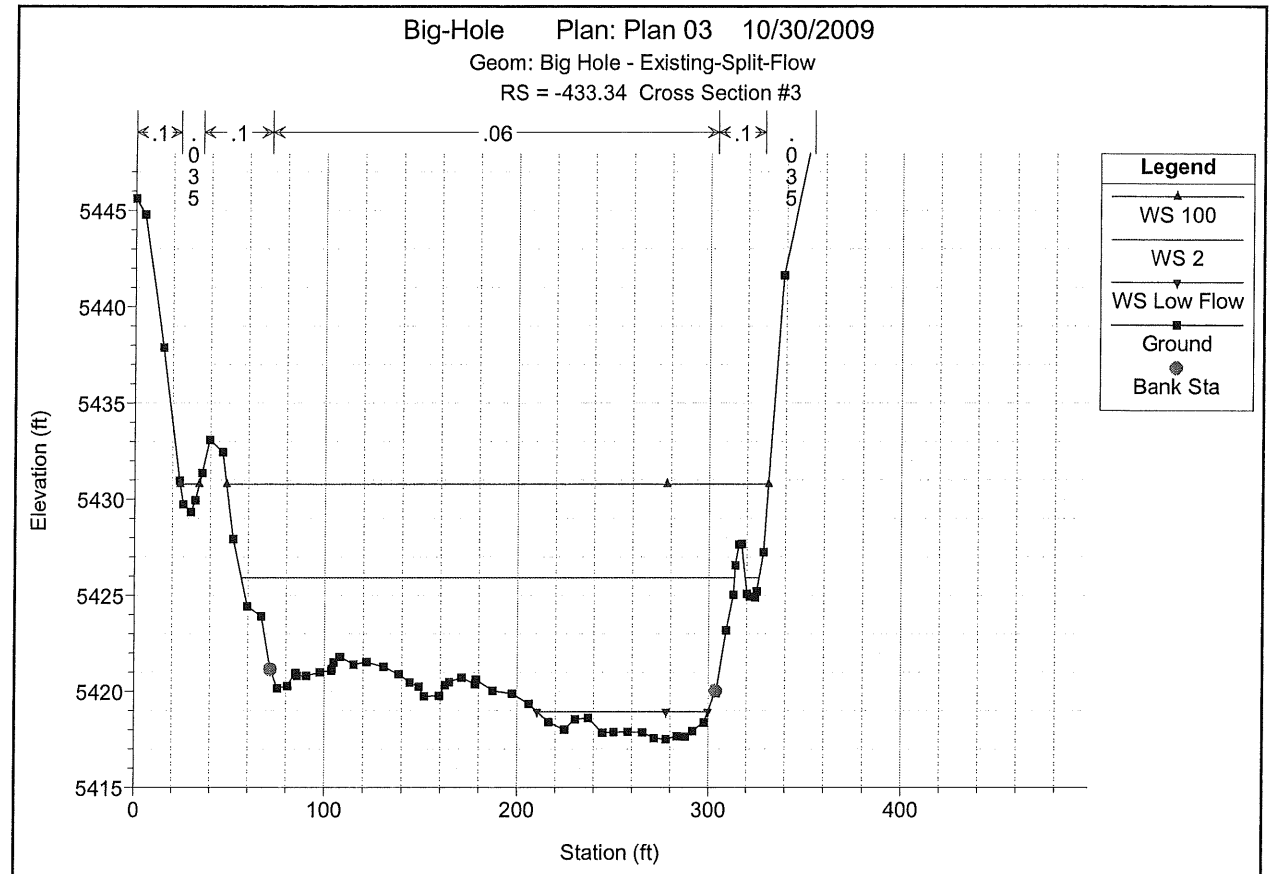

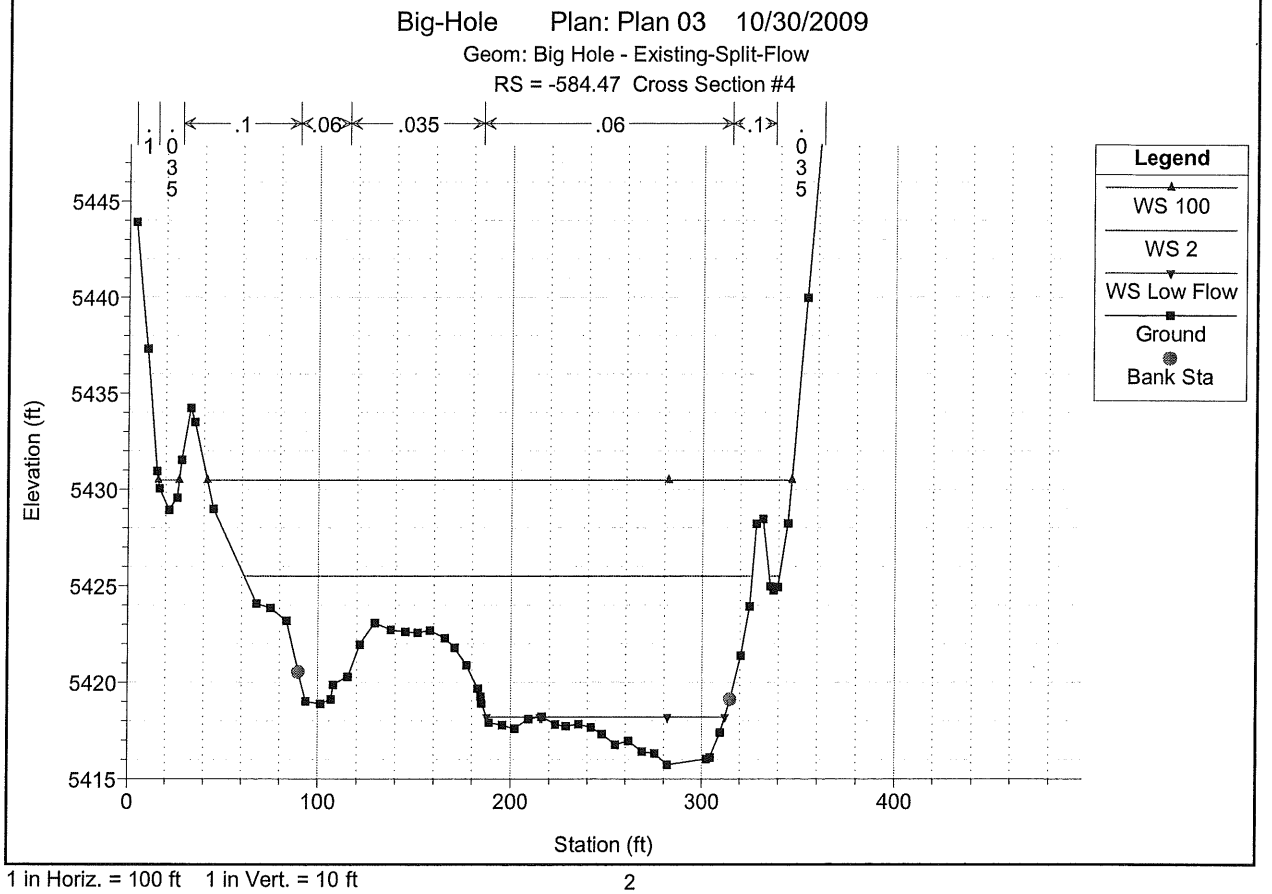

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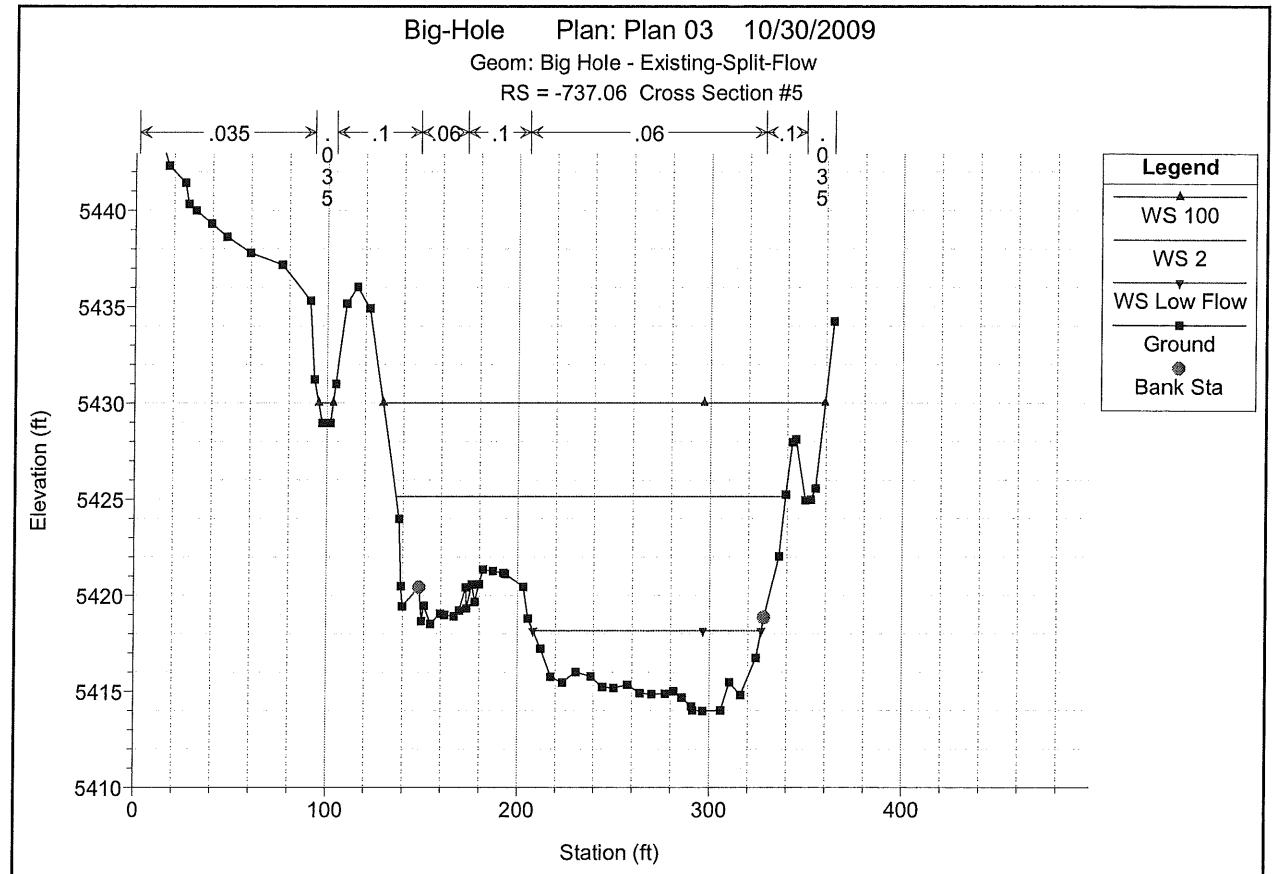

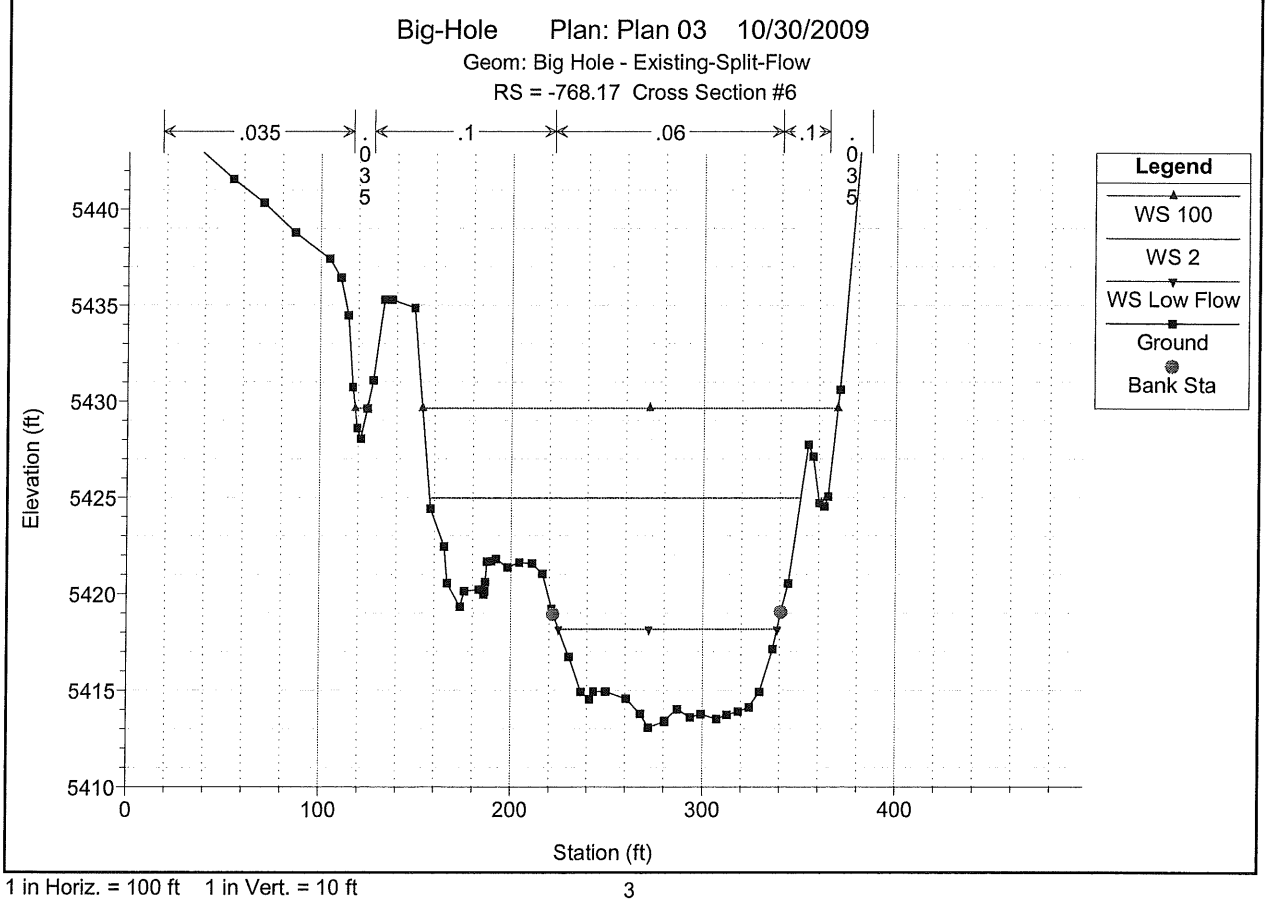

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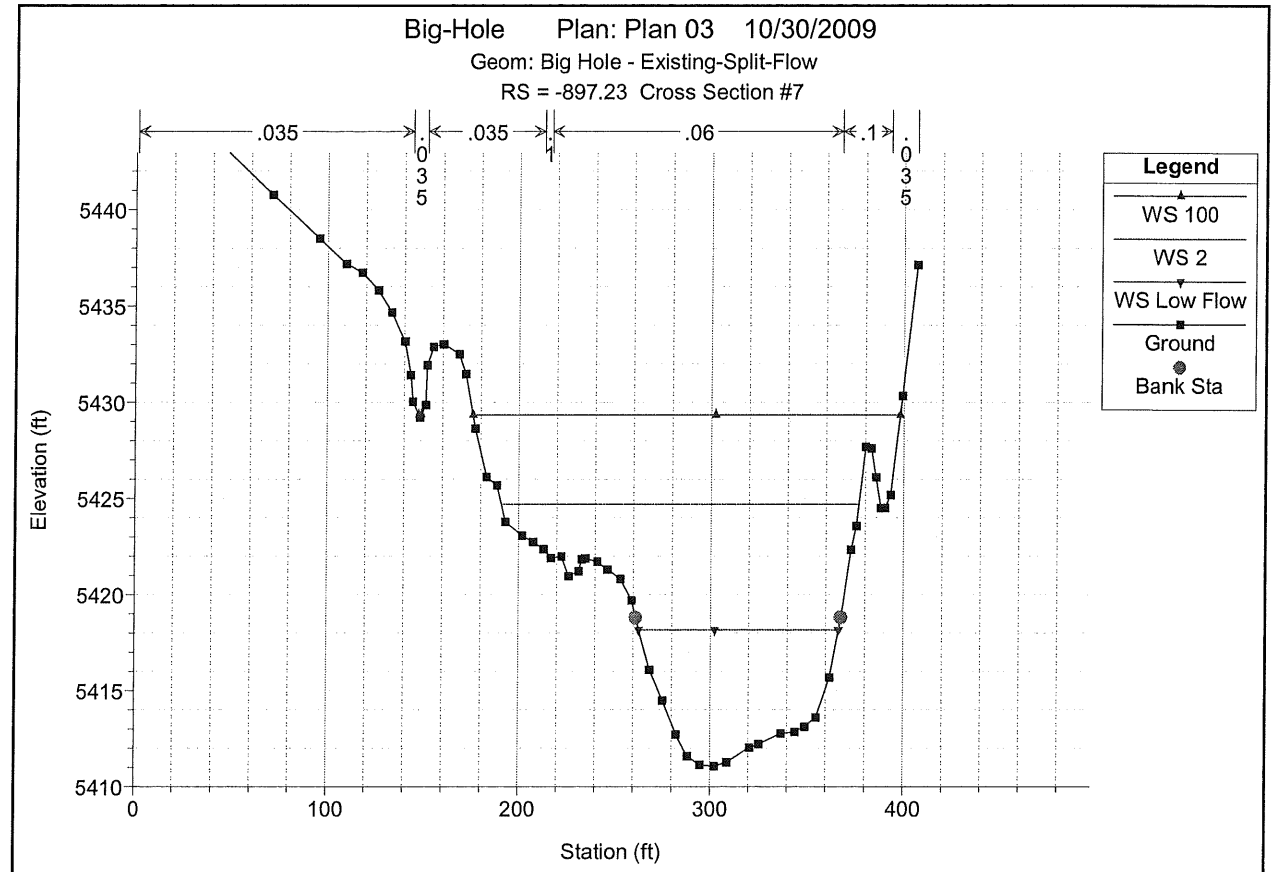
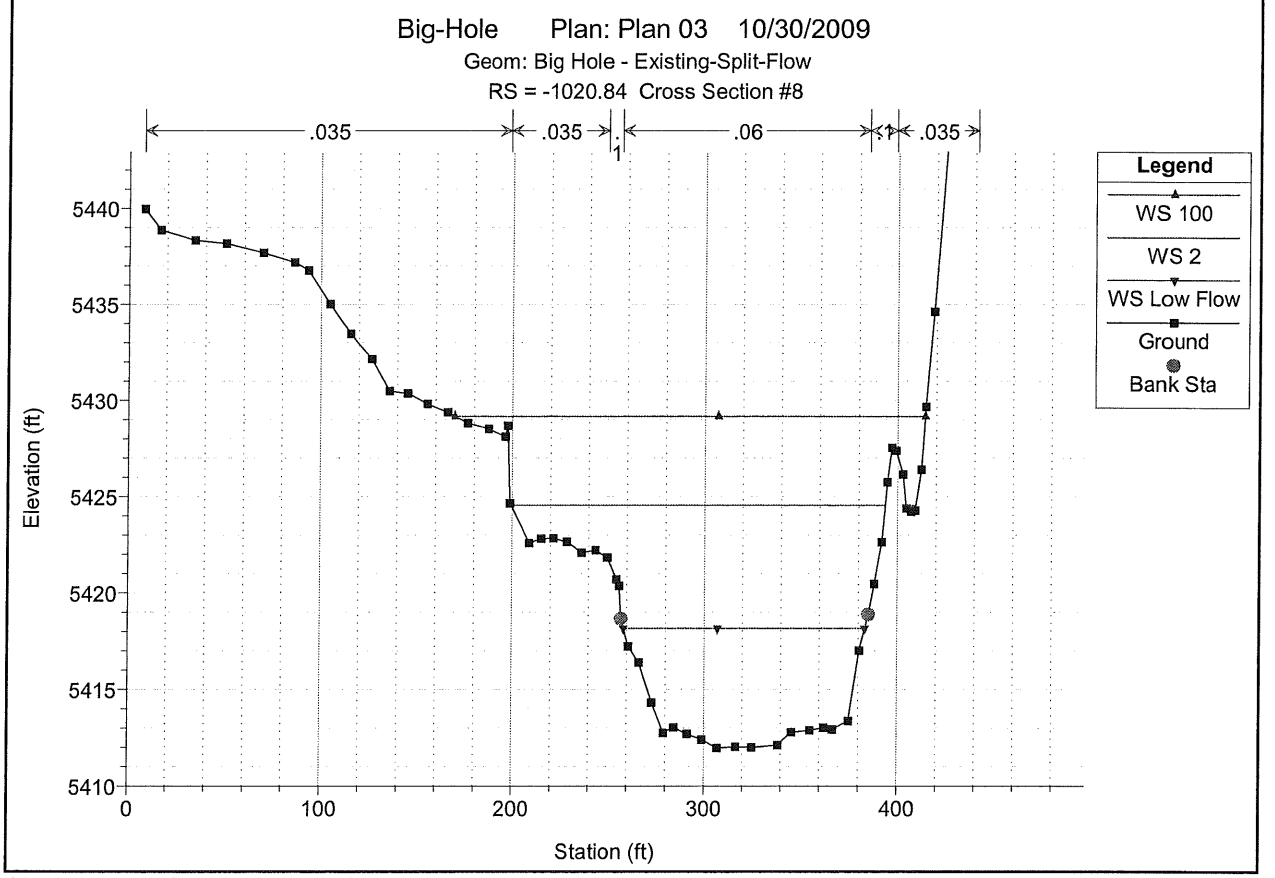
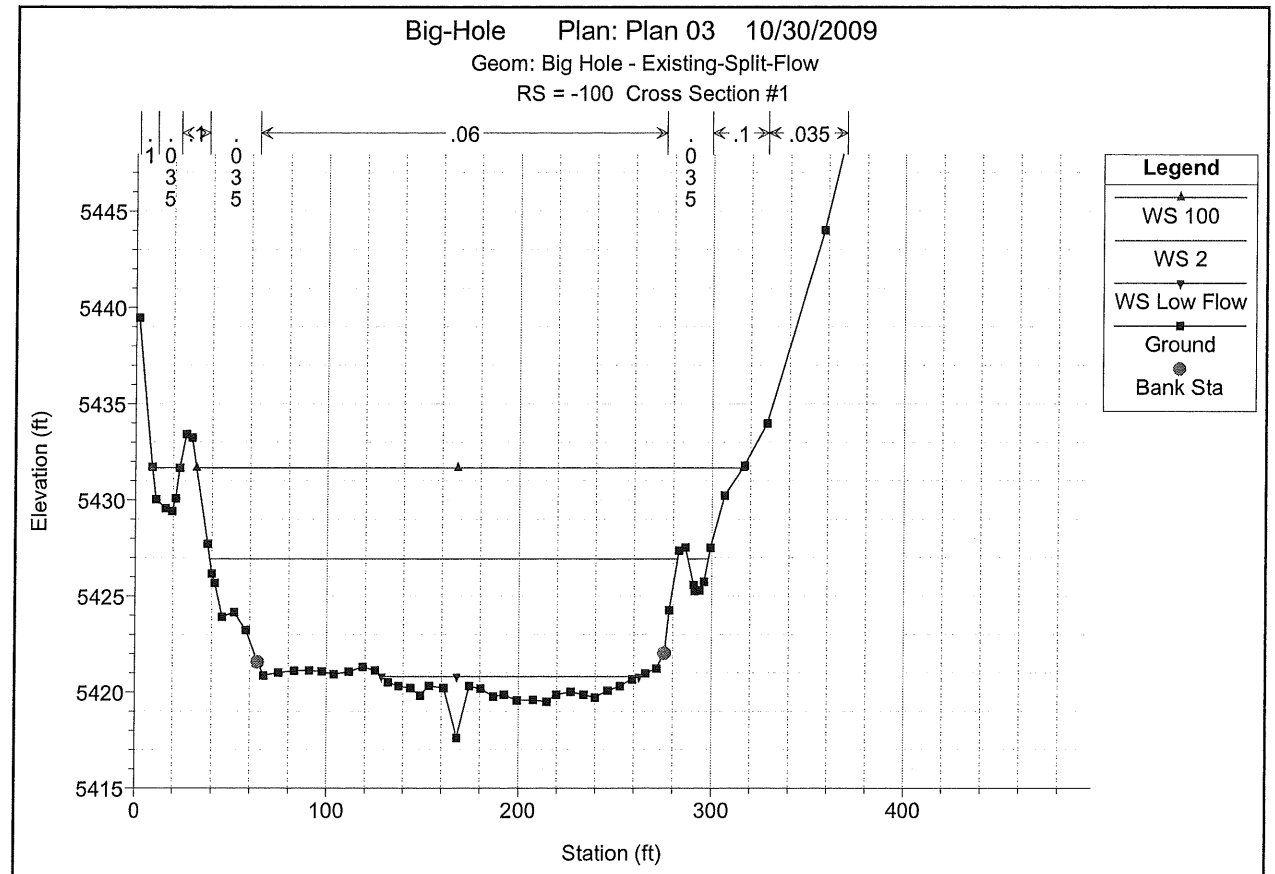
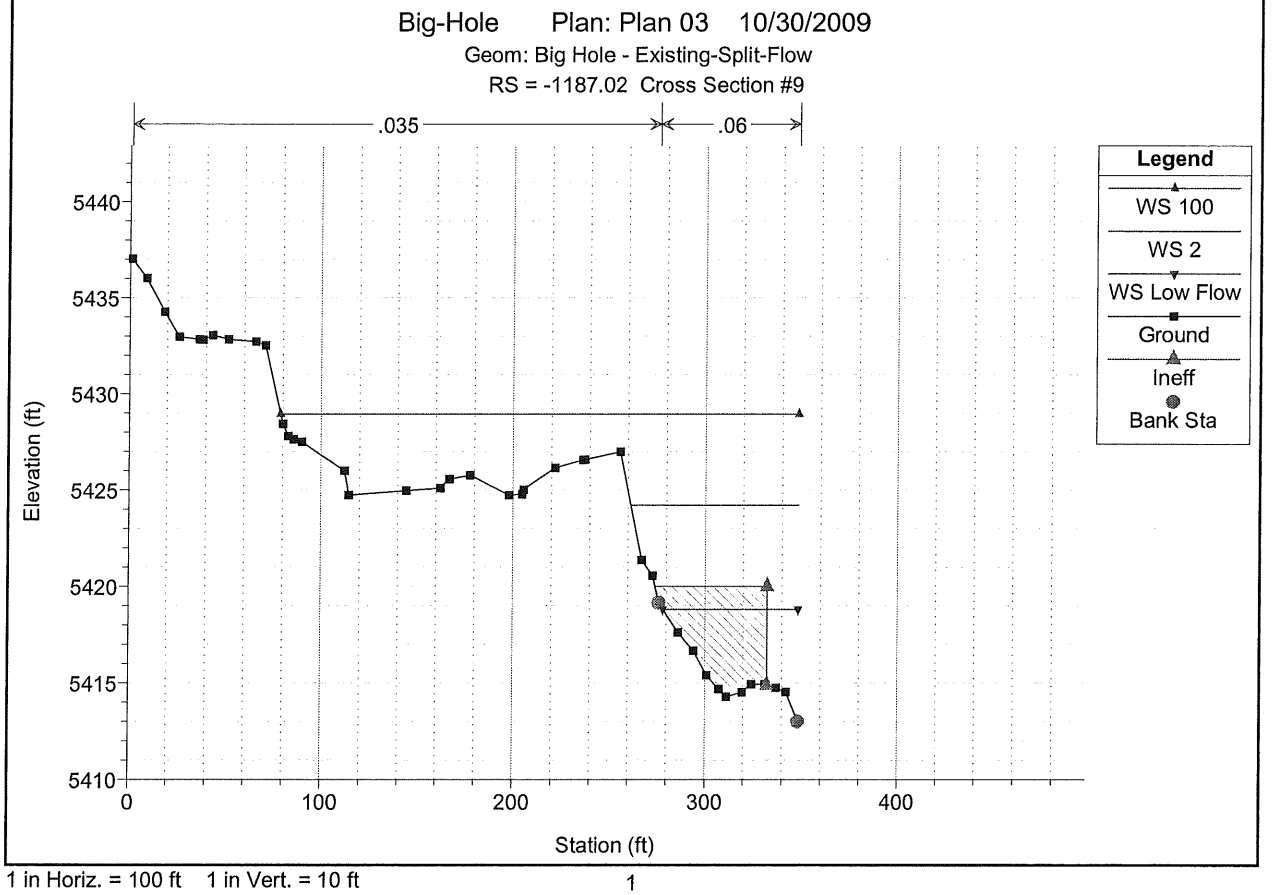


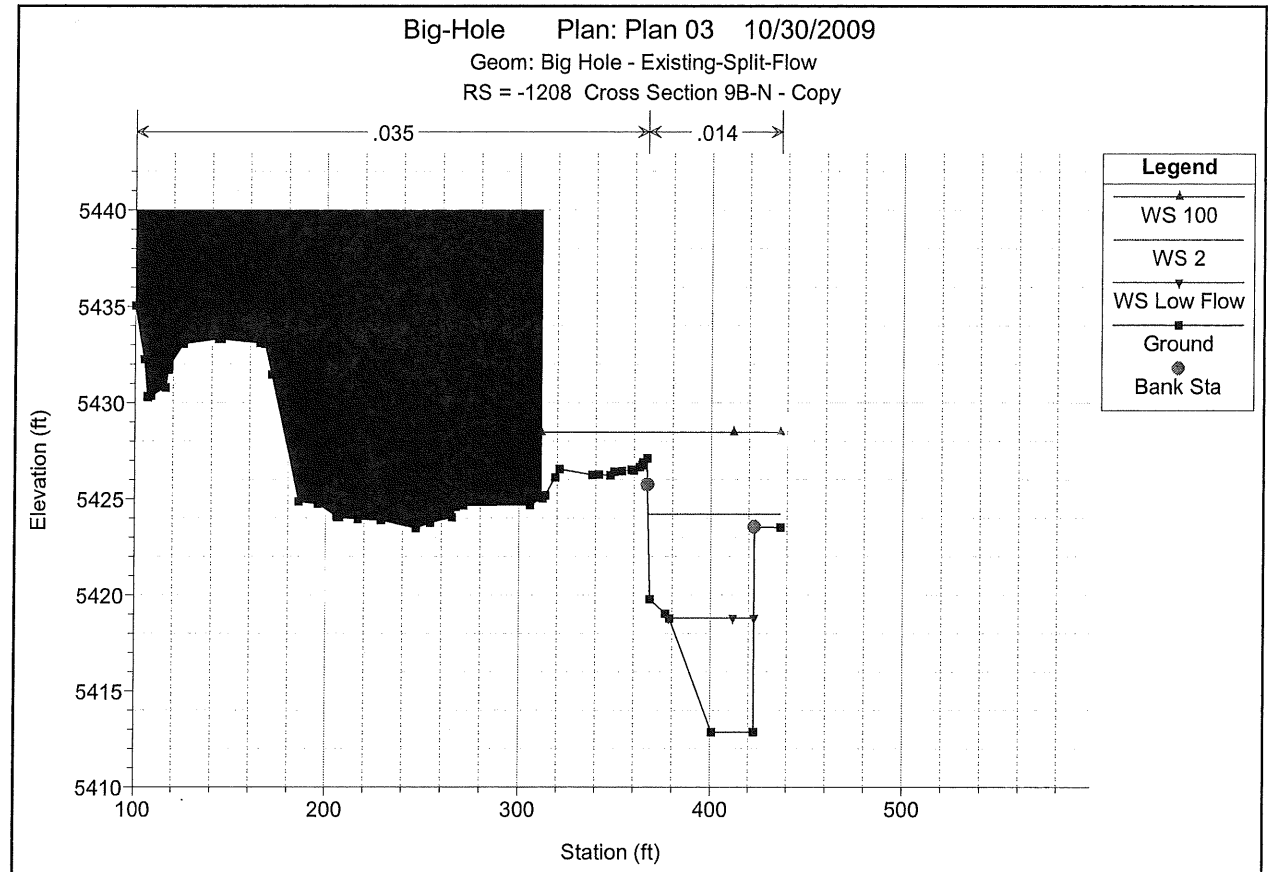


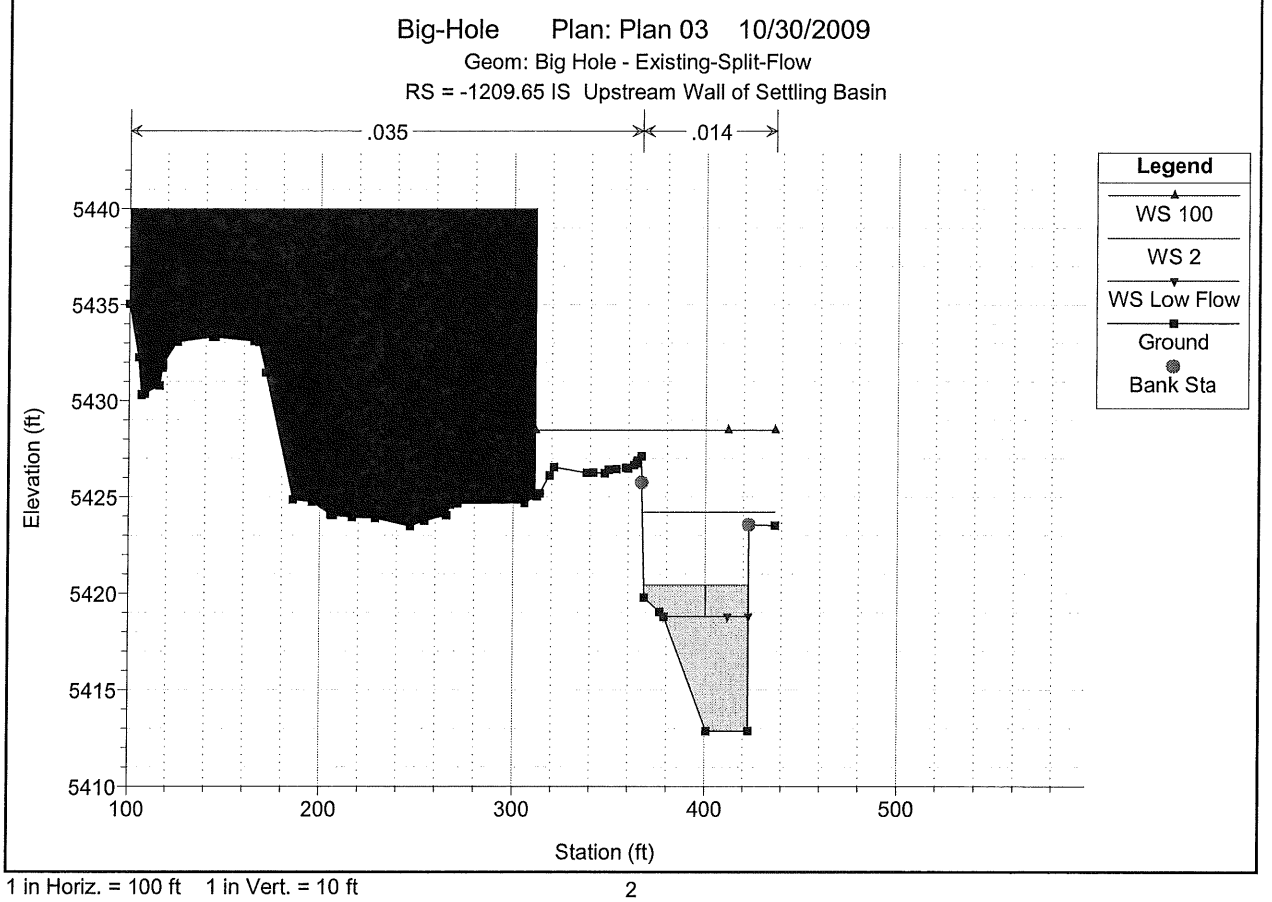
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft





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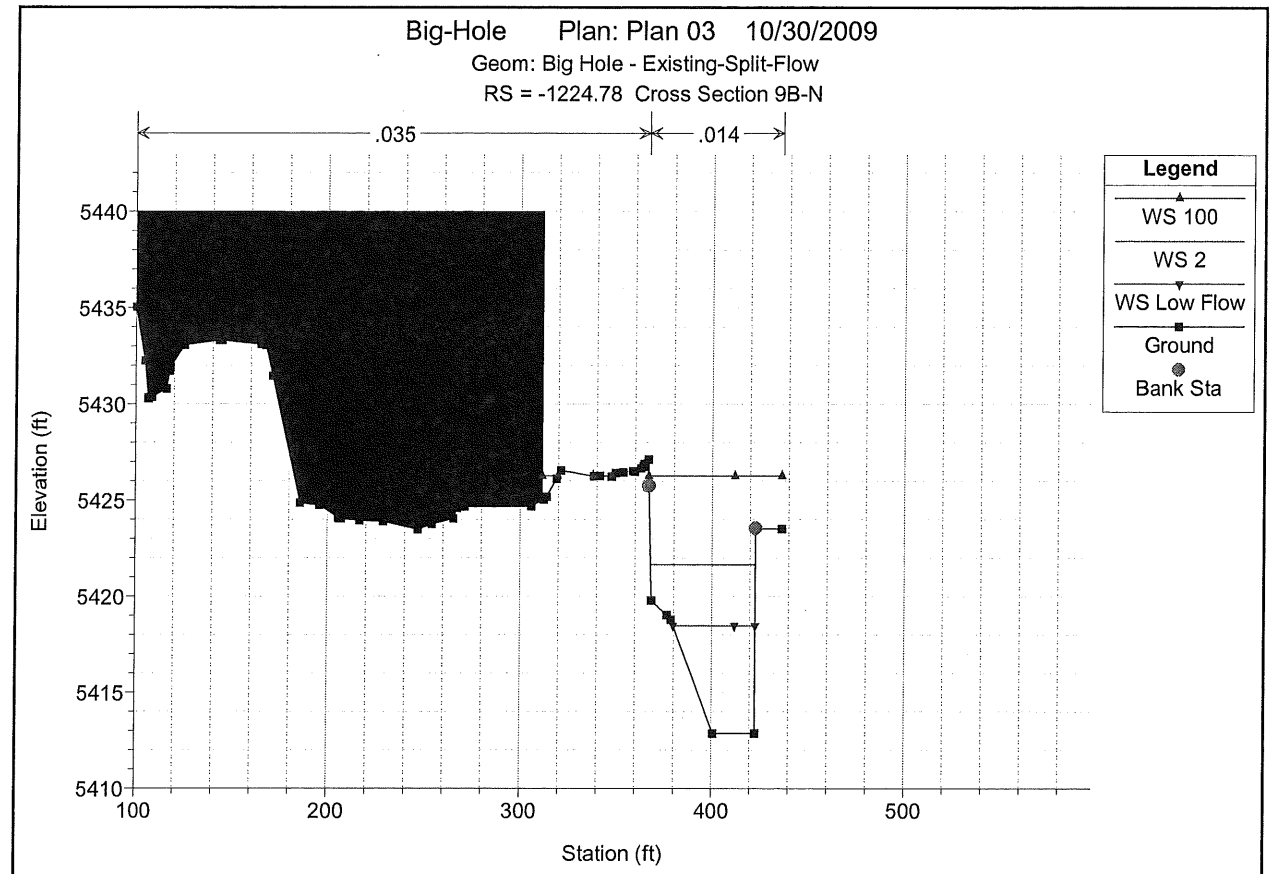

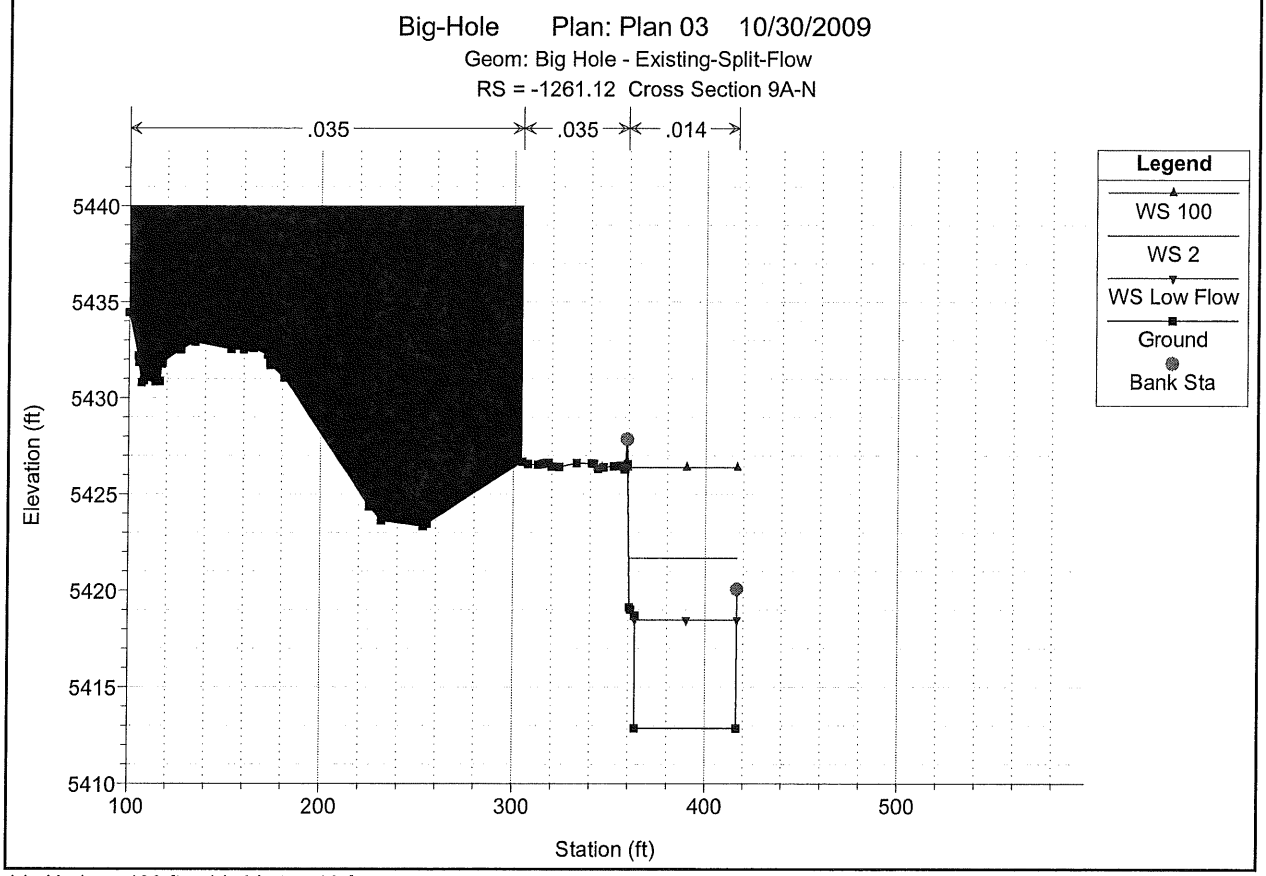

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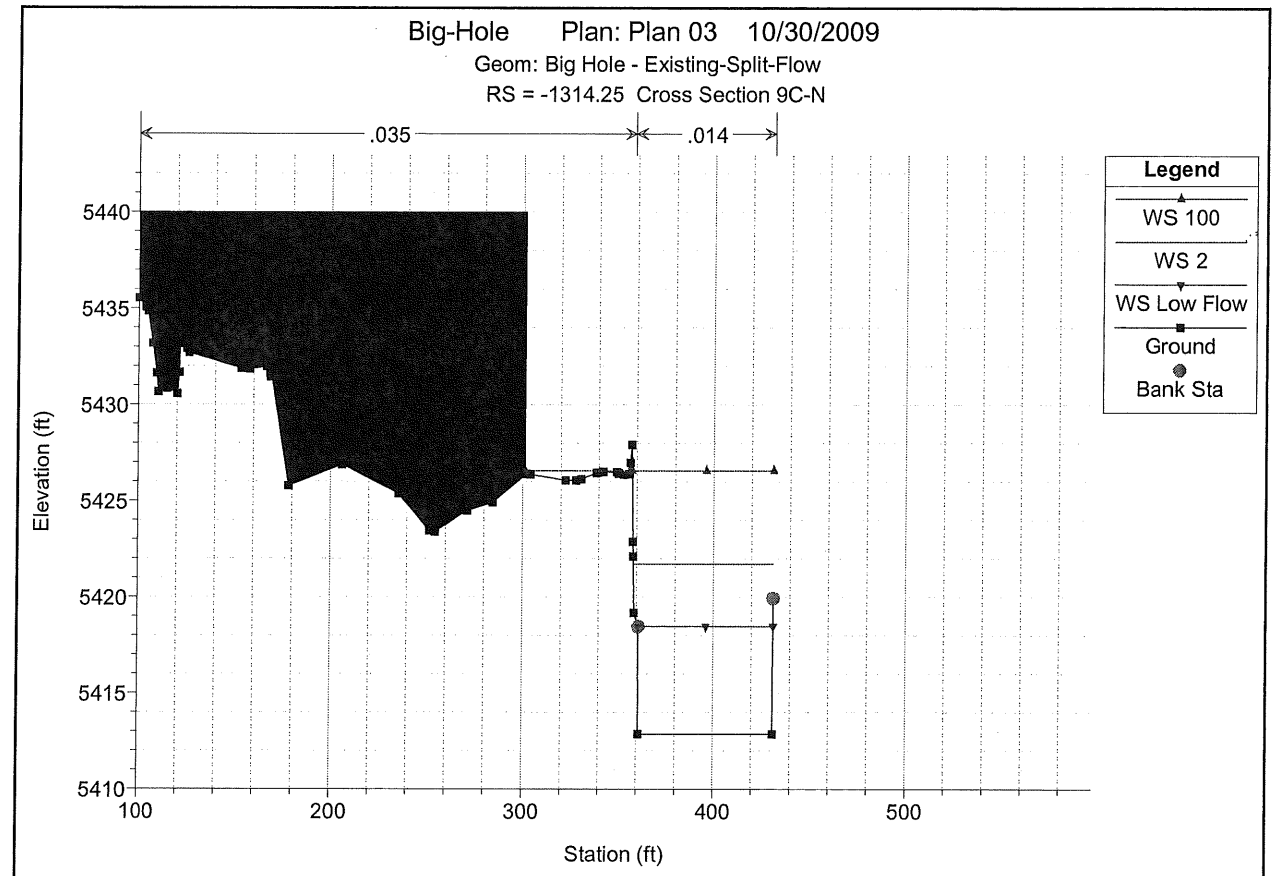

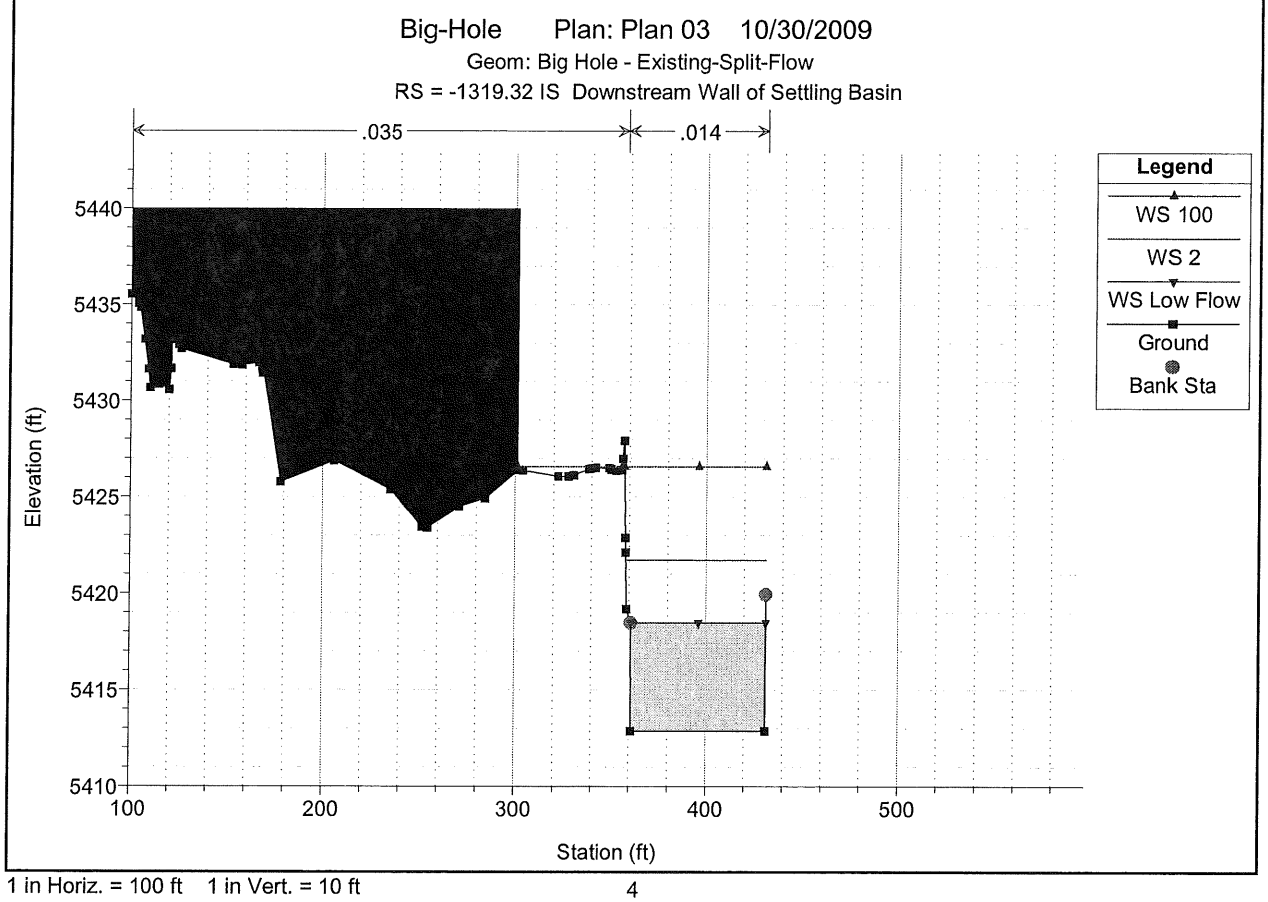

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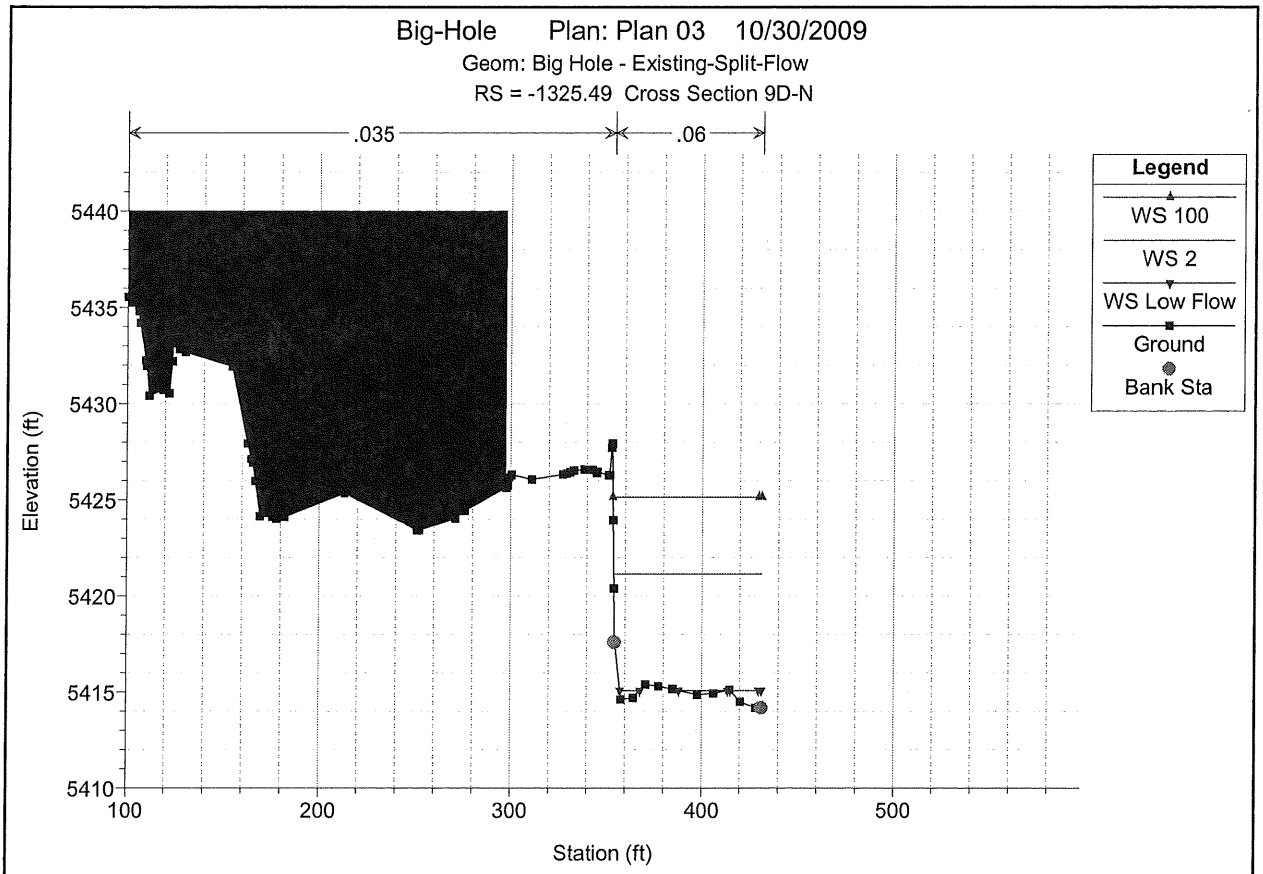
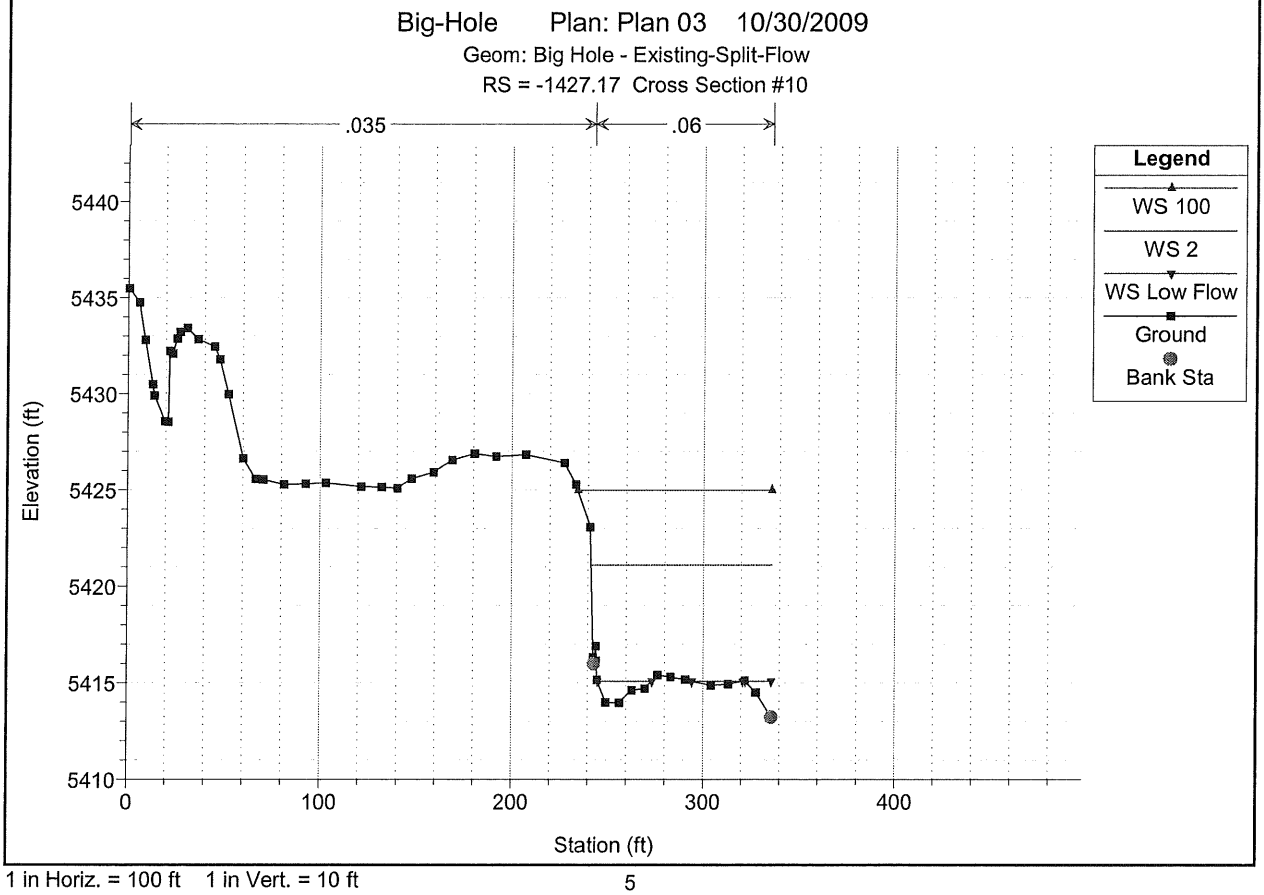
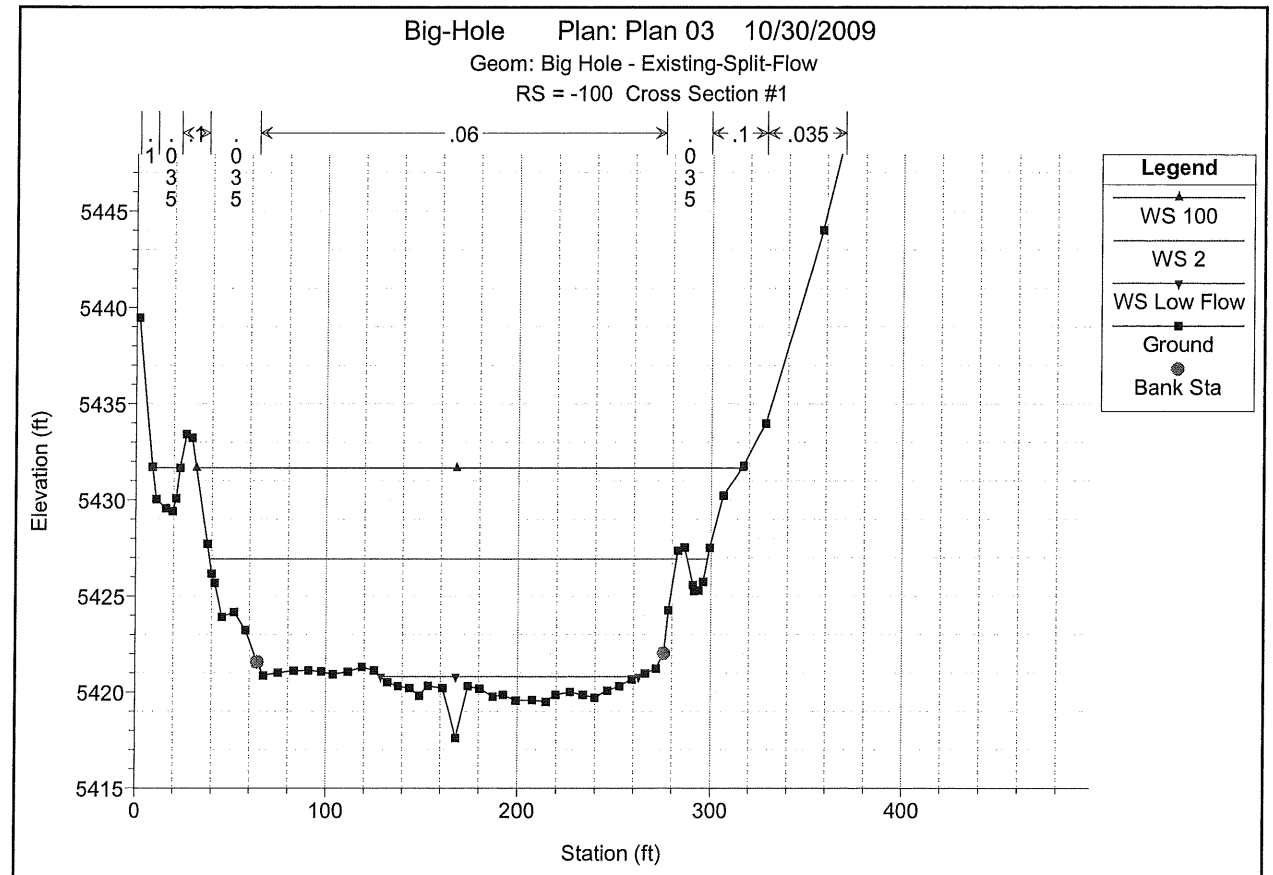
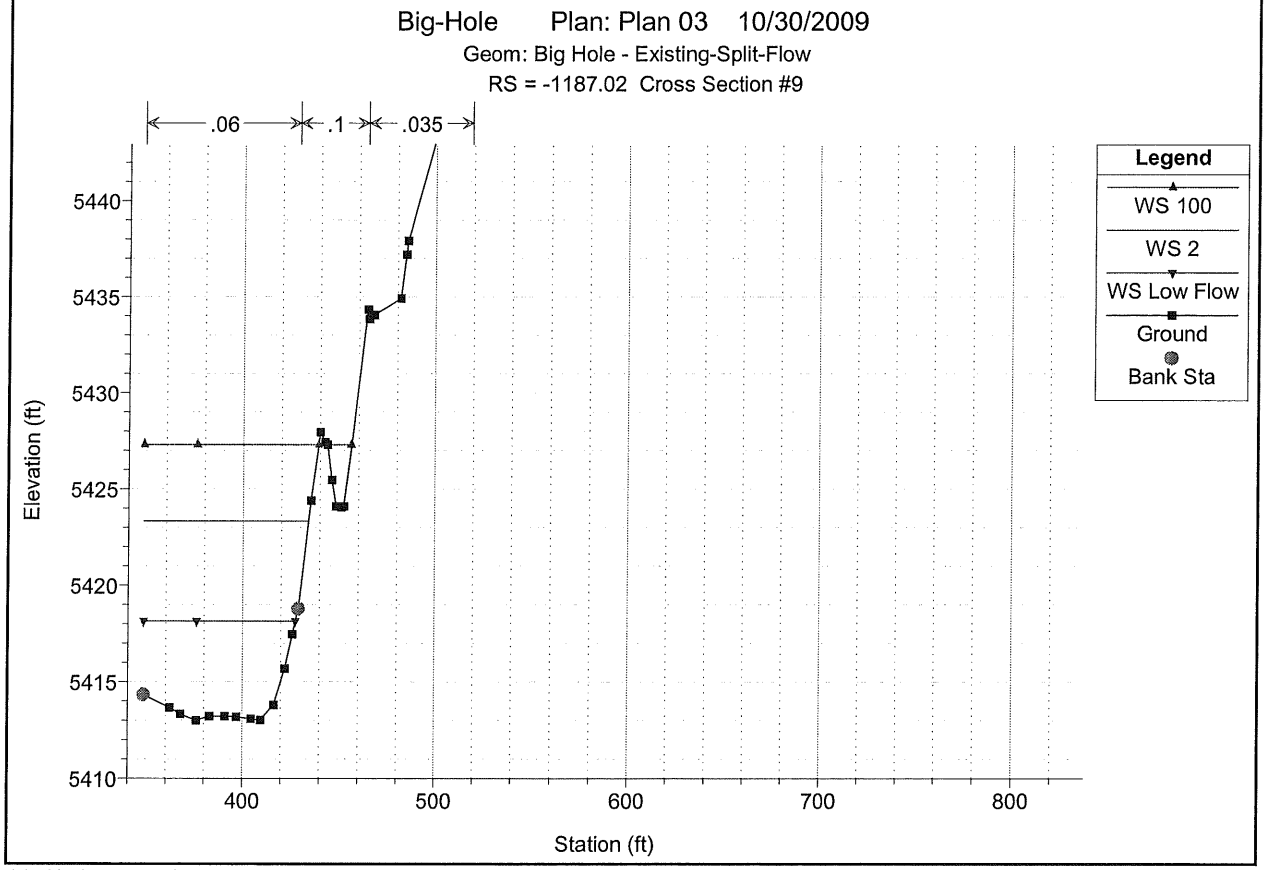




1 in Horiz. = 100 ft 1 in Vert. = 10 ft





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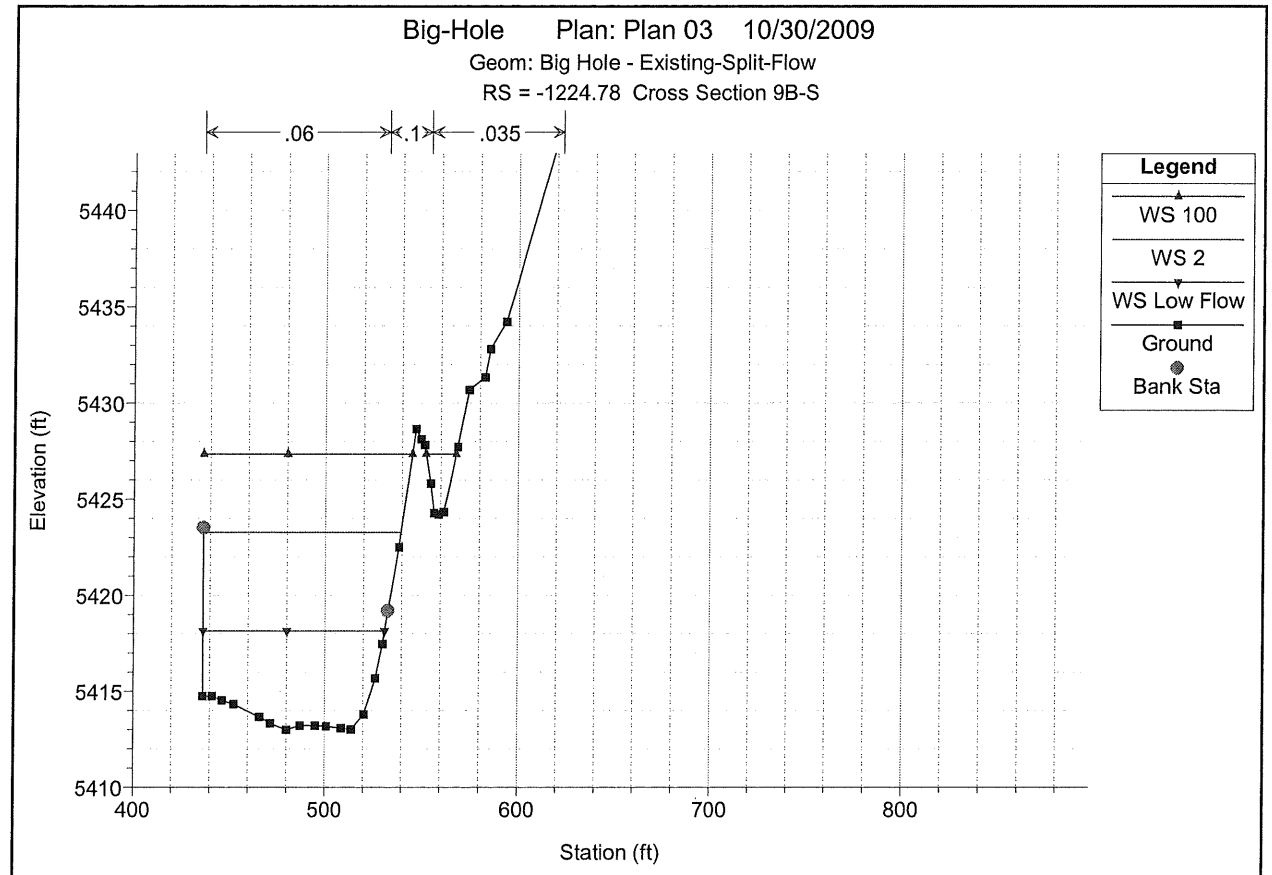
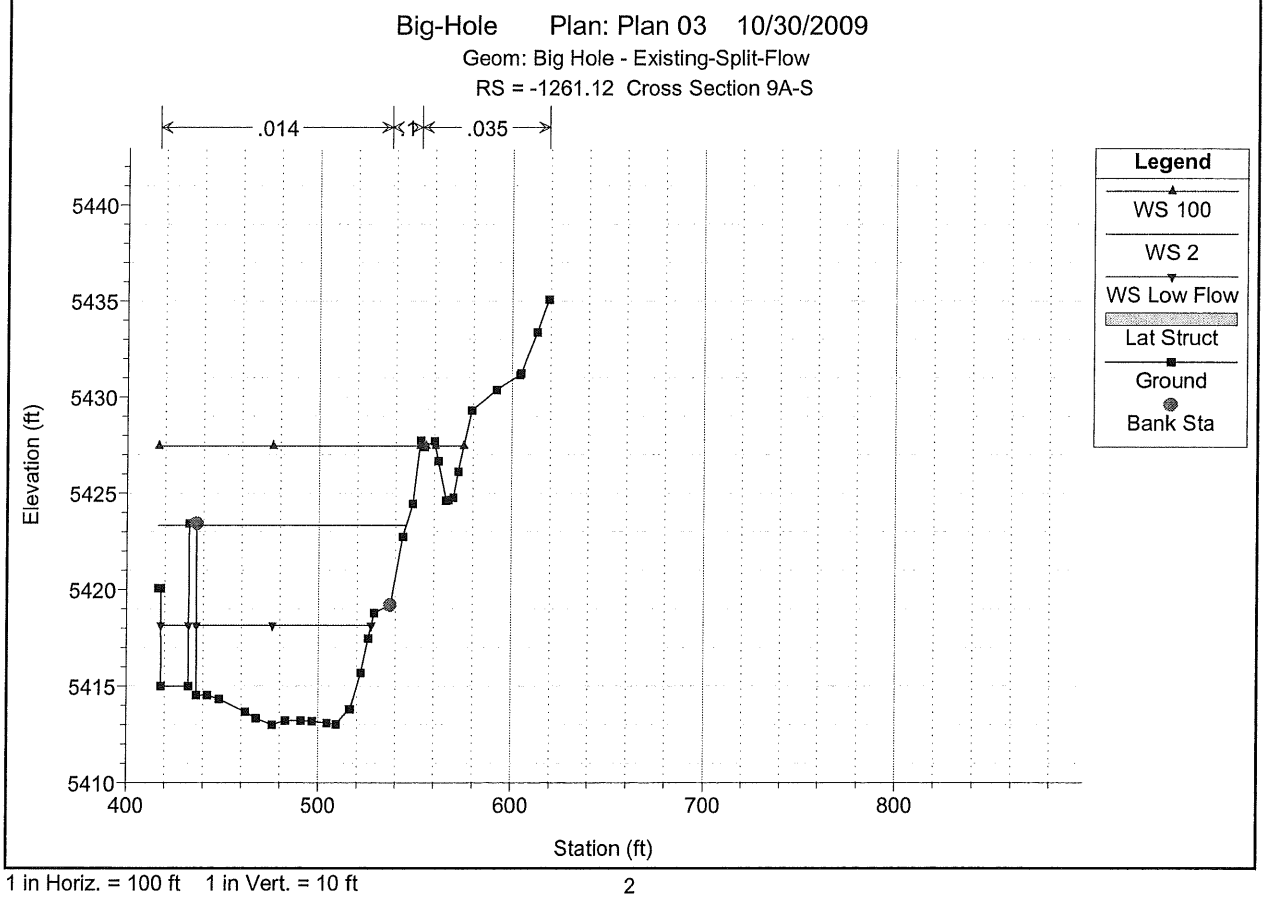
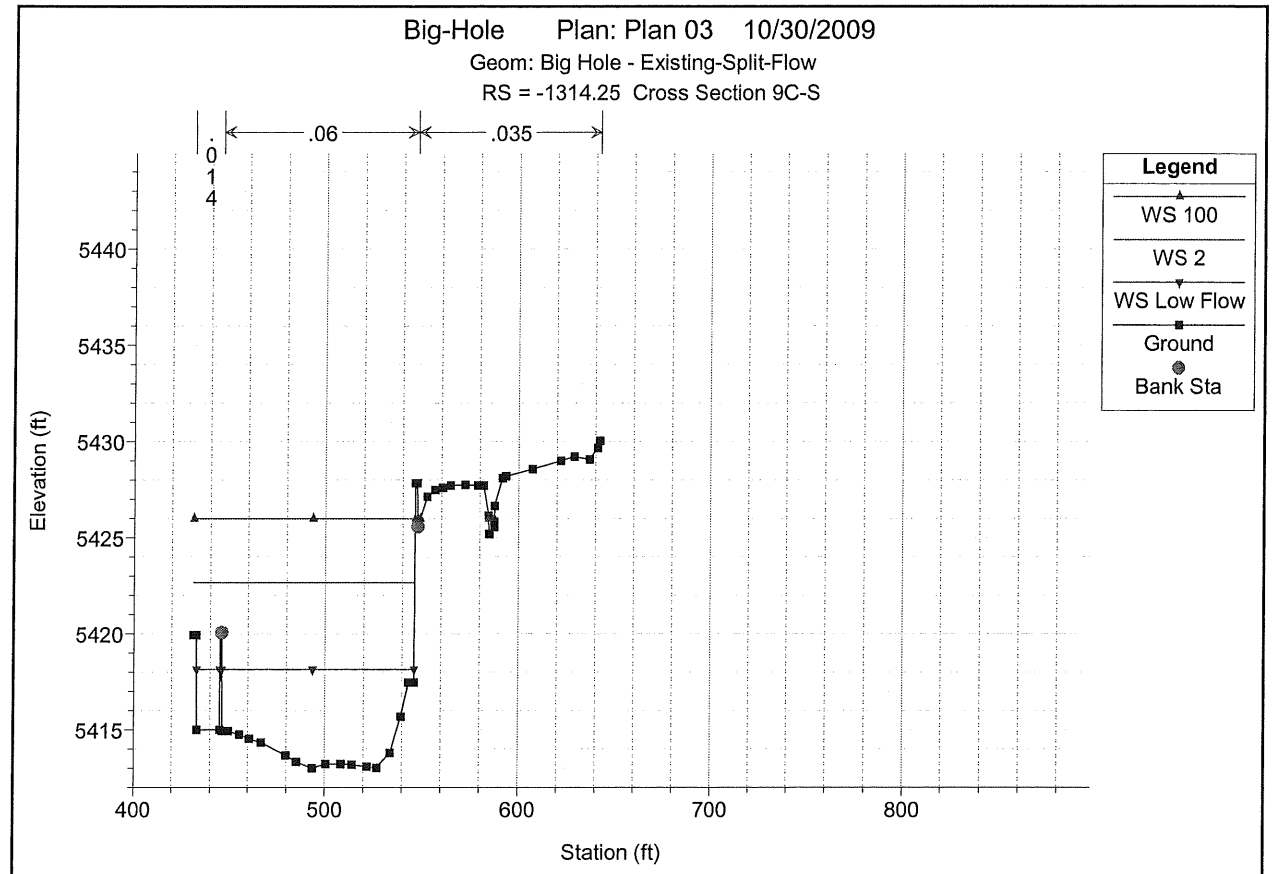
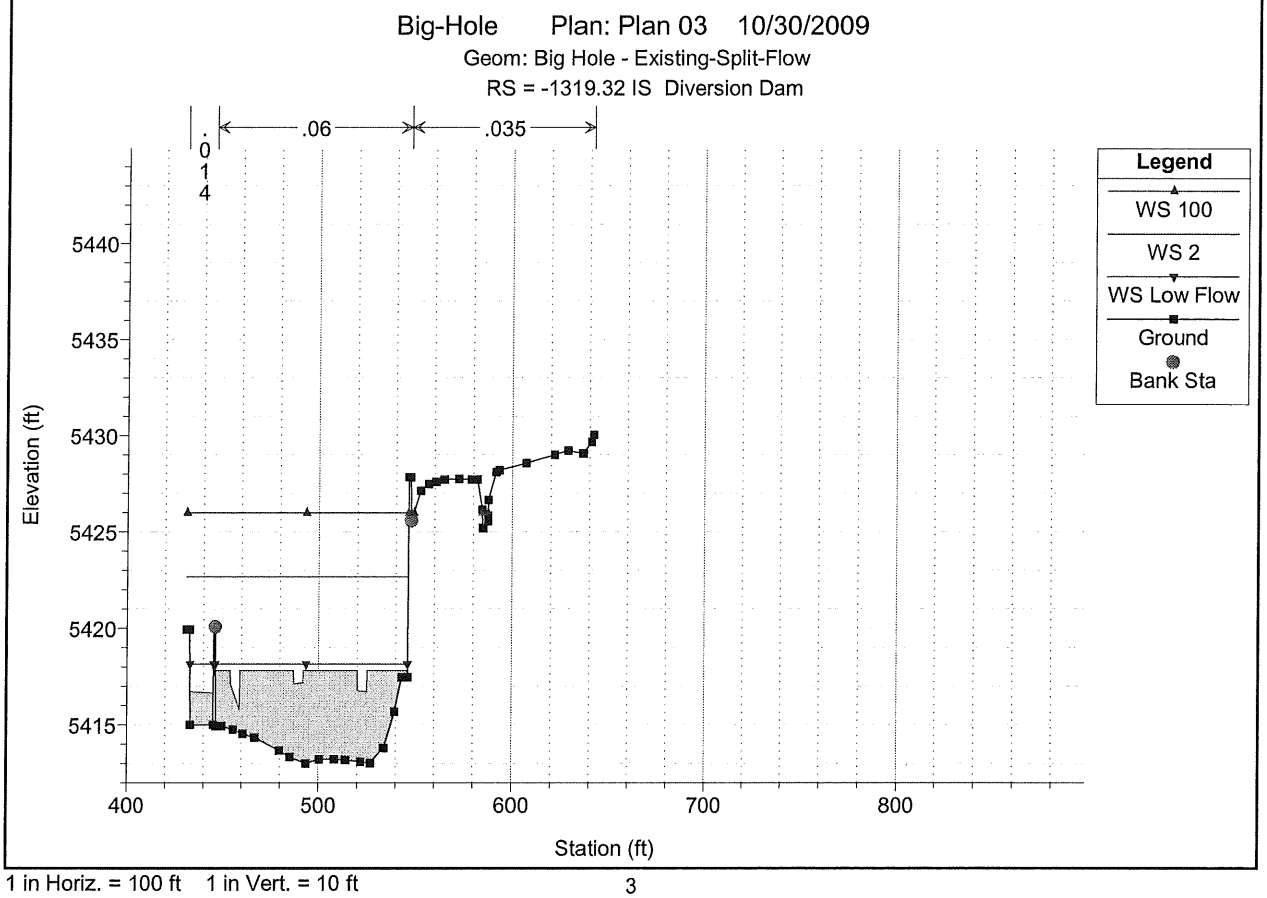


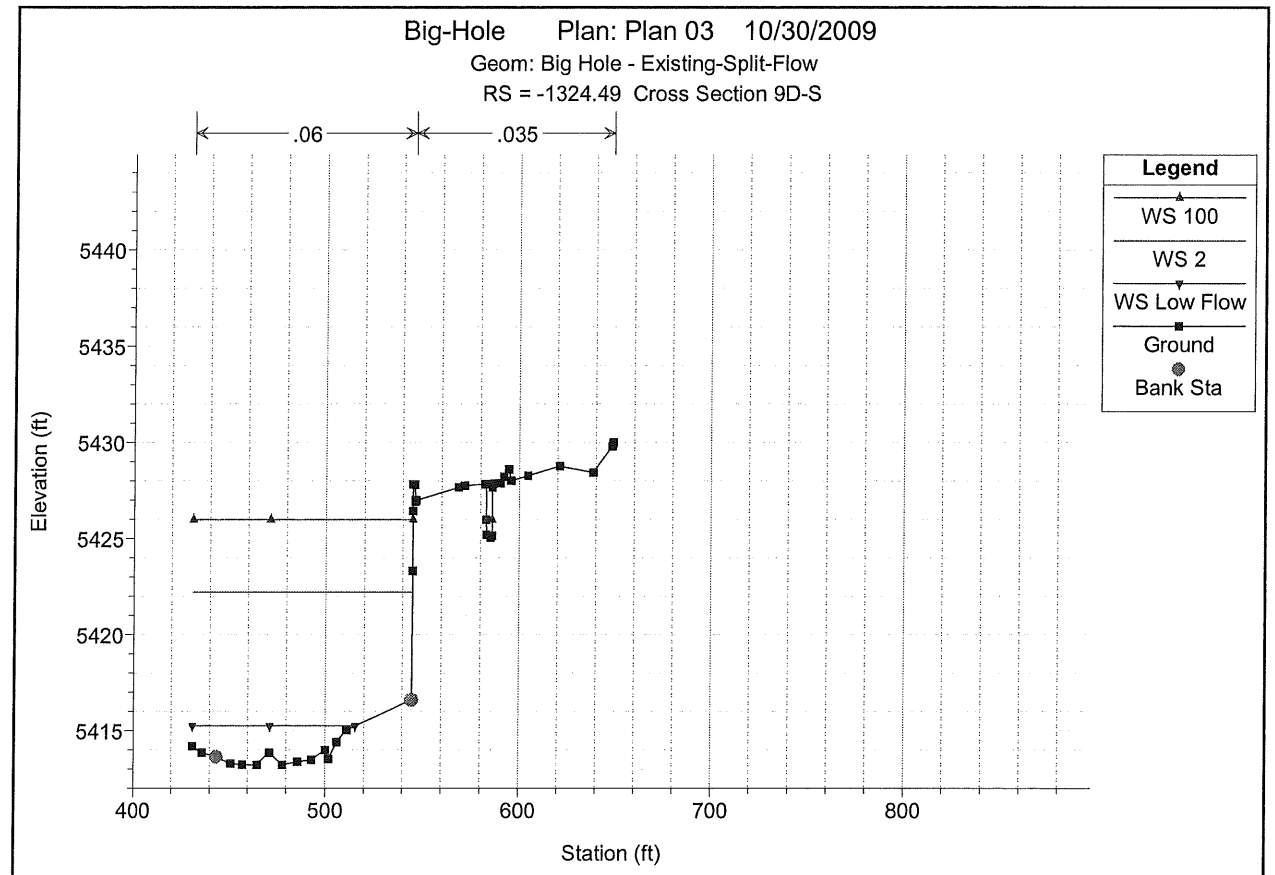


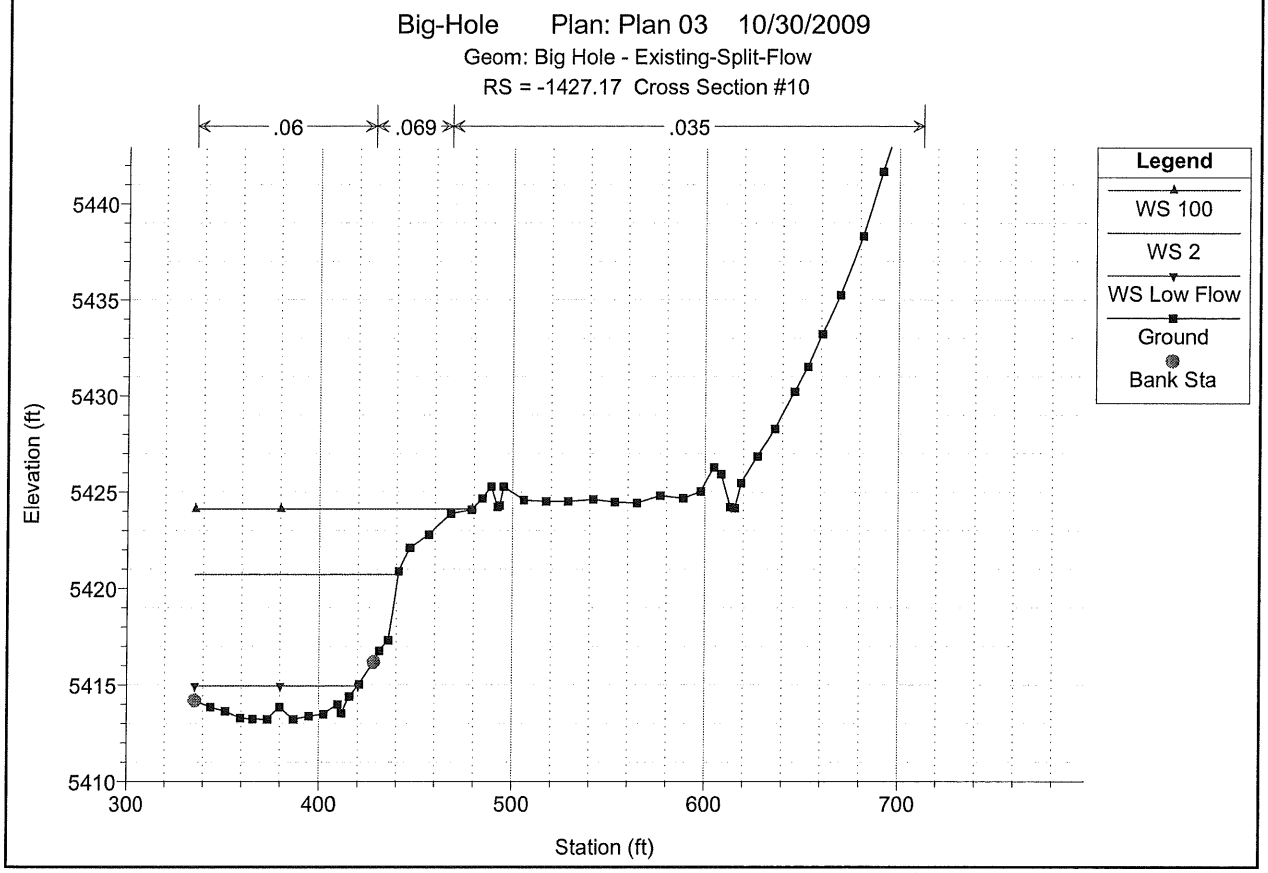
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



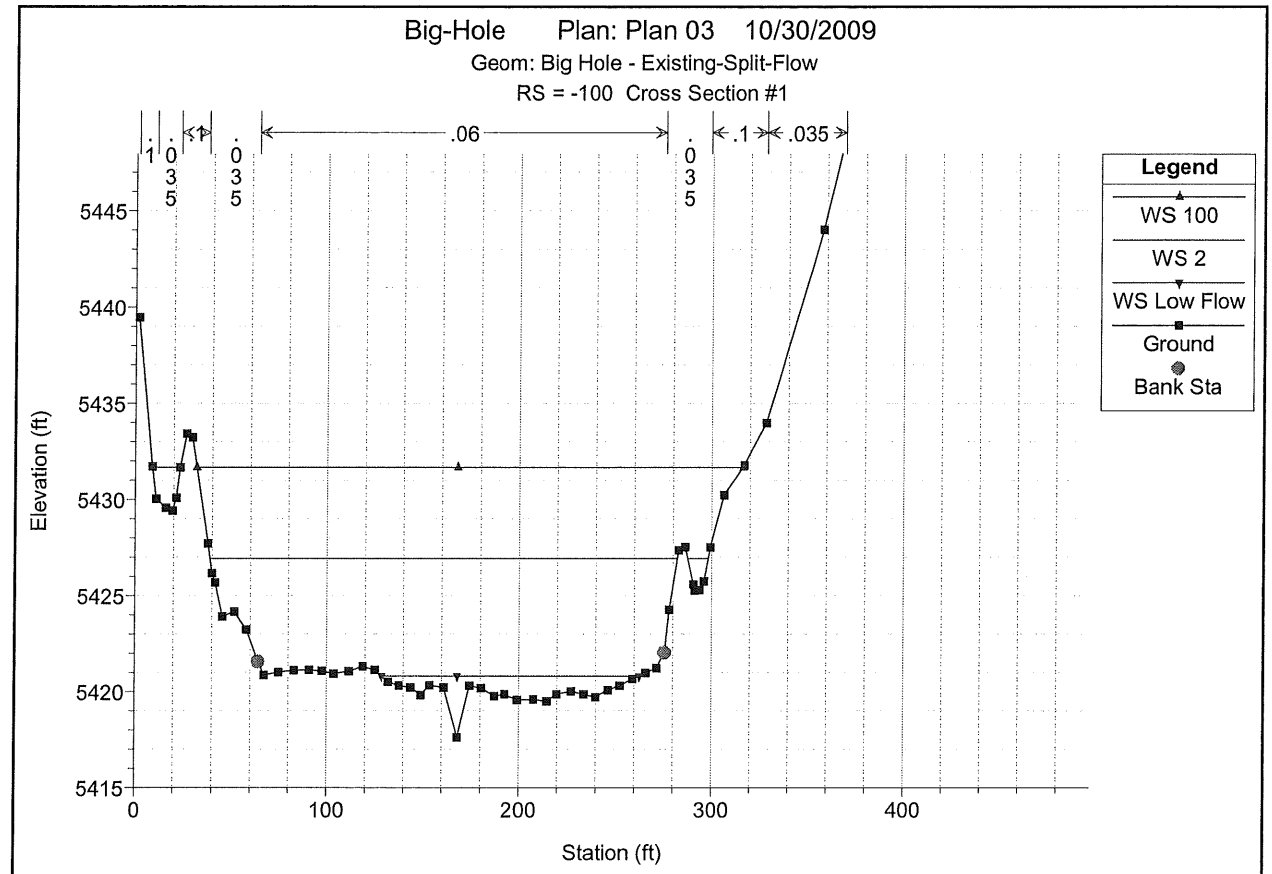


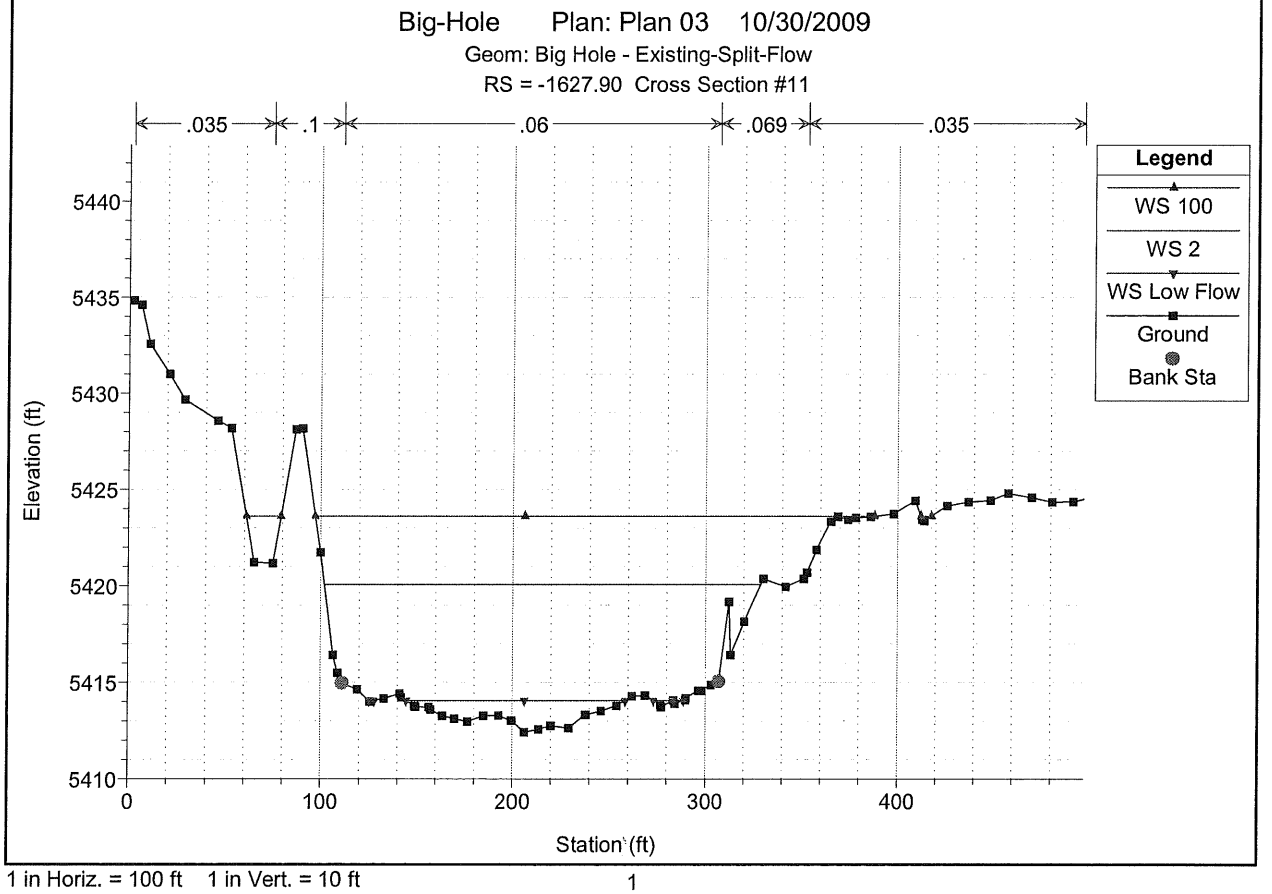
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft





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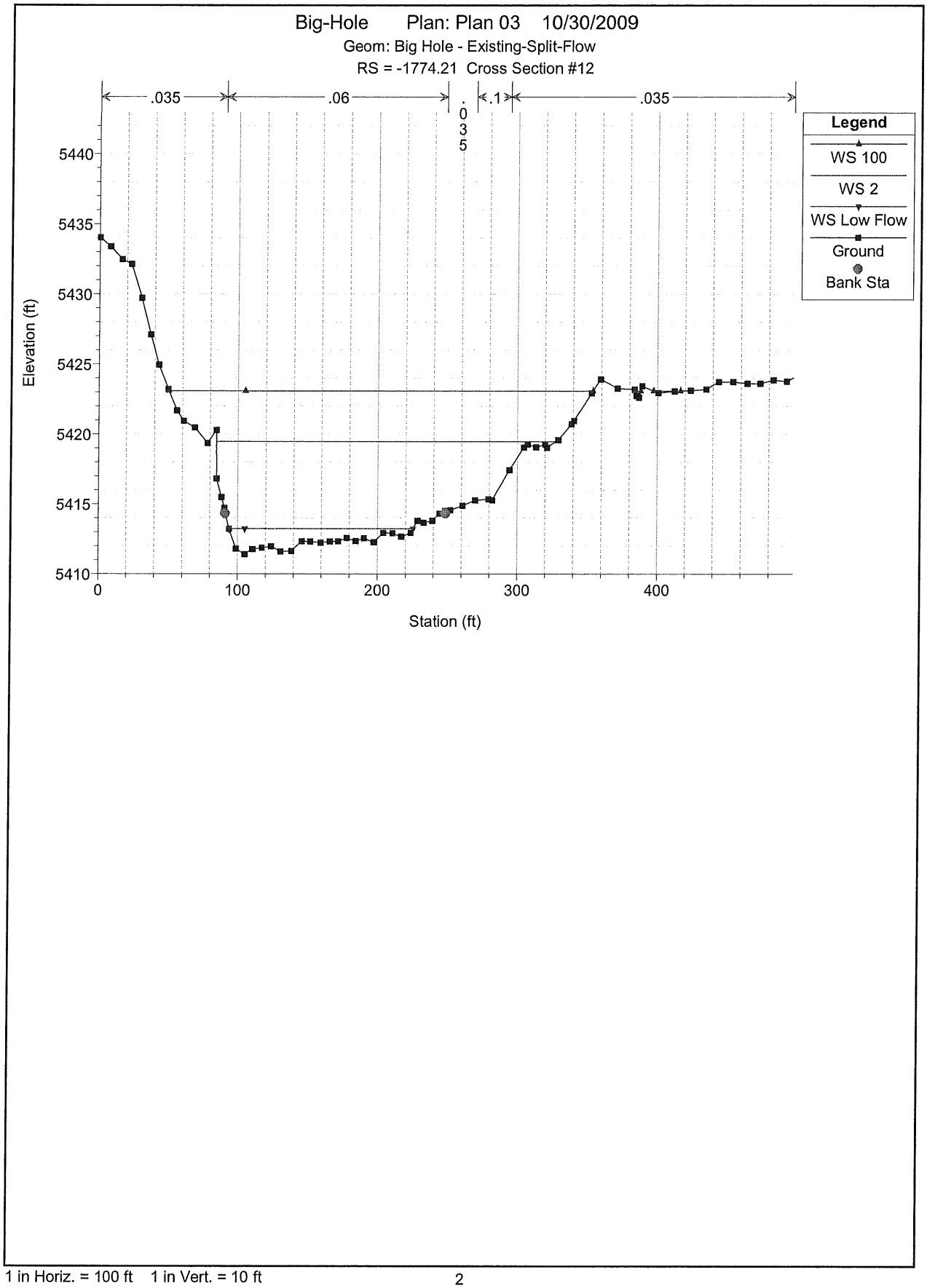

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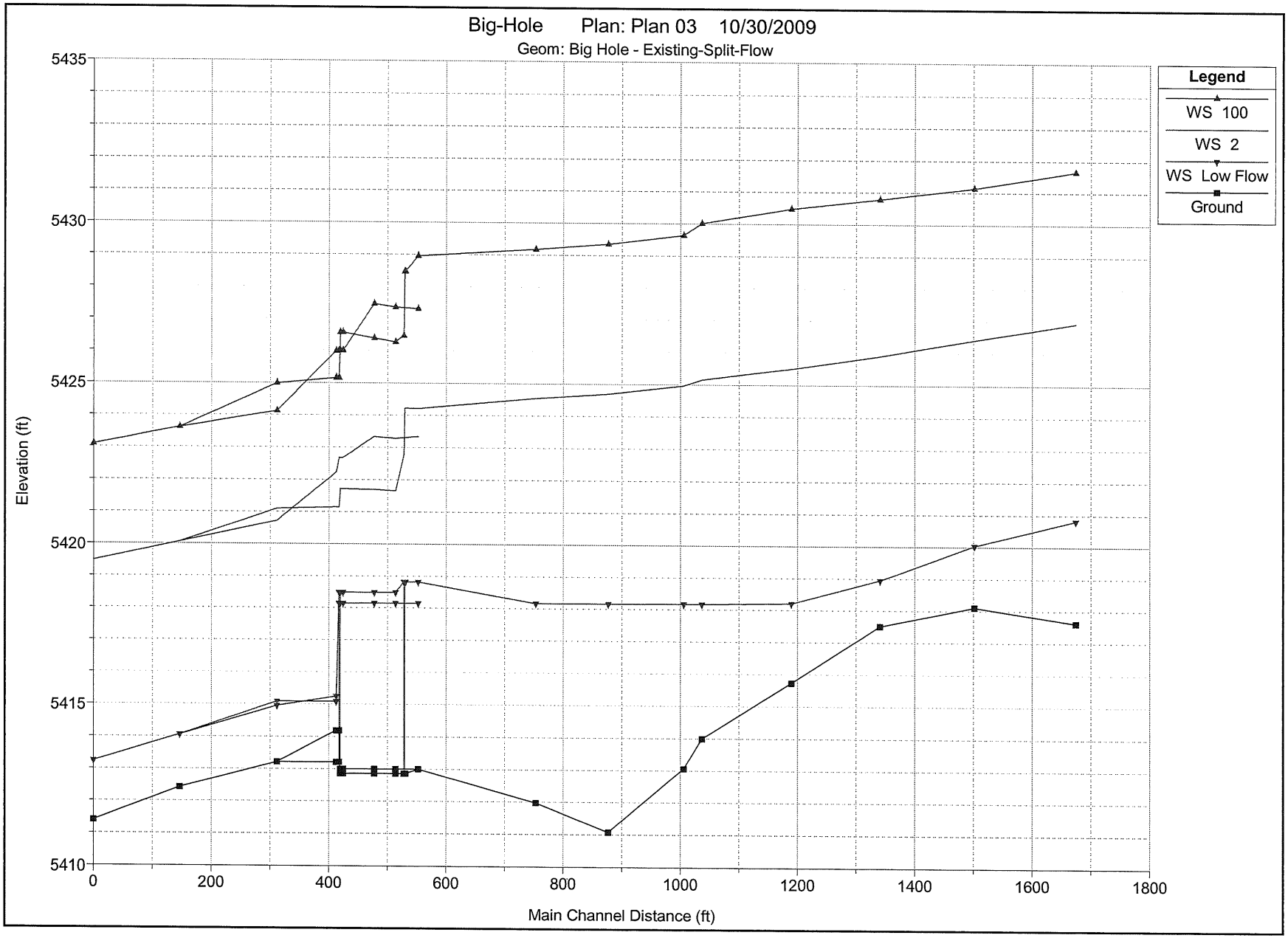
Big-Hole Plan: Plan 03 10/30/2009
Geom: Big Hole - Existing-Split-Flow
Legend
WS 100
WS 2
WS Low Flow
Ground
Elevation (ft)
5435
5430
5425
5420
5415
5410
0
200
400
600
800
1000
1200
1400
1600
1800
Main Channel Distance (ft)

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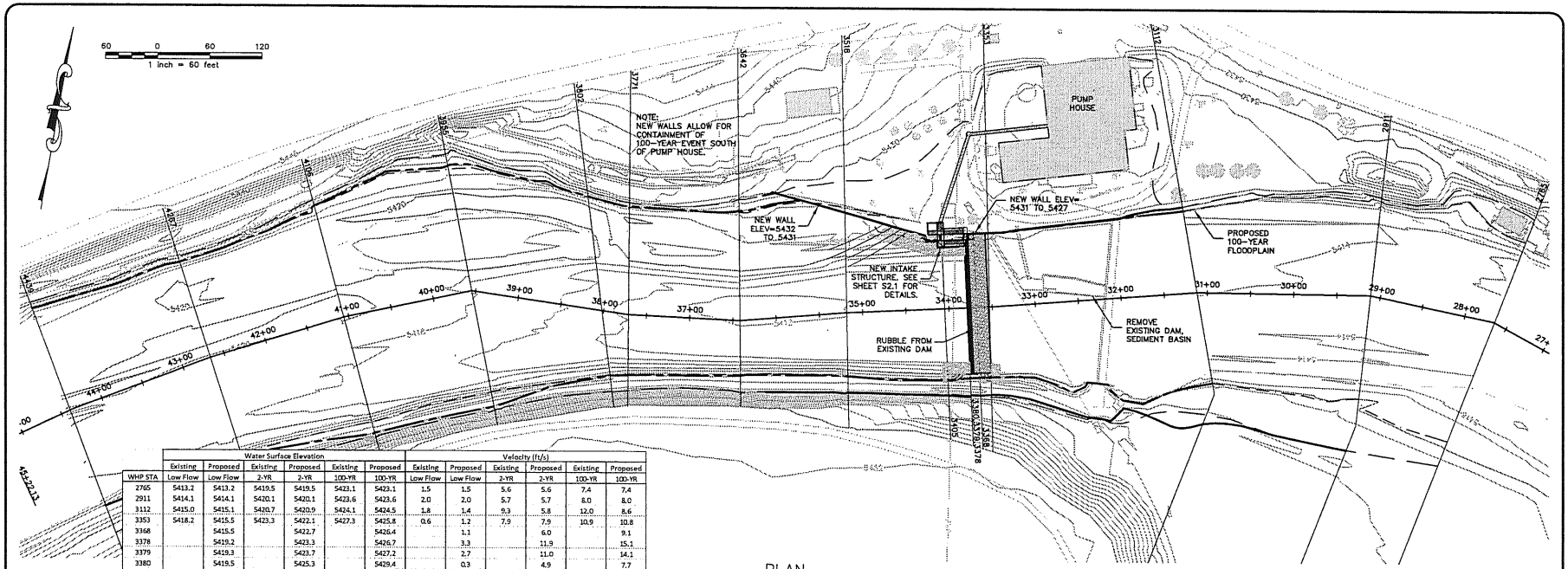
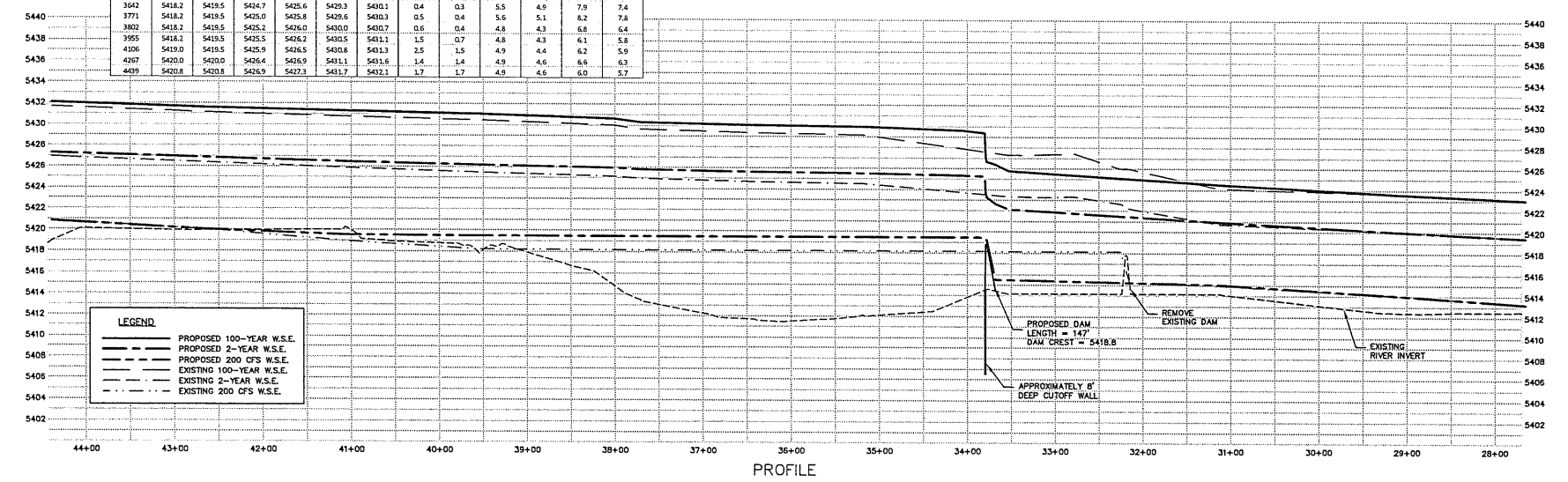


PLAN

	Water Surface Elevation						Velocity (ft/s)					
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
WHP STA	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3353	5418.2	5415.5	5423.3	5422.1	5427.3	5425.8	0.6	1.2	7.9	7.9	10.9	10.8
3368		5415.5		5422.7		5426.4		1.1		6.0		9.1
3378		5419.2		5423.3		5426.7		3.3		11.9		15.1
3379		5419.3		5423.7		5427.2		2.7		11.0		14.1
3380		5419.5		5425.3		5429.4		0.3		4.9		7.7
3405		5419.5		5425.4		5429.6		0.3		4.5		7.0
3518	5418.2	5419.5	5424.5	5425.5	5429.2	5430.0	0.3	0.3	4.8	4.3	6.9	6.4
3642	5418.2	5419.5	5424.7	5425.6	5429.3	5430.1	0.4	0.3	5.5	4.9	7.9	7.4
3771	5418.2	5419.5	5425.0	5425.8	5429.6	5430.3	0.5	0.4	5.6	5.1	8.2	7.8
3802	5418.2	5419.5	5425.2	5426.0	5430.0	5430.7	0.6	0.4	4.8	4.3	6.8	6.4
3955	5418.2	5419.5	5425.5	5426.2	5430.5	5431.1	1.5	0.7	4.8	4.3	6.1	5.8
4106	5419.0	5419.5	5425.9	5426.5	5430.8	5431.3	2.5	1.5	4.9	4.4	6.2	5.9
4267	5420.0	5420.0	5426.4	5426.9	5431.1	5431.6	1.4	1.4	4.9	4.6	6.6	6.3
4439	5420.8	5420.8	5426.9	5427.3	5431.7	5432.1	1.7	1.7	4.9	4.6	6.0	5.7



PROFILE

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No.	Revision	By	Date

WARNING
1/2
IF THIS BAR DOES NOT MEASURE 1/2" THE DRAWING IS NOT TO SCALE

BIG HOLE RIVER DIVERSION DAM
REPLACEMENT PROJECT

OPTION 2 PLAN AND PROFILE

WHPacific
11985 W Bryan St., Suite 200
Garden City, ID 83714
703.658.5500 Fax 703.643.7706
www.whpacific.com

DOWL HKM
130 N. Main St.
P.O. Box 3588
Butte, MT 59701-2839
406.723.8213
406.723.5271 (FAX)
dowlhkm.com

Sheet No.
2

Option 2

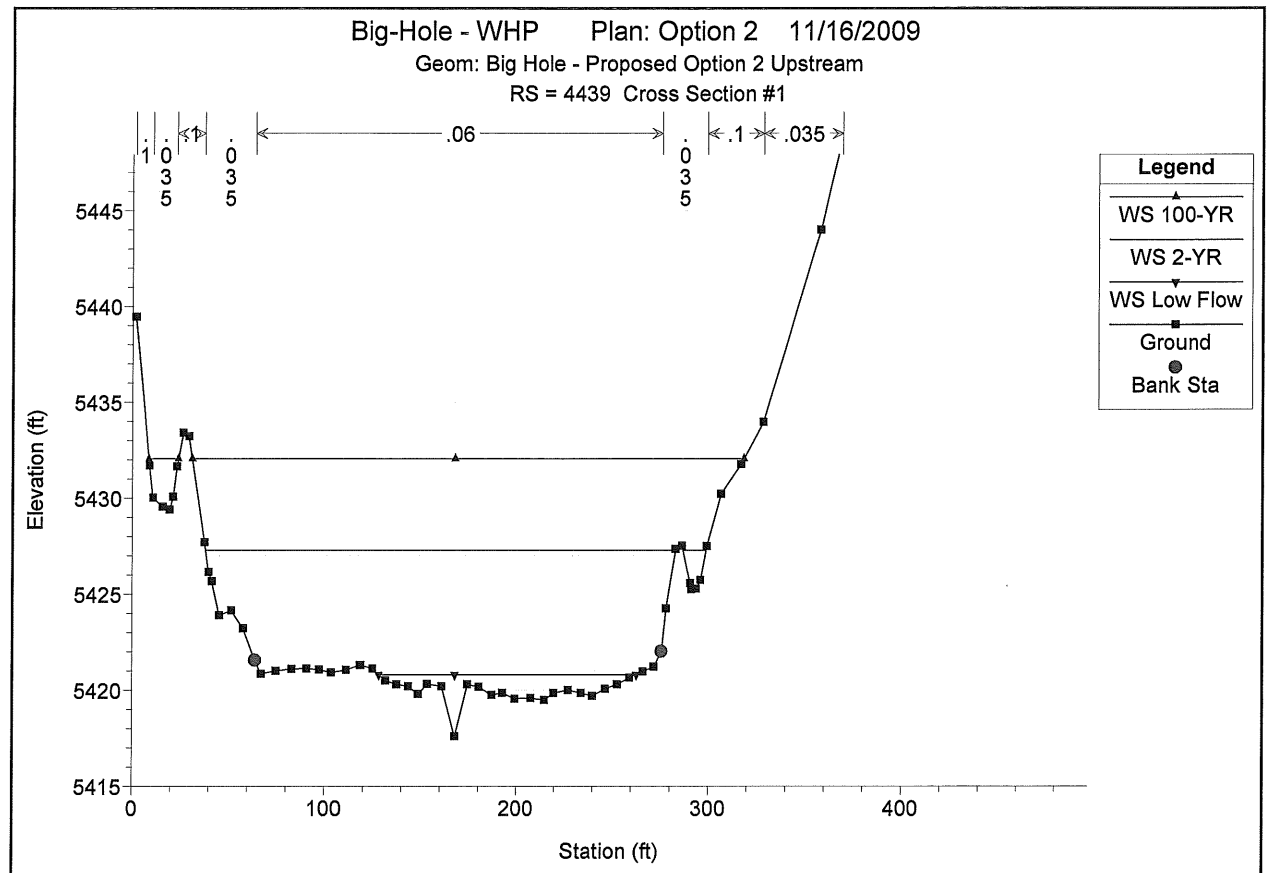
Project: Big Hole - WHP
Plan : Option 2 (.p19)

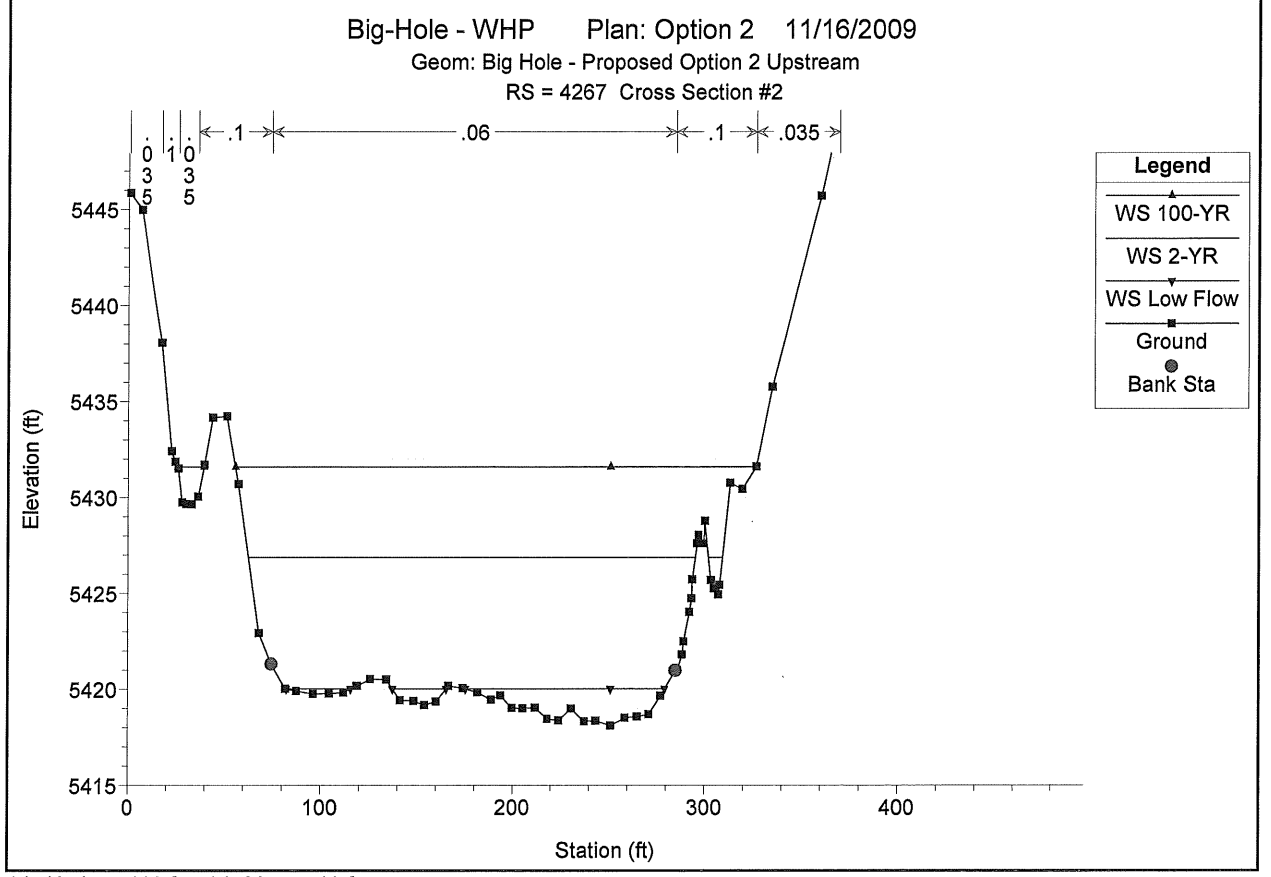
Geometry: Big Hole - Proposed option 2 Upstream (.g04)
Flow : Translated - Flows - No Split (.f09)

HEC-RAS Plan: Option 2 River: Big Hole Reach: Upstream Chl

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	7239.00	5417.62	5427.30	5423.65	5427.62	0.002611	4.59	1587.97	256.44	0.31
Upstream Chl	4439	16712.00	5417.62	5432.07	5426.09	5432.58	0.002016	5.71	2912.97	302.73	0.29
Upstream Chl	4439	200.00	5417.62	5420.82	5420.24	5420.87	0.005122	1.65	121.32	134.11	0.31
Upstream Chl	4267	7239.00	5418.11	5426.88	5422.76	5427.19	0.002337	4.55	1650.34	239.14	0.29
Upstream Chl	4267	16712.00	5418.11	5431.60	5425.22	5432.20	0.002327	6.31	2865.52	284.45	0.32
Upstream Chl	4267	200.00	5418.11	5420.03	5419.22	5420.06	0.004238	1.44	139.23	165.16	0.28
Upstream Chl	4106	7239.00	5417.51	5426.50	5422.68	5426.80	0.002454	4.44	1691.52	267.31	0.30
Upstream Chl	4106	16712.00	5417.51	5431.30	5425.02	5431.82	0.002145	5.90	3039.30	295.56	0.30
Upstream Chl	4106	200.00	5417.51	5419.54	5418.52	5419.57	0.002292	1.47	136.36	98.81	0.22
Upstream Chl	3955	7239.00	5415.73	5426.21	5421.65	5426.49	0.001680	4.32	1773.02	275.92	0.28
Upstream Chl	3955	16712.00	5415.73	5431.05	5424.48	5431.54	0.001488	5.78	3215.52	318.88	0.29
Upstream Chl	3955	200.00	5415.73	5419.48	5417.01	5419.48	0.000235	0.65	307.57	146.73	0.08
Upstream Chl	3802	7239.00	5413.99	5425.96	5420.27	5426.24	0.001636	4.33	1752.96	212.33	0.25
Upstream Chl	3802	16712.00	5413.99	5430.65	5423.29	5431.26	0.002204	6.41	2814.77	241.46	0.30
Upstream Chl	3802	200.00	5413.99	5419.47	5415.38	5419.47	0.000040	0.39	510.56	146.59	0.04
Upstream Chl	3771	7239.00	5413.06	5425.81	5419.54	5426.18	0.001706	5.06	1668.91	201.62	0.27
Upstream Chl	3771	16712.00	5413.06	5430.32	5423.39	5431.16	0.002566	7.79	2634.95	226.29	0.35
Upstream Chl	3771	200.00	5413.06	5419.47	5414.36	5419.47	0.000025	0.35	570.50	122.02	0.03
Upstream Chl	3642	7239.00	5411.07	5425.62	5418.37	5425.97	0.001423	4.95	1627.90	196.23	0.25
Upstream Chl	3642	16712.00	5411.07	5430.09	5422.89	5430.83	0.002087	7.35	2589.96	231.33	0.32
Upstream Chl	3642	200.00	5411.07	5419.46	5412.44	5419.46	0.000013	0.30	668.69	108.95	0.02
Upstream Chl	3518	7239.00	5411.97	5425.52	5417.90	5425.79	0.001122	4.33	1777.86	203.47	0.22
Upstream Chl	3518	16712.00	5411.97	5429.96	5421.46	5430.56	0.001634	6.43	2766.51	261.83	0.28
Upstream Chl	3518	200.00	5411.97	5419.46	5412.99	5419.46	0.000010	0.26	781.86	129.76	0.02
Upstream Chl	3405	7239.00	5412.70	5425.35	5418.57	5425.65	0.001308	4.48	1643.77	171.69	0.23
Upstream Chl	3405	16712.00	5412.70	5429.61	5421.98	5430.34	0.002087	7.00	2442.78	193.29	0.31
Upstream Chl	3405	200.00	5412.70	5419.46	5413.85	5419.46	0.000013	0.28	728.41	142.77	0.02
Upstream Chl	3380	7239.00	5412.90	5425.25	5418.80	5425.61	0.001736	4.91	1514.65	163.93	0.26
Upstream Chl	3380	16712.00	5412.90	5429.38	5422.41	5430.26	0.002939	7.71	2230.38	176.87	0.35
Upstream Chl	3380	200.00	5412.90	5419.46	5413.98	5419.46	0.000016	0.30	675.18	131.79	0.02
Upstream Chl	3379	7239.00	5418.80	5423.63	5423.28	5425.46	0.012802	11.03	671.92	147.33	0.88
Upstream Chl	3379	16712.00	5418.80	5427.16	5426.67	5430.06	0.010465	14.11	1249.29	174.26	0.86
Upstream Chl	3379	200.00	5418.80	5419.31	5419.22	5419.45	0.014612	2.73	70.18	131.32	0.67
Upstream Chl	3378	7239.00	5418.80	5423.28	5423.28	5425.42	0.016502	11.92	620.20	146.11	0.99
Upstream Chl	3378	16712.00	5418.80	5426.67	5426.67	5430.01	0.012956	15.12	1164.17	173.68	0.95
Upstream Chl	3378	200.00	5418.80	5419.22	5419.22	5419.43	0.026503	3.24	58.27	130.94	0.88
Upstream Chl	3368	7239.00	5412.90	5422.66	5418.72	5423.21	0.003548	5.99	1224.01	163.03	0.37
Upstream Chl	3368	16712.00	5412.90	5426.40	5421.96	5427.65	0.004993	9.11	1874.33	187.89	0.46
Upstream Chl	3368	200.00	5412.90	5415.50	5414.03	5415.52	0.001023	1.08	185.04	115.72	0.15
Upstream Chl	3353	7239.00	5413.00	5422.14	5419.48	5423.09	0.009418	7.86	931.74	167.12	0.57
Upstream Chl	3353	16712.00	5413.00	5425.77	5423.38	5427.51	0.009399	10.78	1637.99	291.43	0.61
Upstream Chl	3353	200.00	5413.00	5415.48	5413.97	5415.50	0.001155	1.24	160.82	120.91	0.16
Upstream Chl	3112	7239.00	5413.21	5420.93	5417.93	5421.45	0.004482	5.80	1270.70	199.75	0.40
Upstream Chl	3112	16712.00	5413.21	5424.52	5420.59	5425.62	0.005461	8.55	2052.31	284.83	0.47
Upstream Chl	3112	200.00	5413.21	5415.05	5414.13	5415.08	0.002991	1.35	148.52	149.30	0.24
Upstream Chl	2911	7239.00	5412.42	5420.06	5417.13	5420.55	0.004377	5.65	1329.99	232.29	0.39
Upstream Chl	2911	16712.00	5412.42	5423.61	5419.76	5424.54	0.004844	7.97	2290.33	379.56	0.45
Upstream Chl	2911	200.00	5412.42	5414.05	5413.54	5414.11	0.008912	1.97	101.61	131.35	0.39
Upstream Chl	2765	7239.00	5411.40	5419.47	5416.55	5419.94	0.003904	5.62	1328.01	244.84	0.38
Upstream Chl	2765	16712.00	5411.40	5423.08	5419.21	5423.87	0.003906	7.43	2369.70	402.87	0.40
Upstream Chl	2765	200.00	5411.40	5413.24	5412.59	5413.28	0.003899	1.53	130.41	131.67	0.27

11/16/09





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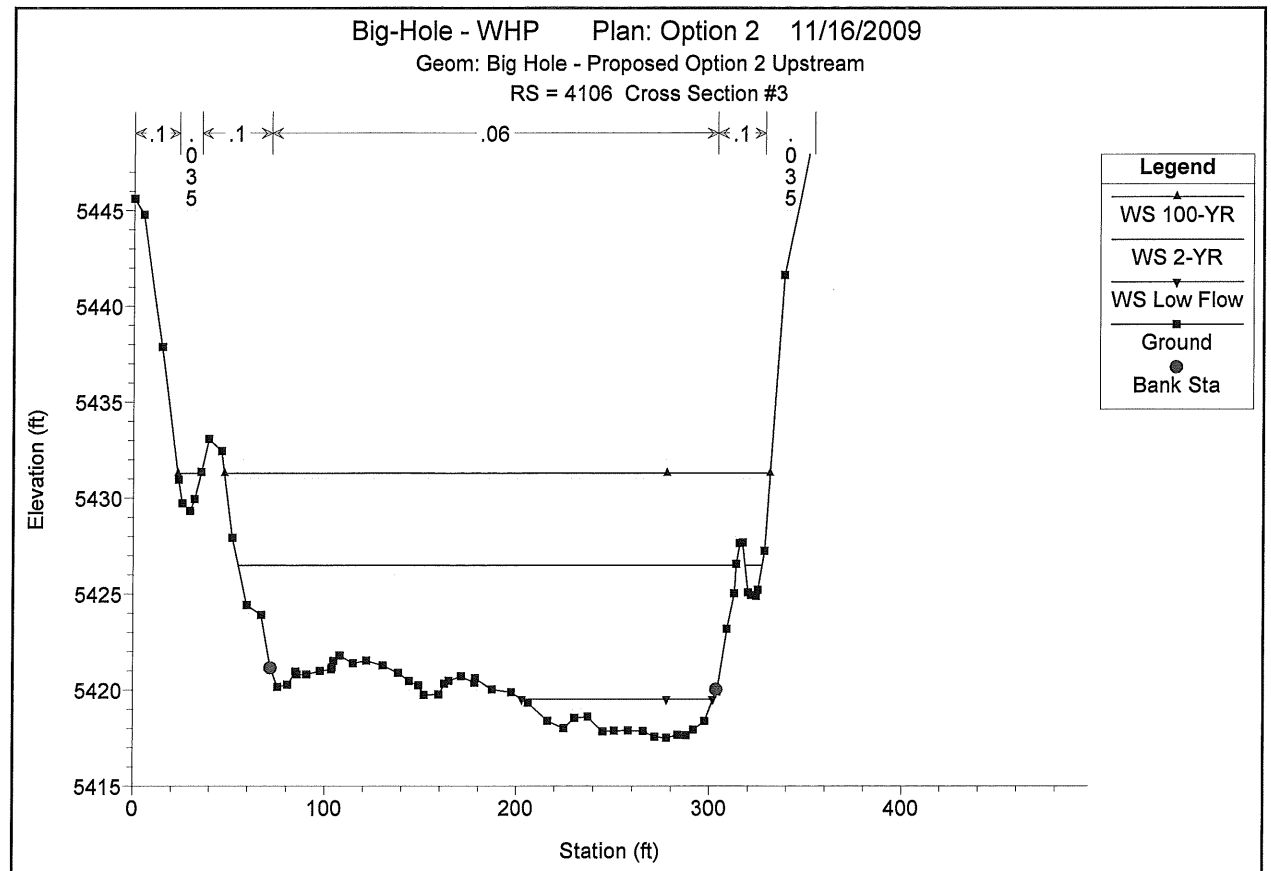

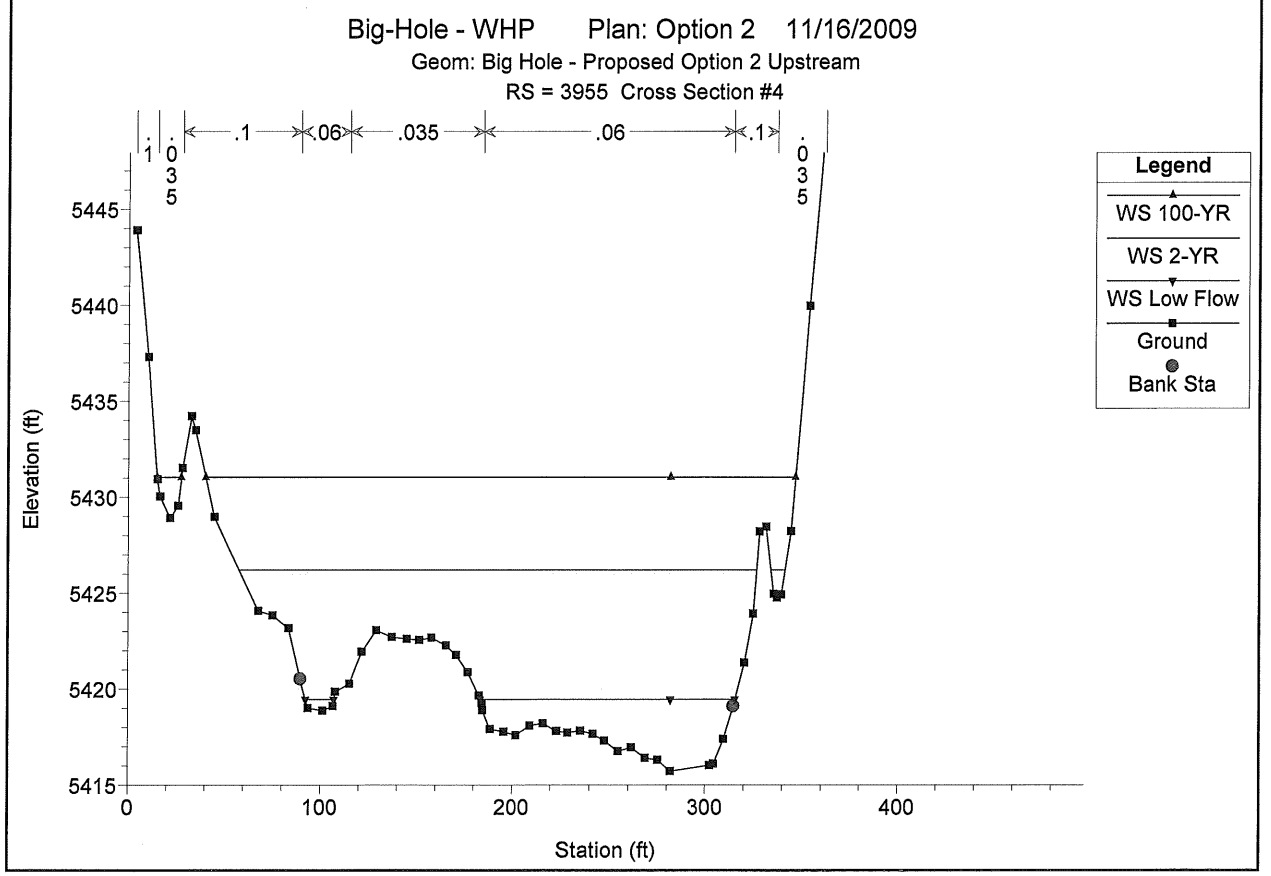

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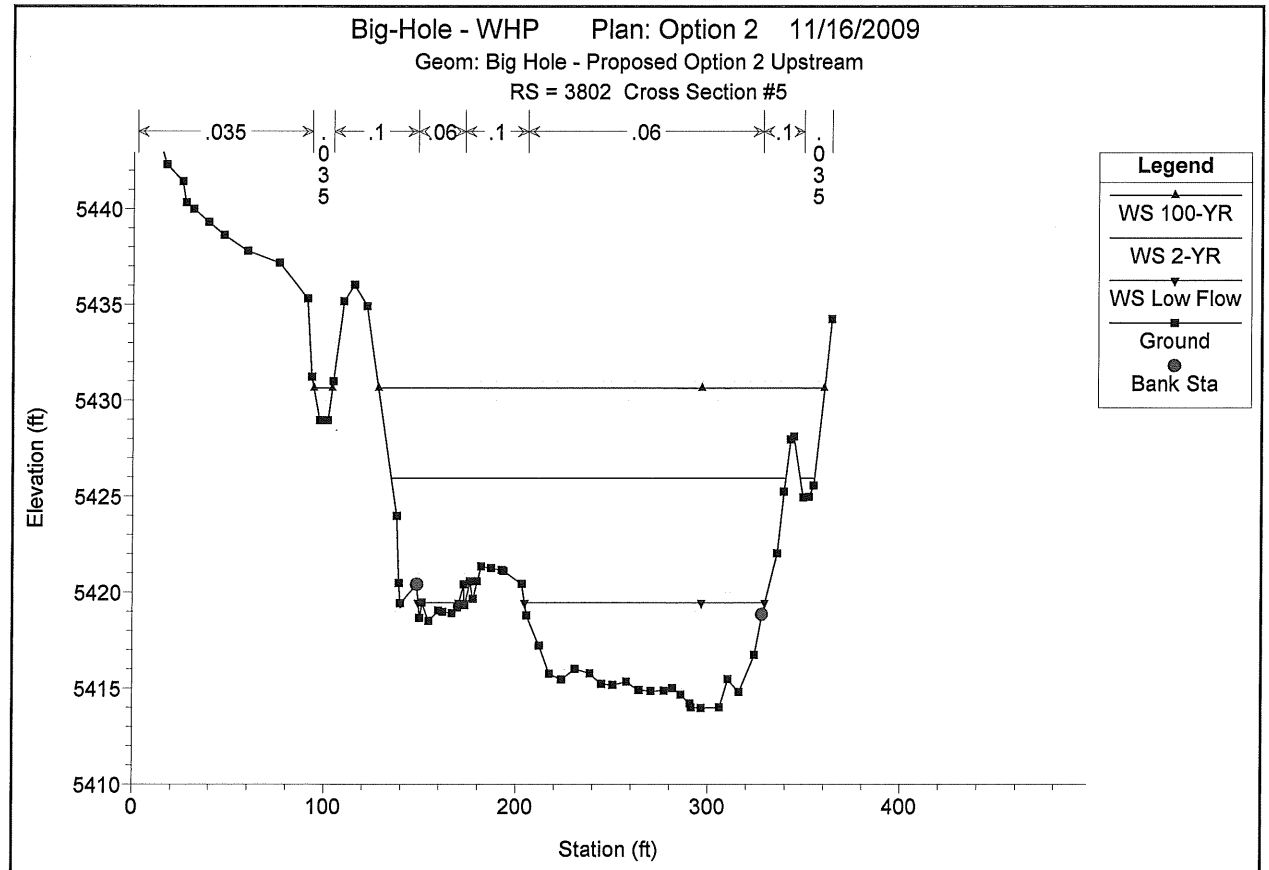

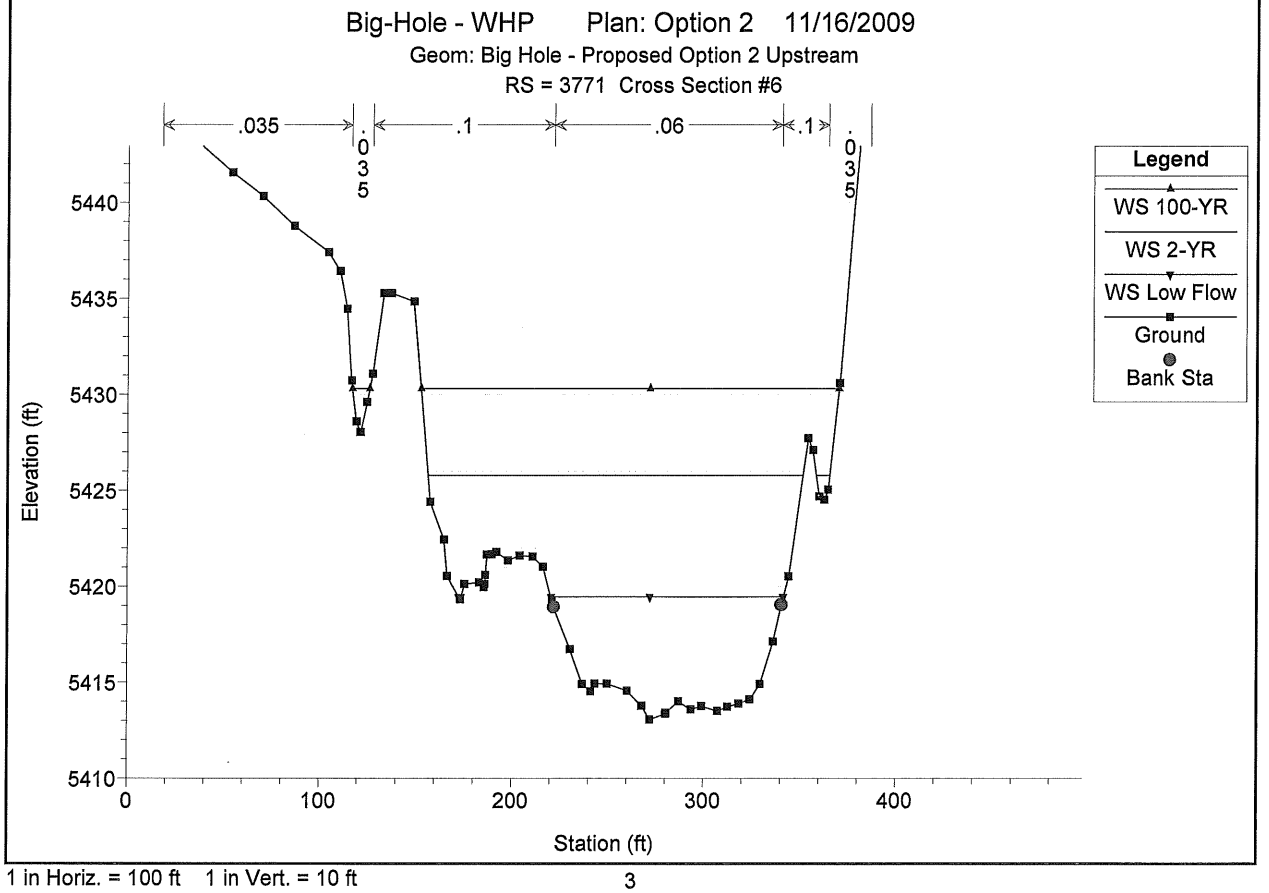

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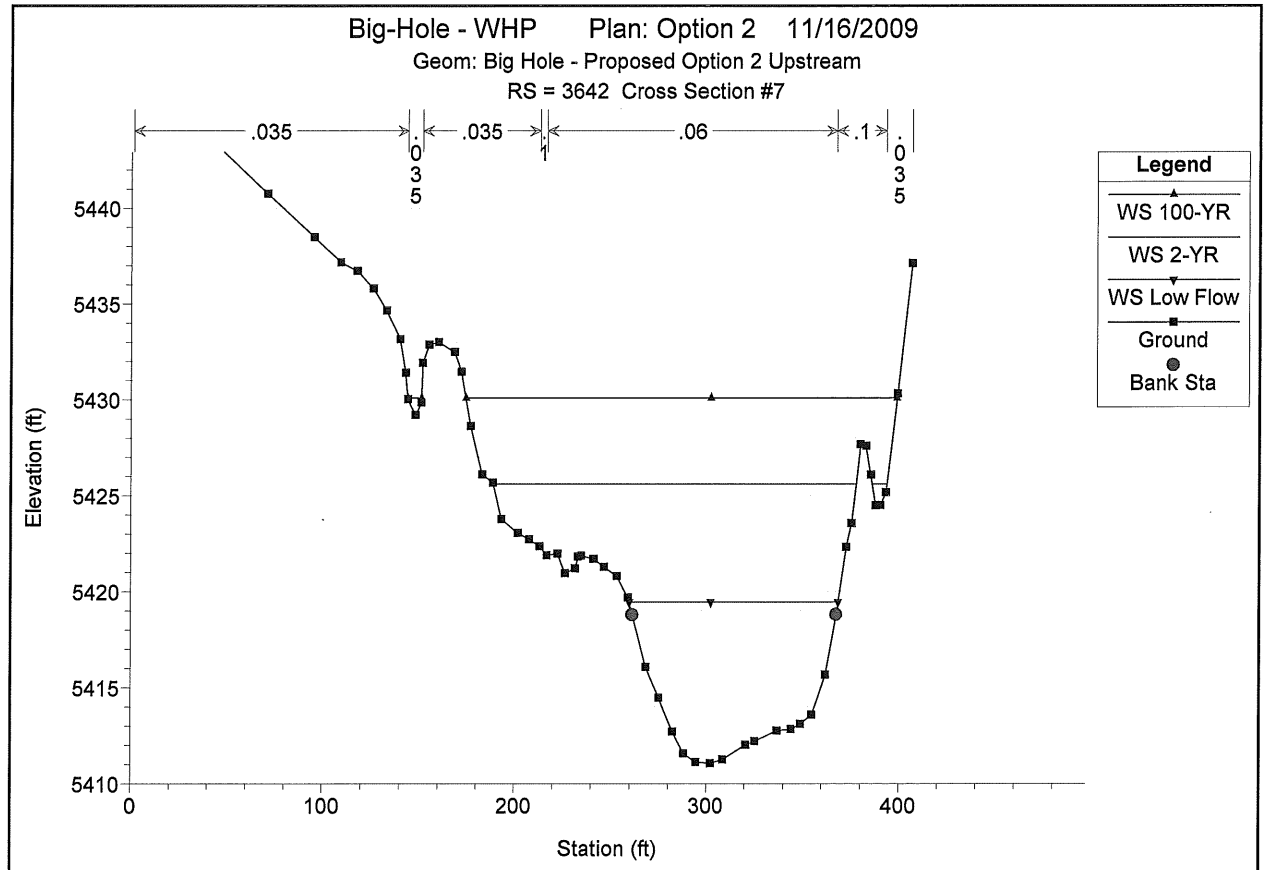

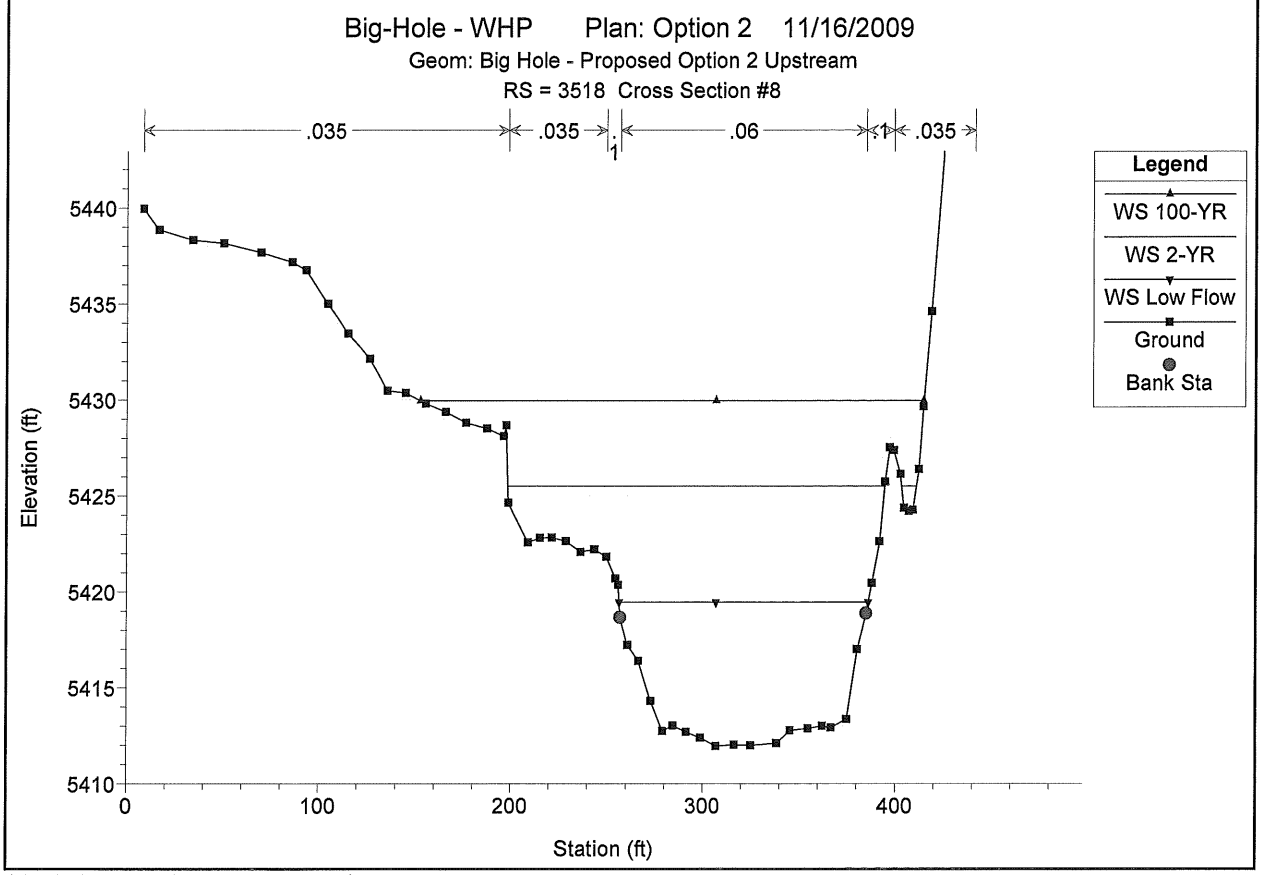

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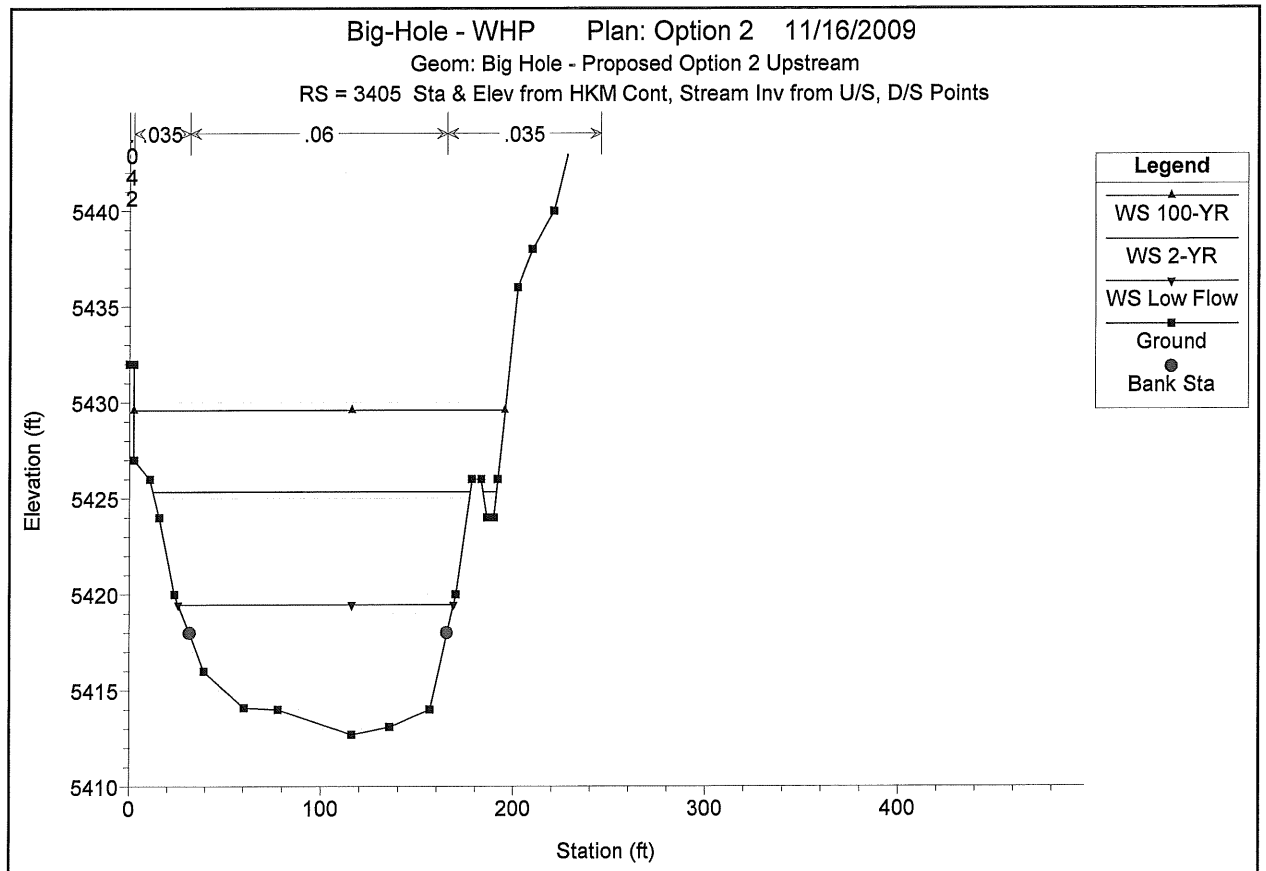

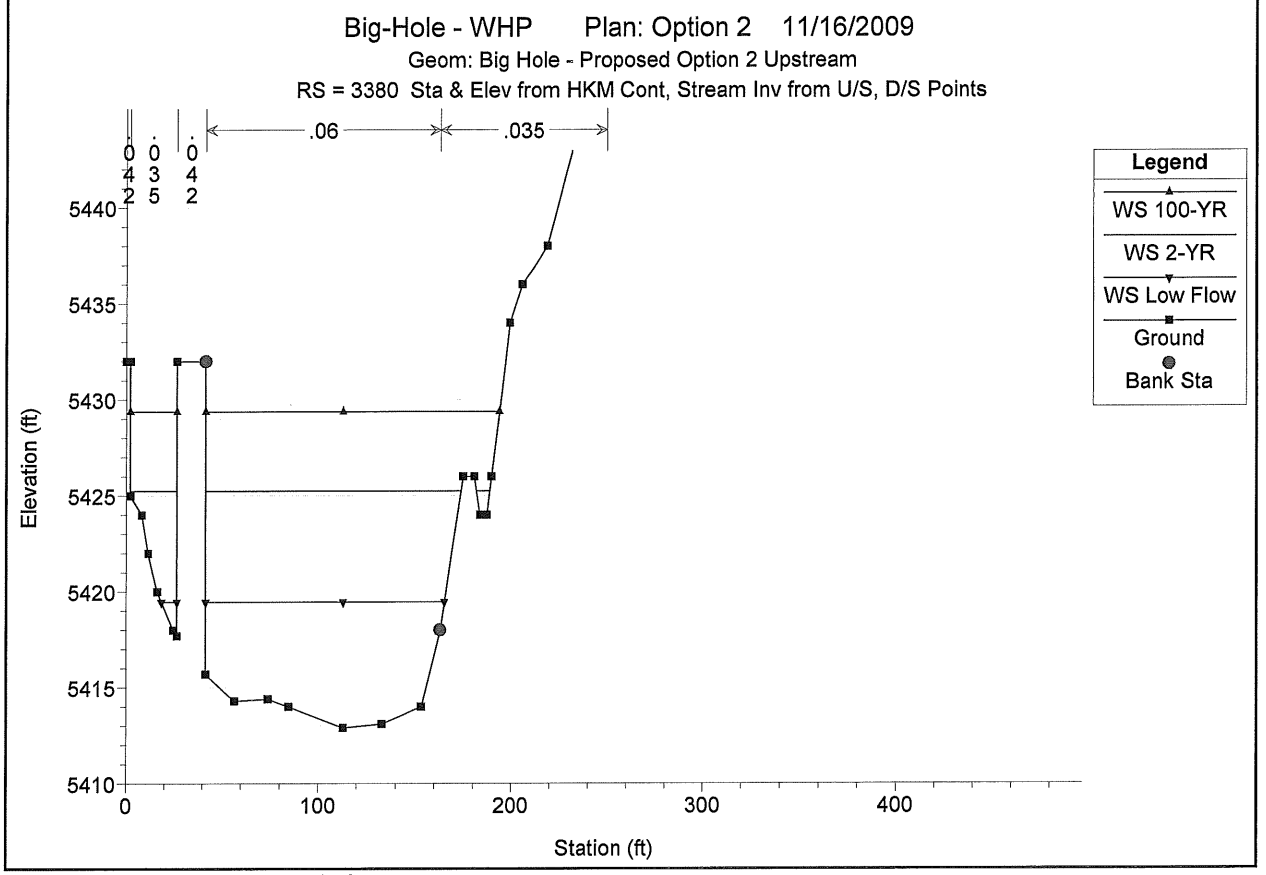

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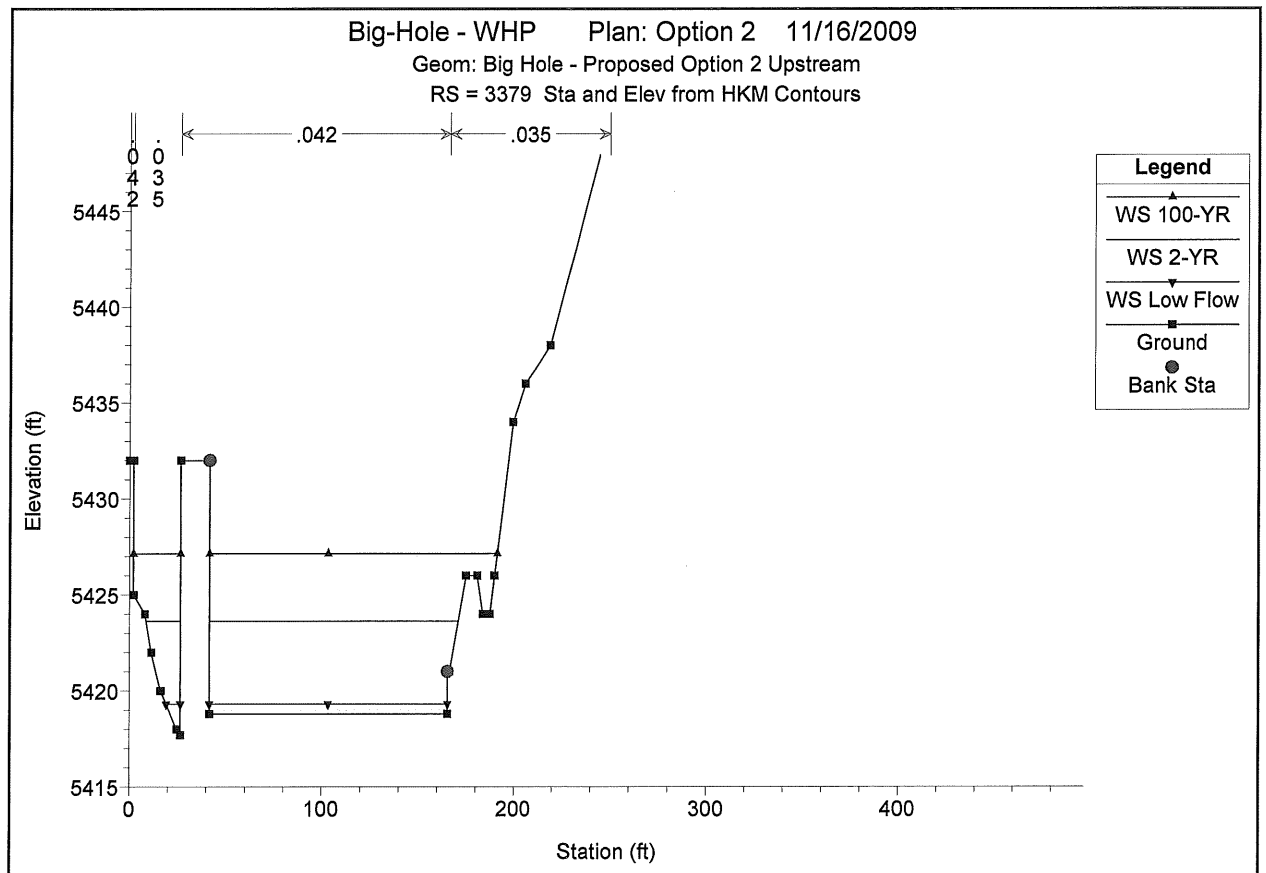

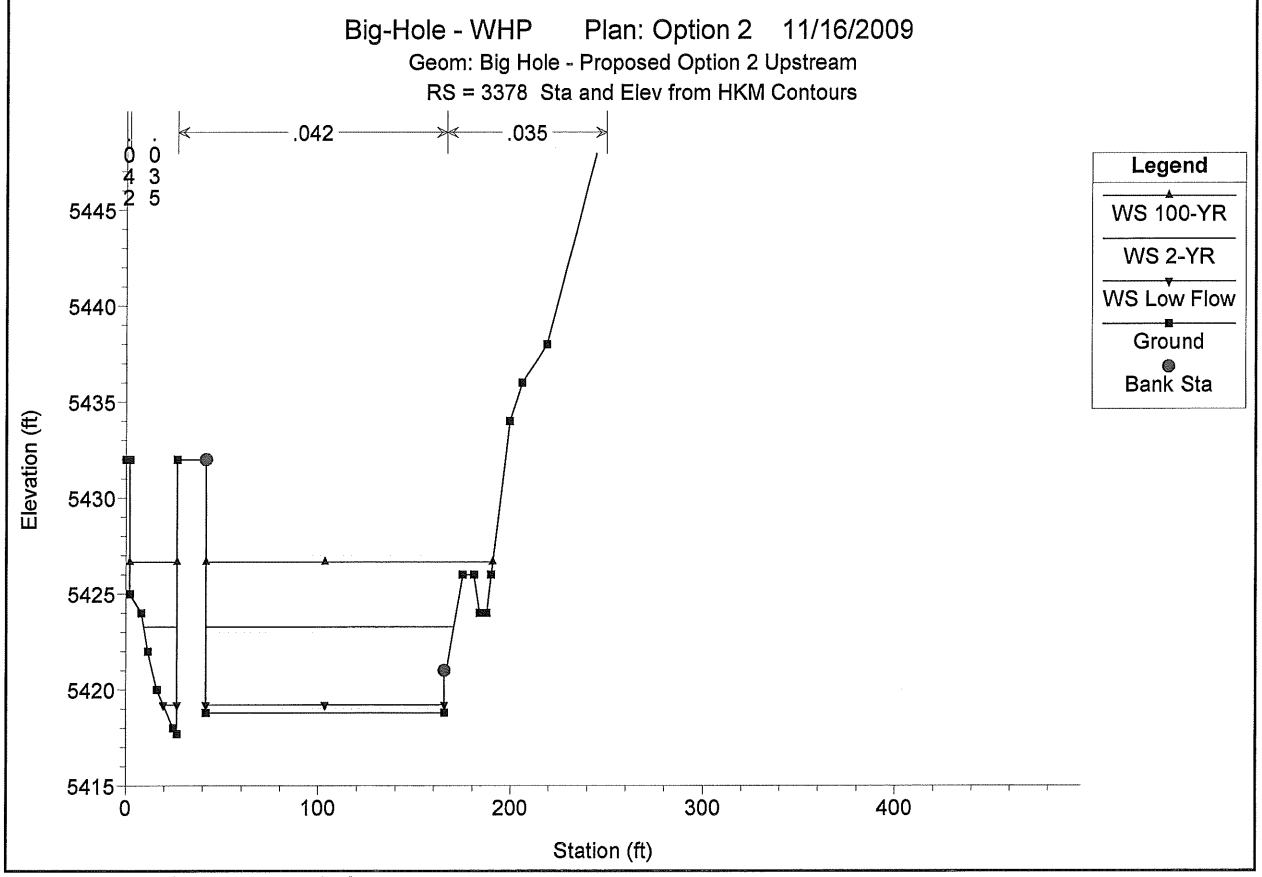

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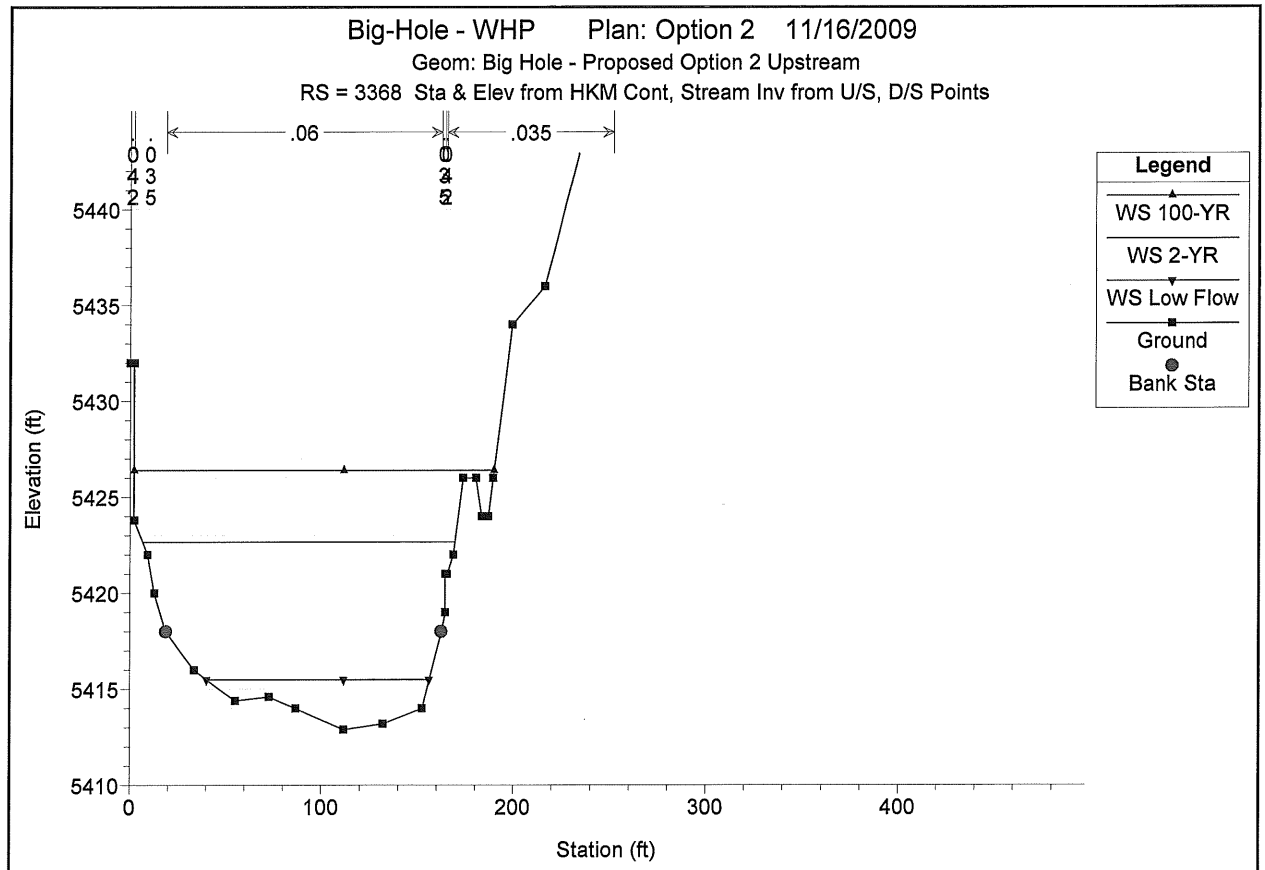

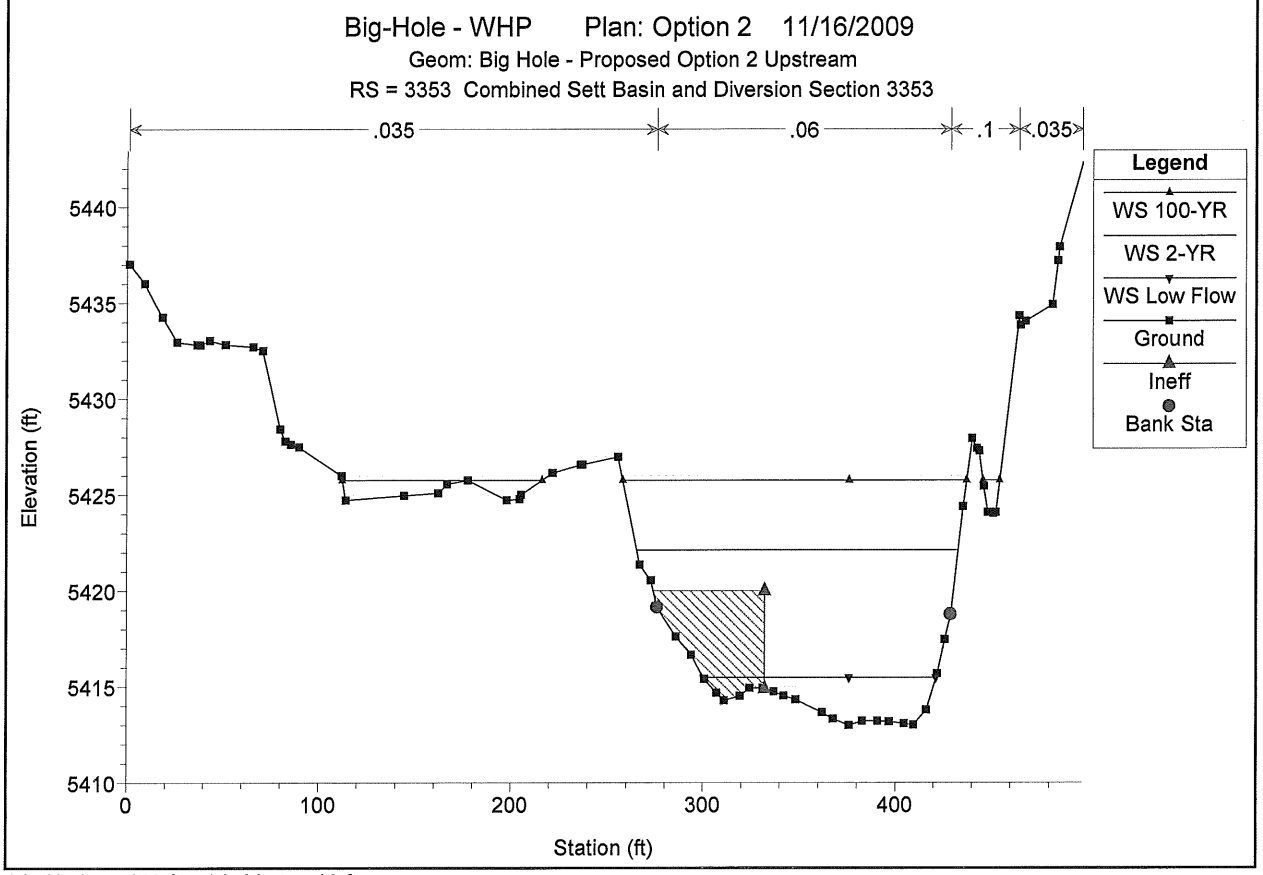

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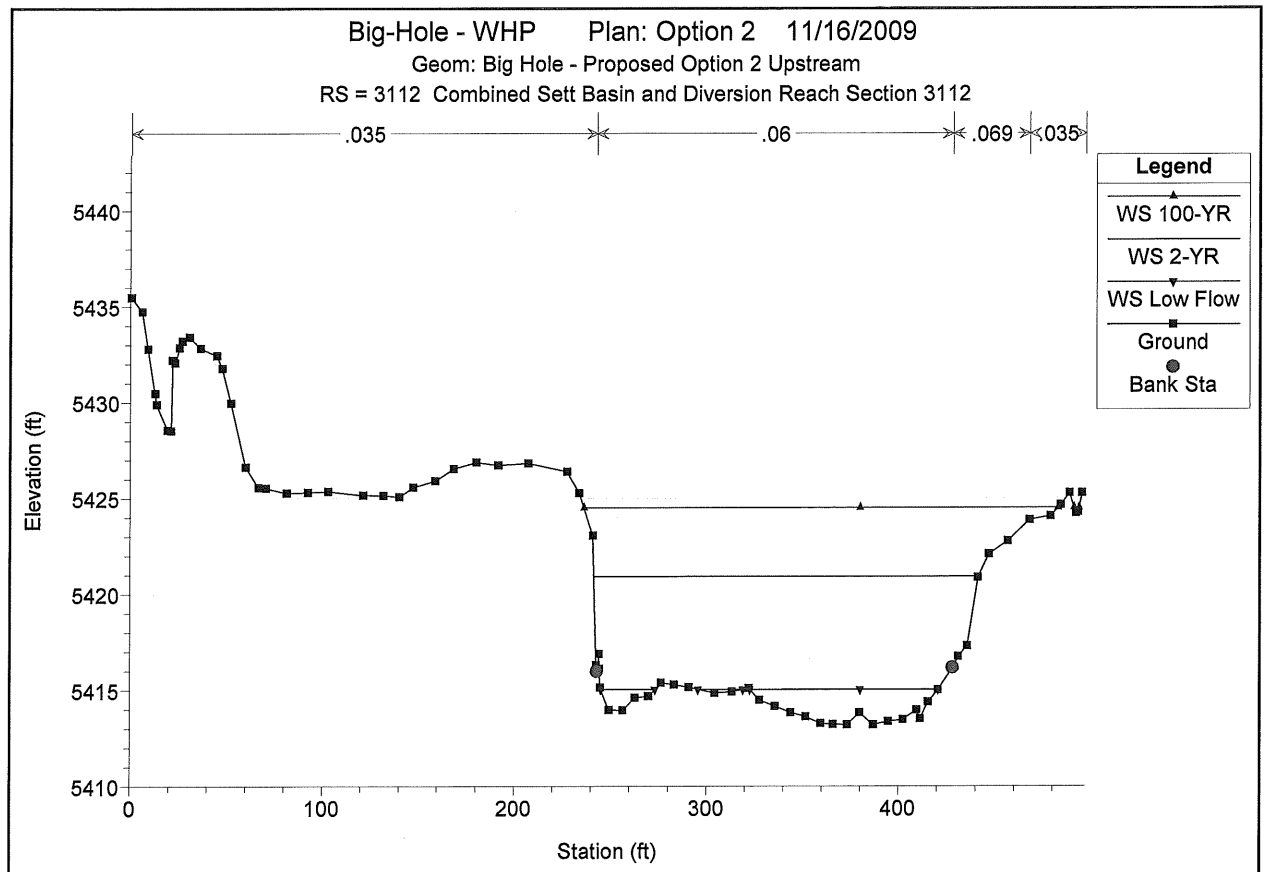

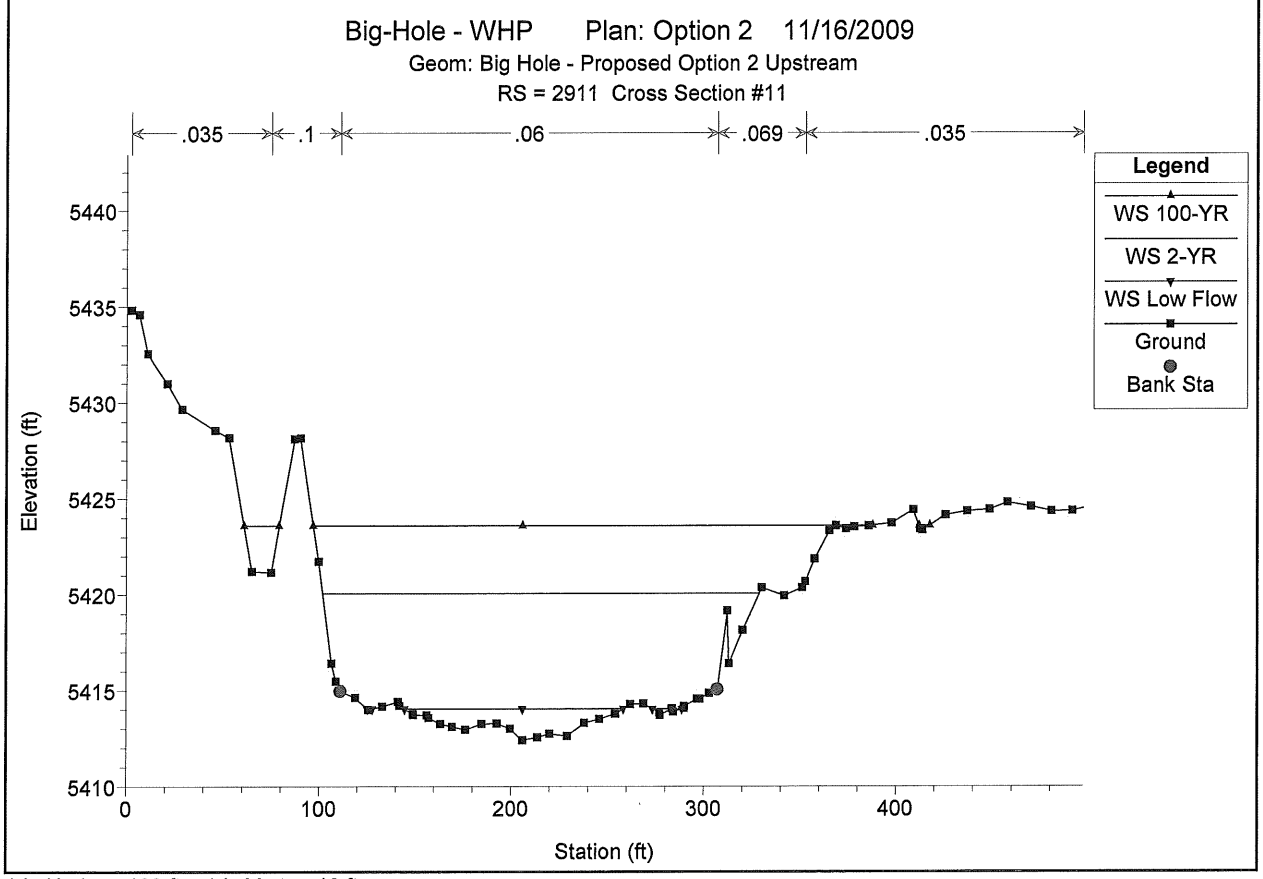

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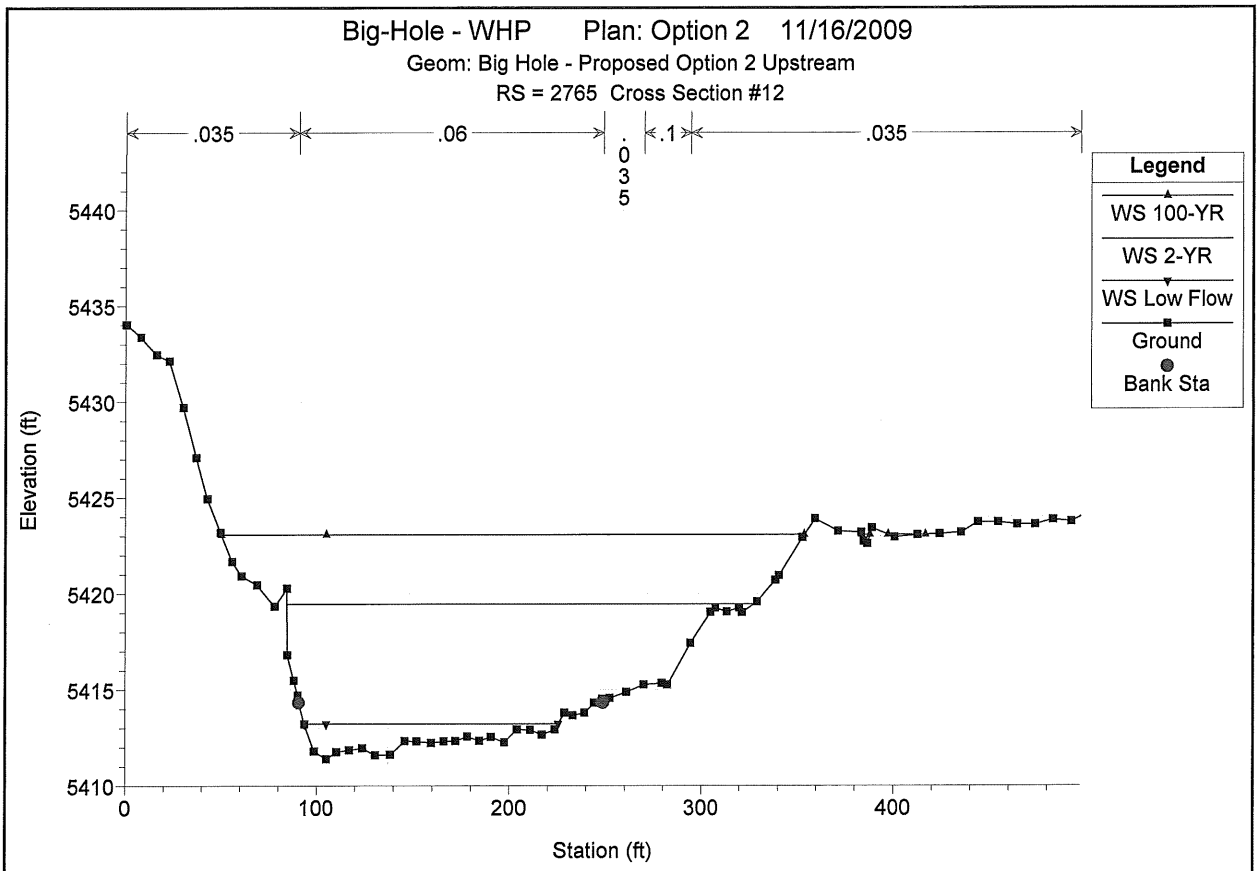
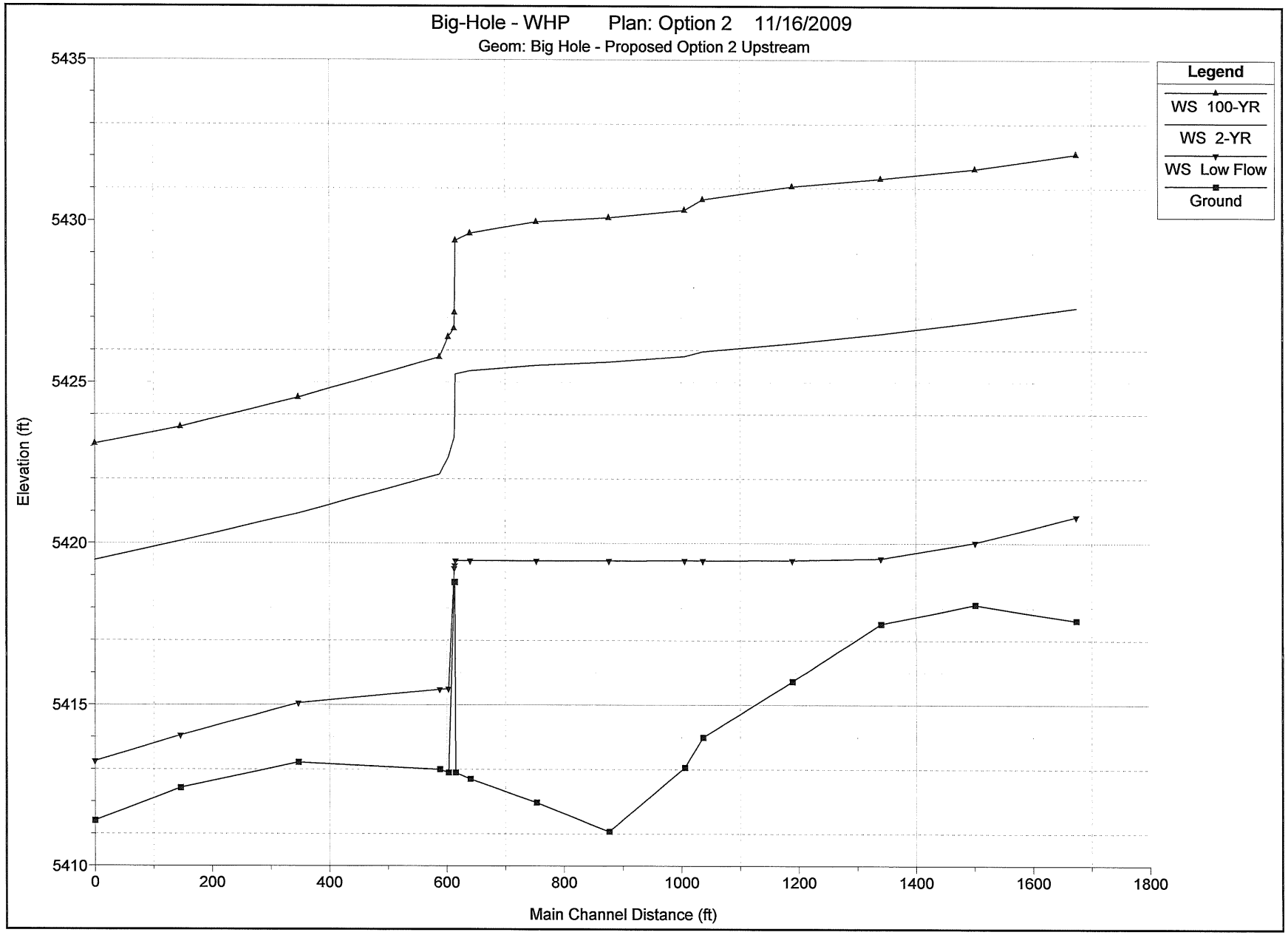


1 in Horiz. = 100 ft 1 in Vert. = 10 ft


Big-Hole - WHP Plan: Option 2 11/16/2009
Geom: Big Hole - Proposed Option 2 Upstream
Legend
WS 100-YR
WS 2-YR
WS Low Flow
Ground
Elevation (ft)
5435
5430
5425
5420
5415
5410
0
200
400
600
800
1000
1200
1400
1600
1800
Main Channel Distance (ft)

OPTION 2

PROJECT: BIG HOLE - WHP
PLAN: OPTION 2 FULLY OPEN (.p15)

GEOMETRY: OPTION 2 FULLY OPEN (.g15)
FLOW: INTAKE STRUCTURE FLOWS (.f08)

HEC-RAS Plan: Opt 2 Fully River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	200 cfs	200	5417.62	5420.8	5420.2	5420.87	0.005113	1.6	121.4	134.1	0.31
Upstream Chl	4439	500 cfs	500	5417.62	5421.5	5420.7	5421.57	0.005628	2.1	243.7	208.8	0.33
Upstream Chl	4439	750 cfs	750	5417.62	5421.9	5420.9	5421.98	0.004862	2.3	326.4	212.2	0.33
Upstream Chl	4439	1000 cfs	1000	5417.62	5422.2	5421.2	5422.34	0.004415	2.5	400.2	214.4	0.32
Upstream Chl	4439	1250 cfs	1250	5417.62	5422.6	5421.4	5422.67	0.004112	2.7	467.9	215.9	0.32
Upstream Chl	4439	1500 cfs	1500	5417.62	5422.8	5421.5	5422.97	0.003899	2.8	531.0	217.2	0.32
Upstream Chl	4439	1750 cfs	1750	5417.62	5423.1	5421.6	5423.25	0.003775	3.0	588.8	218.5	0.32
Upstream Chl	4439	2000 cfs	2000	5417.62	5423.4	5421.7	5423.51	0.003669	3.1	644.2	220.1	0.32
Upstream Chl	4439	2500 cfs	2500	5417.62	5423.8	5422.0	5424.02	0.003483	3.3	750.2	223.8	0.32
Upstream Chl	4439	3000 cfs	3000	5417.62	5424.3	5422.2	5424.48	0.003342	3.6	852.1	233.5	0.32
Upstream Chl	4439	6000 cfs	6000	5417.62	5426.6	5423.3	5426.85	0.002676	4.3	1402.0	251.4	0.30
Upstream Chl	4267	200 cfs	200	5418.11	5420.0	5419.2	5420.06	0.004281	1.4	138.7	164.8	0.28
Upstream Chl	4267	500 cfs	500	5418.11	5420.8	5419.7	5420.89	0.002908	1.7	295.5	206.7	0.25
Upstream Chl	4267	750 cfs	750	5418.11	5421.3	5420.0	5421.38	0.002536	1.9	395.8	212.0	0.24
Upstream Chl	4267	1000 cfs	1000	5418.11	5421.7	5420.2	5421.78	0.002390	2.1	479.9	214.8	0.24
Upstream Chl	4267	1250 cfs	1250	5418.11	5422.0	5420.4	5422.13	0.002366	2.3	551.6	216.7	0.25
Upstream Chl	4267	1500 cfs	1500	5418.11	5422.4	5420.6	5422.45	0.002349	2.4	618.2	218.2	0.25
Upstream Chl	4267	1750 cfs	1750	5418.11	5422.6	5420.7	5422.73	0.002376	2.6	677.3	219.7	0.26
Upstream Chl	4267	2000 cfs	2000	5418.11	5422.9	5420.8	5423.00	0.002385	2.8	734.7	221.3	0.26
Upstream Chl	4267	2500 cfs	2500	5418.11	5423.4	5421.1	5423.51	0.002387	3.0	843.2	223.1	0.27
Upstream Chl	4267	3000 cfs	3000	5418.11	5423.8	5421.3	5423.99	0.002380	3.2	944.9	224.6	0.27
Upstream Chl	4267	6000 cfs	6000	5418.11	5426.2	5422.4	5426.42	0.002271	4.2	1478.2	235.7	0.29
Upstream Chl	4106	200 cfs	200	5417.51	5419.5	5418.5	5419.56	0.002361	1.5	135.0	98.5	0.22
Upstream Chl	4106	500 cfs	500	5417.51	5420.2	5419.0	5420.29	0.004818	2.3	213.5	134.3	0.33
Upstream Chl	4106	750 cfs	750	5417.51	5420.7	5419.3	5420.79	0.005696	2.6	286.0	172.0	0.36
Upstream Chl	4106	1000 cfs	1000	5417.51	5421.1	5419.6	5421.21	0.005730	2.8	362.4	202.7	0.36
Upstream Chl	4106	1250 cfs	1250	5417.51	5421.5	5419.9	5421.58	0.005293	2.9	436.9	218.3	0.36
Upstream Chl	4106	1500 cfs	1500	5417.51	5421.8	5420.2	5421.91	0.004941	2.9	512.7	235.5	0.35
Upstream Chl	4106	1750 cfs	1750	5417.51	5422.1	5420.4	5422.22	0.004410	3.0	583.3	237.0	0.34
Upstream Chl	4106	2000 cfs	2000	5417.51	5422.4	5420.6	5422.51	0.004034	3.1	650.0	238.0	0.33
Upstream Chl	4106	2500 cfs	2500	5417.51	5422.9	5420.9	5423.05	0.003534	3.3	775.2	239.7	0.32
Upstream Chl	4106	3000 cfs	3000	5417.51	5423.4	5421.2	5423.54	0.003232	3.4	890.6	241.4	0.31
Upstream Chl	4106	6000 cfs	6000	5417.51	5425.8	5422.3	5426.04	0.002455	4.1	1499.2	263.3	0.29
Upstream Chl	3955	200 cfs	200	5415.73	5419.5	5417.0	5419.47	0.000240	0.7	305.3	146.6	0.08
Upstream Chl	3955	500 cfs	500	5415.73	5420.0	5417.7	5420.05	0.000701	1.3	390.4	155.4	0.14
Upstream Chl	3955	750 cfs	750	5415.73	5420.4	5418.1	5420.47	0.000996	1.7	454.8	164.5	0.17
Upstream Chl	3955	1000 cfs	1000	5415.73	5420.8	5418.4	5420.85	0.001213	2.0	515.3	169.3	0.19
Upstream Chl	3955	1250 cfs	1250	5415.73	5421.1	5418.6	5421.20	0.001381	2.2	572.2	174.2	0.21
Upstream Chl	3955	1500 cfs	1500	5415.73	5421.4	5418.8	5421.52	0.001507	2.4	627.2	179.1	0.22
Upstream Chl	3955	1750 cfs	1750	5415.73	5421.7	5419.0	5421.83	0.001605	2.6	680.5	183.4	0.23
Upstream Chl	3955	2000 cfs	2000	5415.73	5422.0	5419.1	5422.12	0.001684	2.8	732.2	188.5	0.24
Upstream Chl	3955	2500 cfs	2500	5415.73	5422.5	5419.4	5422.67	0.001799	3.0	833.8	202.0	0.26
Upstream Chl	3955	3000 cfs	3000	5415.73	5423.0	5419.7	5423.17	0.001872	3.2	942.7	237.8	0.28
Upstream Chl	3955	6000 cfs	6000	5415.73	5425.5	5421.1	5425.73	0.001648	4.0	1575.9	270.1	0.27
Upstream Chl	3802	200 cfs	200	5413.99	5419.5	5415.4	5419.45	0.000041	0.4	508.3	146.2	0.04
Upstream Chl	3802	500 cfs	500	5413.99	5420.0	5415.9	5420.00	0.000166	0.9	590.5	158.3	0.08
Upstream Chl	3802	750 cfs	750	5413.99	5420.4	5416.2	5420.39	0.000282	1.2	652.2	167.3	0.10
Upstream Chl	3802	1000 cfs	1000	5413.99	5420.7	5416.5	5420.74	0.000395	1.4	710.6	174.3	0.12
Upstream Chl	3802	1250 cfs	1250	5413.99	5421.0	5416.7	5421.07	0.000502	1.7	766.1	180.6	0.14
Upstream Chl	3802	1500 cfs	1500	5413.99	5421.3	5416.9	5421.37	0.000601	1.9	821.0	193.3	0.15
Upstream Chl	3802	1750 cfs	1750	5413.99	5421.6	5417.1	5421.67	0.000690	2.0	875.9	196.1	0.17
Upstream Chl	3802	2000 cfs	2000	5413.99	5421.9	5417.3	5421.94	0.000770	2.2	928.3	196.8	0.17
Upstream Chl	3802	2500 cfs	2500	5413.99	5422.4	5417.6	5422.47	0.000911	2.5	1027.4	197.8	0.19
Upstream Chl	3802	3000 cfs	3000	5413.99	5422.8	5418.0	5422.95	0.001032	2.8	1119.3	198.4	0.20
Upstream Chl	3802	6000 cfs	6000	5413.99	5425.3	5419.7	5425.49	0.001447	3.9	1606.9	207.6	0.24
Upstream Chl	3771	200 cfs	200	5413.06	5419.4	5414.4	5419.45	0.000025	0.4	568.6	121.8	0.03
Upstream Chl	3771	500 cfs	500	5413.06	5420.0	5415.0	5420.00	0.000111	0.8	636.2	129.4	0.06
Upstream Chl	3771	750 cfs	750	5413.06	5420.4	5415.3	5420.38	0.000199	1.1	687.8	144.2	0.08
Upstream Chl	3771	1000 cfs	1000	5413.06	5420.7	5415.6	5420.73	0.000291	1.4	737.2	147.1	0.10
Upstream Chl	3771	1250 cfs	1250	5413.06	5421.0	5415.8	5421.05	0.000383	1.6	782.9	148.9	0.12
Upstream Chl	3771	1500 cfs	1500	5413.06	5421.3	5416.0	5421.36	0.000473	1.9	826.8	152.6	0.13
Upstream Chl	3771	1750 cfs	1750	5413.06	5421.6	5416.3	5421.65	0.000560	2.1	870.1	166.0	0.14
Upstream Chl	3771	2000 cfs	2000	5413.06	5421.8	5416.5	5421.92	0.000645	2.3	915.9	180.5	0.15
Upstream Chl	3771	2500 cfs	2500	5413.06	5422.3	5416.8	5422.44	0.000796	2.7	1004.6	181.6	0.17
Upstream Chl	3771	3000 cfs	3000	5413.06	5422.8	5417.2	5422.92	0.000933	3.0	1087.0	183.5	0.19
Upstream Chl	3771	6000 cfs	6000	5413.06	5425.1	5418.9	5425.44	0.001471	4.5	1535.8	198.4	0.25
Upstream Chl	3642	200 cfs	200	5411.07	5419.4	5412.4	5419.45	0.000013	0.3	667.0	108.9	0.02

11/16/09

HEC-RAS Plan: Opt 2 Fully River: Big Hole Reach: Upstream Chl (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3642	500 cfs	500	5411.07	5420.0	5413.2	5419.99	0.000062	0.7	725.5	111.8	0.05
Upstream Chl	3642	750 cfs	750	5411.07	5420.3	5413.6	5420.36	0.000117	1.0	767.2	114.2	0.06
Upstream Chl	3642	1000 cfs	1000	5411.07	5420.7	5413.9	5420.70	0.000179	1.3	805.2	116.5	0.08
Upstream Chl	3642	1250 cfs	1250	5411.07	5421.0	5414.2	5421.01	0.000245	1.5	840.6	120.0	0.09
Upstream Chl	3642	1500 cfs	1500	5411.07	5421.3	5414.4	5421.31	0.000313	1.7	876.0	130.5	0.11
Upstream Chl	3642	1750 cfs	1750	5411.07	5421.5	5414.7	5421.58	0.000381	2.0	911.4	136.0	0.12
Upstream Chl	3642	2000 cfs	2000	5411.07	5421.8	5414.9	5421.85	0.000450	2.2	946.3	142.6	0.13
Upstream Chl	3642	2500 cfs	2500	5411.07	5422.2	5415.4	5422.35	0.000582	2.6	1018.7	158.9	0.15
Upstream Chl	3642	3000 cfs	3000	5411.07	5422.7	5415.8	5422.81	0.000705	2.9	1089.0	165.2	0.17
Upstream Chl	3642	6000 cfs	6000	5411.07	5425.0	5417.7	5425.26	0.001212	4.4	1503.7	191.6	0.23
Upstream Chl	3518	200 cfs	200	5411.97	5419.4	5413.0	5419.45	0.000010	0.3	779.8	129.7	0.02
Upstream Chl	3518	500 cfs	500	5411.97	5420.0	5413.5	5419.98	0.000047	0.6	848.6	131.0	0.04
Upstream Chl	3518	750 cfs	750	5411.97	5420.3	5413.7	5420.35	0.000088	0.8	896.4	131.8	0.06
Upstream Chl	3518	1000 cfs	1000	5411.97	5420.7	5414.0	5420.68	0.000135	1.1	939.5	133.8	0.07
Upstream Chl	3518	1250 cfs	1250	5411.97	5421.0	5414.2	5420.98	0.000185	1.3	979.2	135.5	0.08
Upstream Chl	3518	1500 cfs	1500	5411.97	5421.2	5414.4	5421.27	0.000236	1.5	1017.0	137.2	0.09
Upstream Chl	3518	1750 cfs	1750	5411.97	5421.5	5414.7	5421.54	0.000288	1.7	1052.9	138.7	0.10
Upstream Chl	3518	2000 cfs	2000	5411.97	5421.7	5414.9	5421.80	0.000340	1.9	1087.3	140.2	0.11
Upstream Chl	3518	2500 cfs	2500	5411.97	5422.2	5415.2	5422.28	0.000443	2.2	1153.9	155.3	0.13
Upstream Chl	3518	3000 cfs	3000	5411.97	5422.6	5415.6	5422.73	0.000543	2.5	1221.8	164.2	0.15
Upstream Chl	3518	6000 cfs	6000	5411.97	5424.9	5417.3	5425.11	0.000954	3.9	1651.2	201.1	0.20
Upstream Chl	3405	200 cfs	200	5412.70	5419.4	5413.8	5419.45	0.000013	0.3	726.2	142.7	0.02
Upstream Chl	3405	500 cfs	500	5412.70	5420.0	5414.4	5419.97	0.000061	0.6	801.5	146.0	0.05
Upstream Chl	3405	750 cfs	750	5412.70	5420.3	5414.7	5420.34	0.000112	0.9	854.0	147.3	0.06
Upstream Chl	3405	1000 cfs	1000	5412.70	5420.6	5414.9	5420.66	0.000168	1.1	901.2	148.4	0.08
Upstream Chl	3405	1250 cfs	1250	5412.70	5420.9	5415.2	5420.96	0.000226	1.3	944.2	149.3	0.09
Upstream Chl	3405	1500 cfs	1500	5412.70	5421.2	5415.4	5421.24	0.000284	1.5	984.6	150.2	0.10
Upstream Chl	3405	1750 cfs	1750	5412.70	5421.5	5415.6	5421.50	0.000342	1.7	1022.9	151.1	0.11
Upstream Chl	3405	2000 cfs	2000	5412.70	5421.7	5415.8	5421.75	0.000400	1.9	1059.4	151.9	0.12
Upstream Chl	3405	2500 cfs	2500	5412.70	5422.1	5416.1	5422.22	0.000511	2.2	1127.9	153.4	0.14
Upstream Chl	3405	3000 cfs	3000	5412.70	5422.6	5416.4	5422.66	0.000617	2.5	1191.8	154.8	0.15
Upstream Chl	3405	6000 cfs	6000	5412.70	5424.8	5418.0	5424.99	0.001091	3.9	1543.3	167.9	0.21
Upstream Chl	3380	200 cfs	200	5412.90	5419.4	5414.0	5419.45	0.000016	0.3	673.1	131.7	0.02
Upstream Chl	3380	500 cfs	500	5412.90	5420.0	5414.6	5419.97	0.000073	0.7	742.3	134.6	0.05
Upstream Chl	3380	750 cfs	750	5412.90	5420.3	5414.9	5420.33	0.000136	1.0	790.4	136.1	0.07
Upstream Chl	3380	1000 cfs	1000	5412.90	5420.6	5415.1	5420.66	0.000205	1.2	833.6	137.3	0.08
Upstream Chl	3380	1250 cfs	1250	5412.90	5420.9	5415.3	5420.95	0.000277	1.5	873.0	138.4	0.10
Upstream Chl	3380	1500 cfs	1500	5412.90	5421.2	5415.6	5421.23	0.000351	1.7	910.0	139.5	0.11
Upstream Chl	3380	1750 cfs	1750	5412.90	5421.4	5415.8	5421.49	0.000425	1.9	945.1	140.4	0.12
Upstream Chl	3380	2000 cfs	2000	5412.90	5421.7	5415.9	5421.74	0.000498	2.1	978.5	141.3	0.13
Upstream Chl	3380	2500 cfs	2500	5412.90	5422.1	5416.3	5422.21	0.000642	2.4	1041.3	143.0	0.15
Upstream Chl	3380	3000 cfs	3000	5412.90	5422.5	5416.6	5422.64	0.000781	2.8	1099.7	144.3	0.17
Upstream Chl	3380	6000 cfs	6000	5412.90	5424.7	5418.2	5424.96	0.001435	4.3	1421.9	159.6	0.23
Upstream Chl	3379	200 cfs	200	5418.80	5419.2	5419.2	5419.43	0.026319	3.2	58.4	130.9	0.87
Upstream Chl	3379	500 cfs	500	5418.80	5419.6	5419.6	5419.94	0.026462	4.8	102.9	132.4	0.96
Upstream Chl	3379	750 cfs	750	5418.80	5419.8	5419.8	5420.29	0.025900	5.6	132.8	133.3	0.99
Upstream Chl	3379	1000 cfs	1000	5418.80	5420.0	5420.0	5420.60	0.025352	6.2	159.6	134.1	1.01
Upstream Chl	3379	1250 cfs	1250	5418.80	5420.2	5420.2	5420.89	0.023769	6.7	186.5	134.7	1.00
Upstream Chl	3379	1500 cfs	1500	5418.80	5420.4	5420.4	5421.16	0.022924	7.1	210.9	135.1	1.00
Upstream Chl	3379	1750 cfs	1750	5418.80	5420.5	5420.5	5421.41	0.022477	7.5	233.2	135.5	1.01
Upstream Chl	3379	2000 cfs	2000	5418.80	5420.7	5420.7	5421.65	0.021989	7.9	254.9	135.9	1.01
Upstream Chl	3379	2500 cfs	2500	5418.80	5421.0	5421.0	5422.10	0.020992	8.5	296.7	137.6	1.01
Upstream Chl	3379	3000 cfs	3000	5418.80	5421.3	5421.3	5422.53	0.019907	9.0	337.6	138.8	1.00
Upstream Chl	3379	6000 cfs	6000	5418.80	5423.6	5422.7	5424.85	0.009288	9.3	660.4	147.1	0.75
Upstream Chl	3378	200 cfs	200	5414.50	5419.0	5419.0	5419.23	0.033354	3.6	55.0	145.1	0.99
Upstream Chl	3378	500 cfs	500	5414.50	5419.4	5419.4	5419.76	0.029386	5.0	99.1	146.5	1.02
Upstream Chl	3378	750 cfs	750	5414.50	5419.6	5419.6	5420.12	0.025071	5.7	132.6	147.6	0.99
Upstream Chl	3378	1000 cfs	1000	5414.50	5419.8	5419.8	5420.44	0.025592	6.4	156.7	148.4	1.02
Upstream Chl	3378	1250 cfs	1250	5414.50	5420.0	5420.0	5420.74	0.024242	6.9	182.2	149.2	1.02
Upstream Chl	3378	1500 cfs	1500	5414.50	5420.2	5420.2	5421.01	0.022130	7.2	209.0	149.7	1.00
Upstream Chl	3378	1750 cfs	1750	5414.50	5420.4	5420.4	5421.27	0.021417	7.6	231.7	150.1	1.00
Upstream Chl	3378	2000 cfs	2000	5414.50	5420.5	5420.5	5421.52	0.021426	8.0	251.1	150.5	1.01
Upstream Chl	3378	2500 cfs	2500	5414.50	5420.9	5420.9	5421.99	0.019579	8.5	295.2	151.3	0.99
Upstream Chl	3378	3000 cfs	3000	5414.50	5421.3	5421.2	5422.44	0.015260	8.4	356.7	154.0	0.90
Upstream Chl	3378	6000 cfs	6000	5414.50	5423.5	5422.7	5424.83	0.008998	9.4	639.5	161.8	0.76
Upstream Chl	3370		Inl Struct									

HEC-RAS Plan: Opt 2 Fully River: Big Hole Reach: Upstream Chl (Continued)

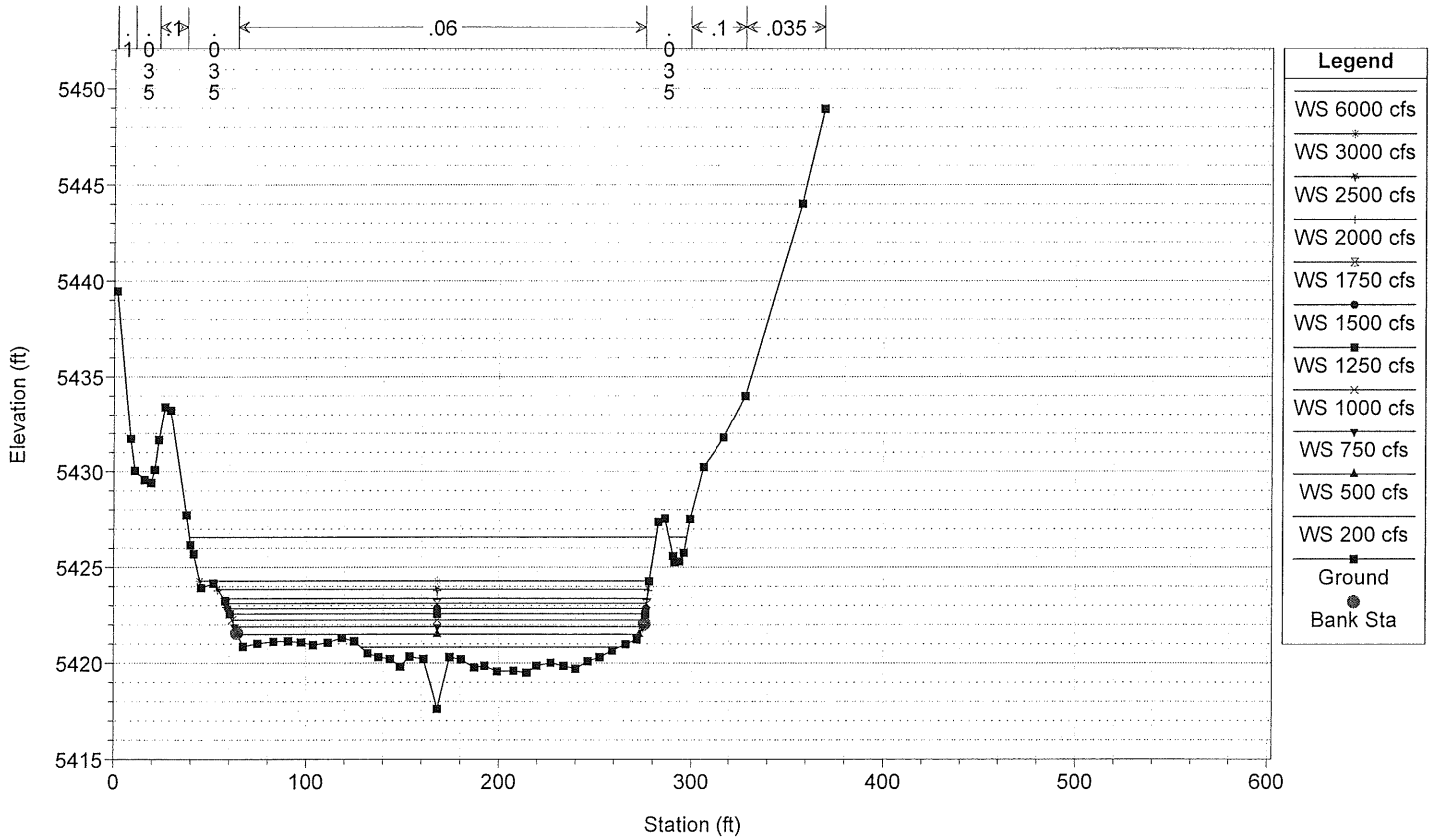
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3368	200 cfs	200	5412.90	5415.5	5414.0	5415.52	0.001023	1.1	185.0	115.7	0.15
Upstream Chl	3368	500 cfs	500	5412.90	5416.4	5414.6	5416.44	0.001545	1.7	294.9	127.6	0.20
Upstream Chl	3368	750 cfs	750	5412.90	5416.9	5414.9	5416.98	0.001860	2.1	361.4	132.7	0.22
Upstream Chl	3368	1000 cfs	1000	5412.90	5417.3	5415.2	5417.42	0.002112	2.4	418.7	136.9	0.24
Upstream Chl	3368	1250 cfs	1250	5412.90	5417.7	5415.4	5417.82	0.002313	2.7	471.0	140.6	0.26
Upstream Chl	3368	1500 cfs	1500	5412.90	5418.1	5415.6	5418.18	0.002469	2.9	519.5	143.8	0.27
Upstream Chl	3368	1750 cfs	1750	5412.90	5418.4	5415.8	5418.52	0.002548	3.1	564.7	145.3	0.28
Upstream Chl	3368	2000 cfs	2000	5412.90	5418.7	5416.0	5418.83	0.002620	3.3	607.3	146.8	0.28
Upstream Chl	3368	2500 cfs	2500	5412.90	5419.2	5416.4	5419.40	0.002745	3.7	686.3	149.0	0.30
Upstream Chl	3368	3000 cfs	3000	5412.90	5419.7	5416.7	5419.92	0.002855	4.0	758.4	150.4	0.31
Upstream Chl	3368	6000 cfs	6000	5412.90	5422.0	5418.2	5422.44	0.003271	5.4	1115.6	159.5	0.35
Upstream Chl	3353	200 cfs	200	5413.00	5415.5	5414.0	5415.50	0.001155	1.2	160.8	120.9	0.16
Upstream Chl	3353	500 cfs	500	5413.00	5416.3	5414.6	5416.42	0.001985	2.1	239.2	127.7	0.23
Upstream Chl	3353	750 cfs	750	5413.00	5416.8	5415.0	5416.94	0.002572	2.6	283.7	131.8	0.27
Upstream Chl	3353	1000 cfs	1000	5413.00	5417.2	5415.2	5417.38	0.003087	3.1	320.5	136.0	0.30
Upstream Chl	3353	1250 cfs	1250	5413.00	5417.6	5415.5	5417.77	0.003540	3.5	352.9	139.7	0.32
Upstream Chl	3353	1500 cfs	1500	5413.00	5417.9	5415.7	5418.13	0.003952	3.9	382.1	142.6	0.34
Upstream Chl	3353	1750 cfs	1750	5413.00	5418.2	5416.0	5418.45	0.004334	4.3	408.9	145.0	0.36
Upstream Chl	3353	2000 cfs	2000	5413.00	5418.4	5416.2	5418.76	0.004692	4.6	433.7	147.3	0.38
Upstream Chl	3353	2500 cfs	2500	5413.00	5418.9	5416.6	5419.32	0.005335	5.2	478.9	151.3	0.41
Upstream Chl	3353	3000 cfs	3000	5413.00	5419.3	5417.0	5419.83	0.005881	5.8	519.0	153.8	0.44
Upstream Chl	3353	6000 cfs	6000	5413.00	5421.5	5418.9	5422.33	0.009556	7.3	825.0	165.1	0.56
Upstream Chl	3112	200 cfs	200	5413.21	5415.1	5414.1	5415.08	0.002991	1.3	148.5	149.3	0.24
Upstream Chl	3112	500 cfs	500	5413.21	5415.7	5414.6	5415.79	0.003448	1.9	266.2	180.5	0.27
Upstream Chl	3112	750 cfs	750	5413.21	5416.1	5414.9	5416.20	0.003657	2.2	336.0	183.5	0.29
Upstream Chl	3112	1000 cfs	1000	5413.21	5416.4	5415.2	5416.54	0.003851	2.5	394.4	186.0	0.31
Upstream Chl	3112	1250 cfs	1250	5413.21	5416.7	5415.4	5416.85	0.003955	2.8	448.7	187.9	0.32
Upstream Chl	3112	1500 cfs	1500	5413.21	5417.0	5415.5	5417.14	0.004025	3.0	499.3	190.3	0.32
Upstream Chl	3112	1750 cfs	1750	5413.21	5417.2	5415.7	5417.40	0.004071	3.2	546.9	192.5	0.33
Upstream Chl	3112	2000 cfs	2000	5413.21	5417.5	5415.8	5417.66	0.004108	3.4	592.2	193.4	0.34
Upstream Chl	3112	2500 cfs	2500	5413.21	5417.9	5416.1	5418.13	0.004166	3.7	676.3	194.2	0.35
Upstream Chl	3112	3000 cfs	3000	5413.21	5418.3	5416.3	5418.56	0.004211	4.0	753.9	194.9	0.35
Upstream Chl	3112	6000 cfs	6000	5413.21	5420.3	5417.5	5420.70	0.004410	5.4	1137.7	198.4	0.39
Upstream Chl	2911	200 cfs	200	5412.42	5414.1	5413.6	5414.11	0.008912	2.0	101.6	131.3	0.39
Upstream Chl	2911	500 cfs	500	5412.42	5414.7	5414.0	5414.83	0.007006	2.3	216.9	184.7	0.37
Upstream Chl	2911	750 cfs	750	5412.42	5415.2	5414.3	5415.27	0.005922	2.5	298.0	197.0	0.36
Upstream Chl	2911	1000 cfs	1000	5412.42	5415.5	5414.5	5415.63	0.005343	2.7	365.9	198.8	0.35
Upstream Chl	2911	1250 cfs	1250	5412.42	5415.8	5414.7	5415.95	0.005018	2.9	427.0	200.0	0.35
Upstream Chl	2911	1500 cfs	1500	5412.42	5416.1	5414.8	5416.25	0.004823	3.1	482.9	201.0	0.35
Upstream Chl	2911	1750 cfs	1750	5412.42	5416.4	5415.0	5416.52	0.004711	3.3	534.4	202.0	0.35
Upstream Chl	2911	2000 cfs	2000	5412.42	5416.6	5415.1	5416.78	0.004634	3.5	582.8	203.5	0.36
Upstream Chl	2911	2500 cfs	2500	5412.42	5417.0	5415.4	5417.25	0.004539	3.8	672.9	206.5	0.36
Upstream Chl	2911	3000 cfs	3000	5412.42	5417.4	5415.6	5417.69	0.004476	4.0	756.7	209.3	0.36
Upstream Chl	2911	6000 cfs	6000	5412.42	5419.4	5416.7	5419.81	0.004381	5.2	1179.3	223.0	0.39
Upstream Chl	2765	200 cfs	200	5411.40	5413.2	5412.6	5413.28	0.003899	1.5	130.4	131.7	0.27
Upstream Chl	2765	500 cfs	500	5411.40	5414.0	5413.0	5414.08	0.003899	2.1	237.9	149.6	0.29
Upstream Chl	2765	750 cfs	750	5411.40	5414.5	5413.2	5414.57	0.003904	2.4	309.6	159.6	0.30
Upstream Chl	2765	1000 cfs	1000	5411.40	5414.9	5413.5	5414.97	0.003904	2.7	370.4	169.8	0.31
Upstream Chl	2765	1250 cfs	1250	5411.40	5415.2	5413.7	5415.31	0.003904	3.0	426.9	178.7	0.32
Upstream Chl	2765	1500 cfs	1500	5411.40	5415.5	5413.9	5415.62	0.003902	3.2	481.2	195.0	0.33
Upstream Chl	2765	1750 cfs	1750	5411.40	5415.7	5414.0	5415.90	0.003904	3.4	532.6	197.2	0.33
Upstream Chl	2765	2000 cfs	2000	5411.40	5416.0	5414.2	5416.16	0.003902	3.5	581.2	199.2	0.33
Upstream Chl	2765	2500 cfs	2500	5411.40	5416.4	5414.5	5416.64	0.003908	3.8	671.0	202.9	0.34
Upstream Chl	2765	3000 cfs	3000	5411.40	5416.8	5414.8	5417.08	0.003901	4.1	754.8	206.2	0.35
Upstream Chl	2765	6000 cfs	6000	5411.40	5418.8	5416.1	5419.21	0.003907	5.3	1172.8	218.5	0.37

HEC-RAS Plan: Opt 2 Fully River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Q Total	Q Weir	Q Gates
			(ft)	(ft)	(cfs)	(cfs)	(cfs)
Upstream Chl	3370	200 cfs	5419.23	5419.02	200.00	72.32	127.68
Upstream Chl	3370	500 cfs	5419.76	5419.36	500.00	308.36	191.64
Upstream Chl	3370	750 cfs	5420.12	5419.62	750.00	526.01	223.99
Upstream Chl	3370	1000 cfs	5420.44	5419.81	1000.00	749.76	250.24
Upstream Chl	3370	1250 cfs	5420.74	5420.00	1250.00	967.01	282.99
Upstream Chl	3370	1500 cfs	5421.01	5420.21	1500.00	1186.57	313.43
Upstream Chl	3370	1750 cfs	5421.27	5420.39	1750.00	1410.78	339.22
Upstream Chl	3370	2000 cfs	5421.52	5420.53	2000.00	1639.23	360.77
Upstream Chl	3370	2500 cfs	5421.99	5420.87	2500.00	2107.46	392.54
Upstream Chl	3370	3000 cfs	5422.44	5421.34	3000.00	2593.11	406.89
Upstream Chl	3370	6000 cfs	5424.83	5423.47	6000.00	5591.89	408.11

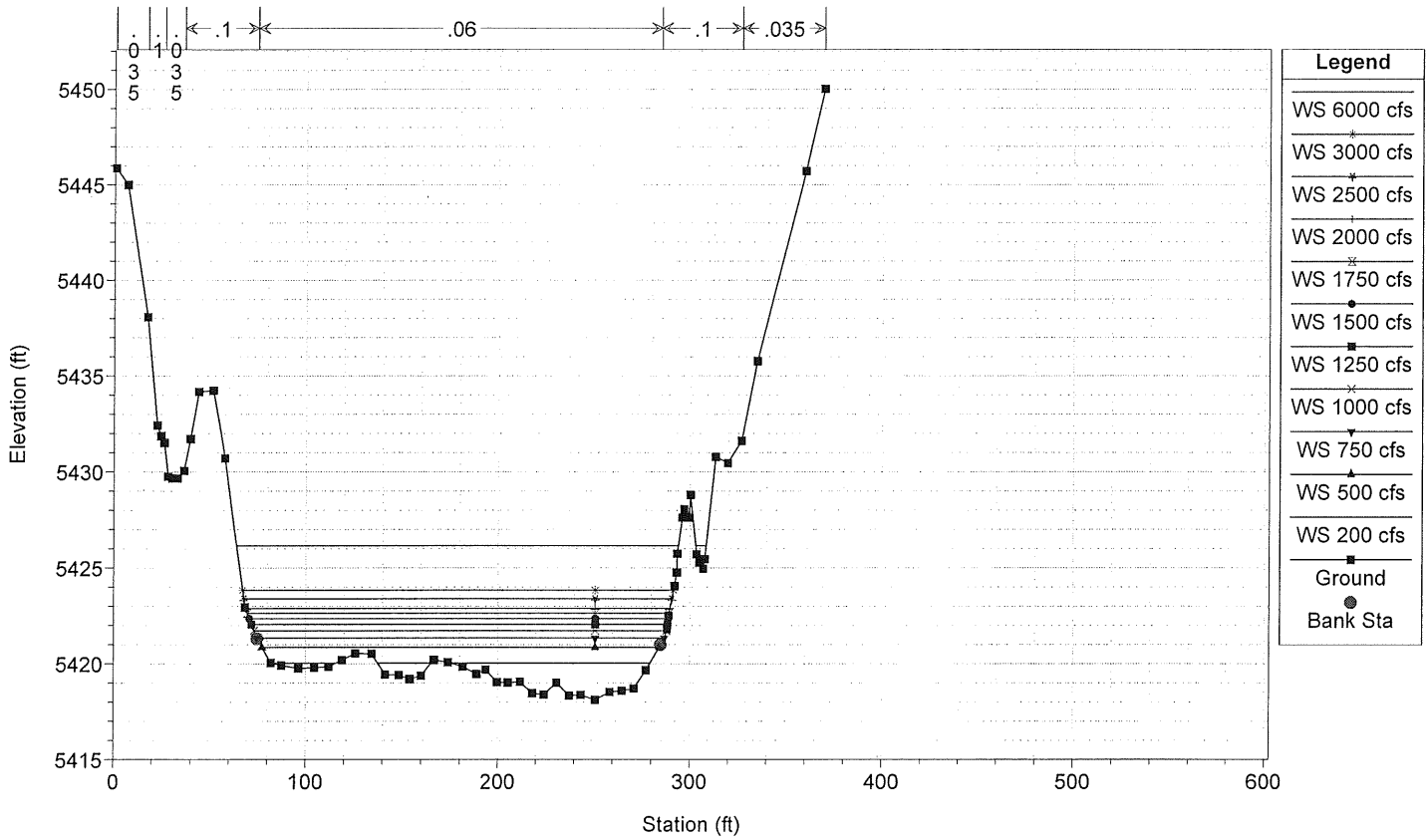
Big-Hole - WHP Plan: Option 2 Fully Open 11/16/2009

RS = 4439 Cross Section #1



Big-Hole - WHP Plan: Option 2 Fully Open 11/16/2009

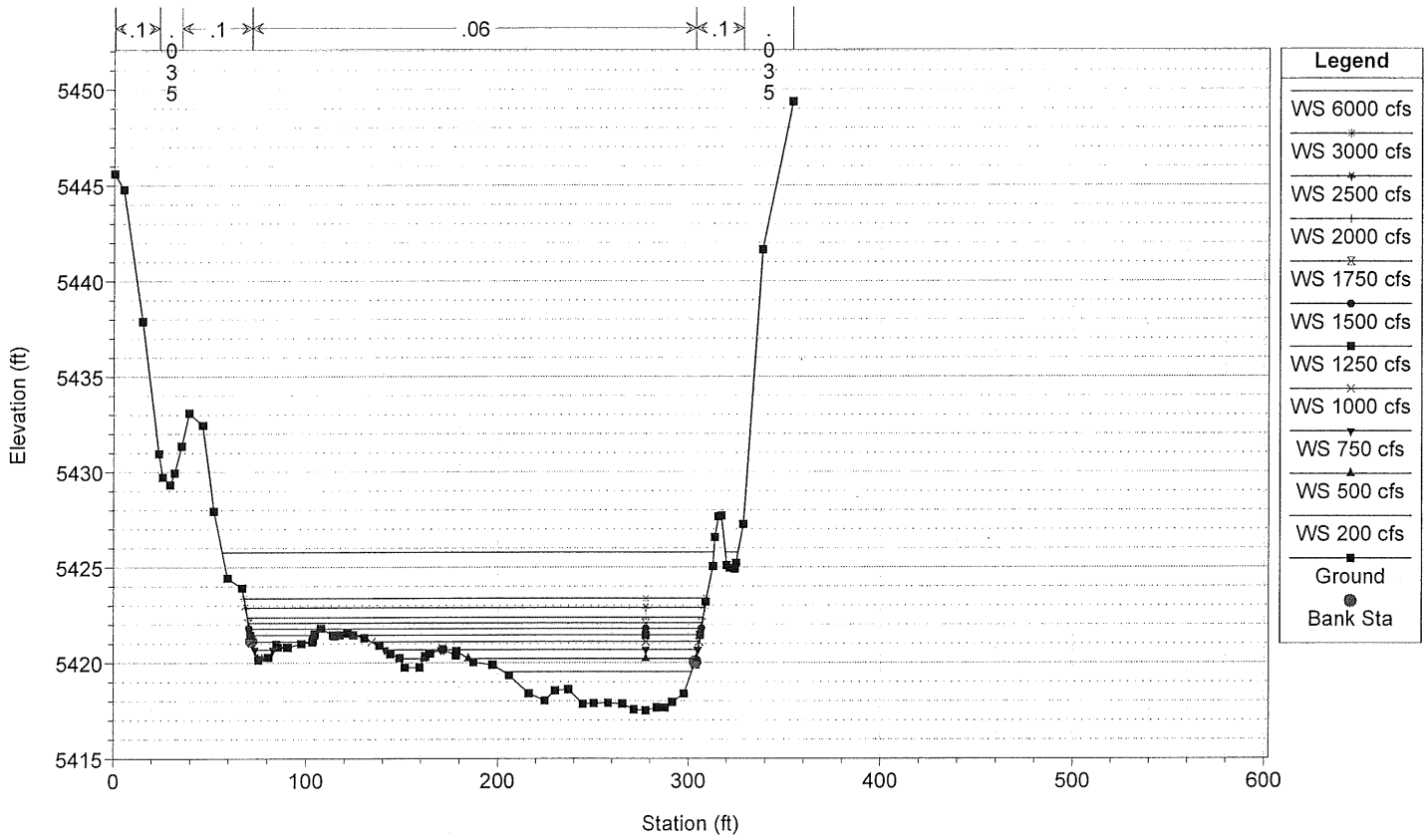
RS = 4267 Cross Section #2



1 in Horiz. = 100 ft 1 in Vert. = 10 ft

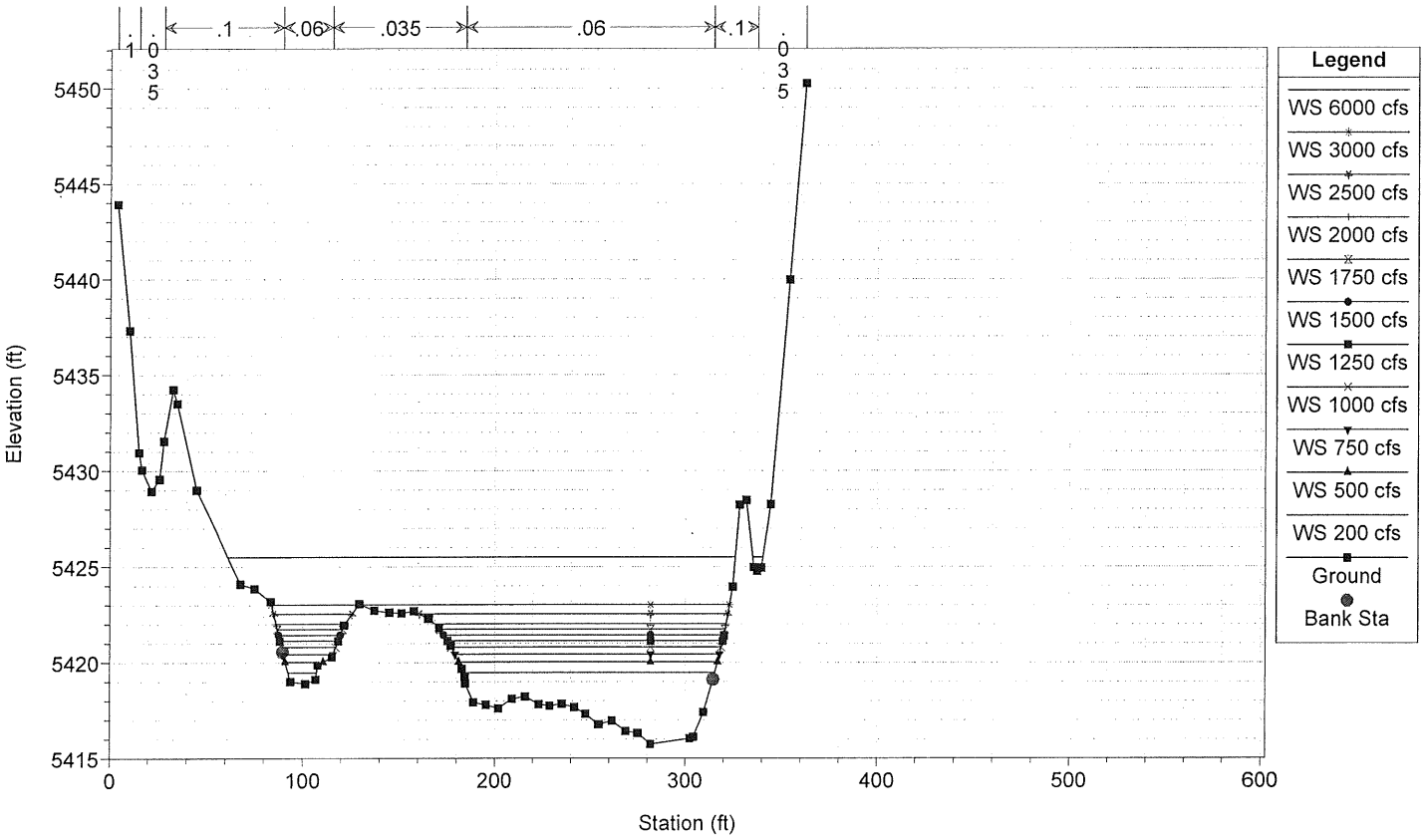
Big-Hole - WHP Plan: Option 2 Fully Open 11/16/2009

RS = 4106 Cross Section #3

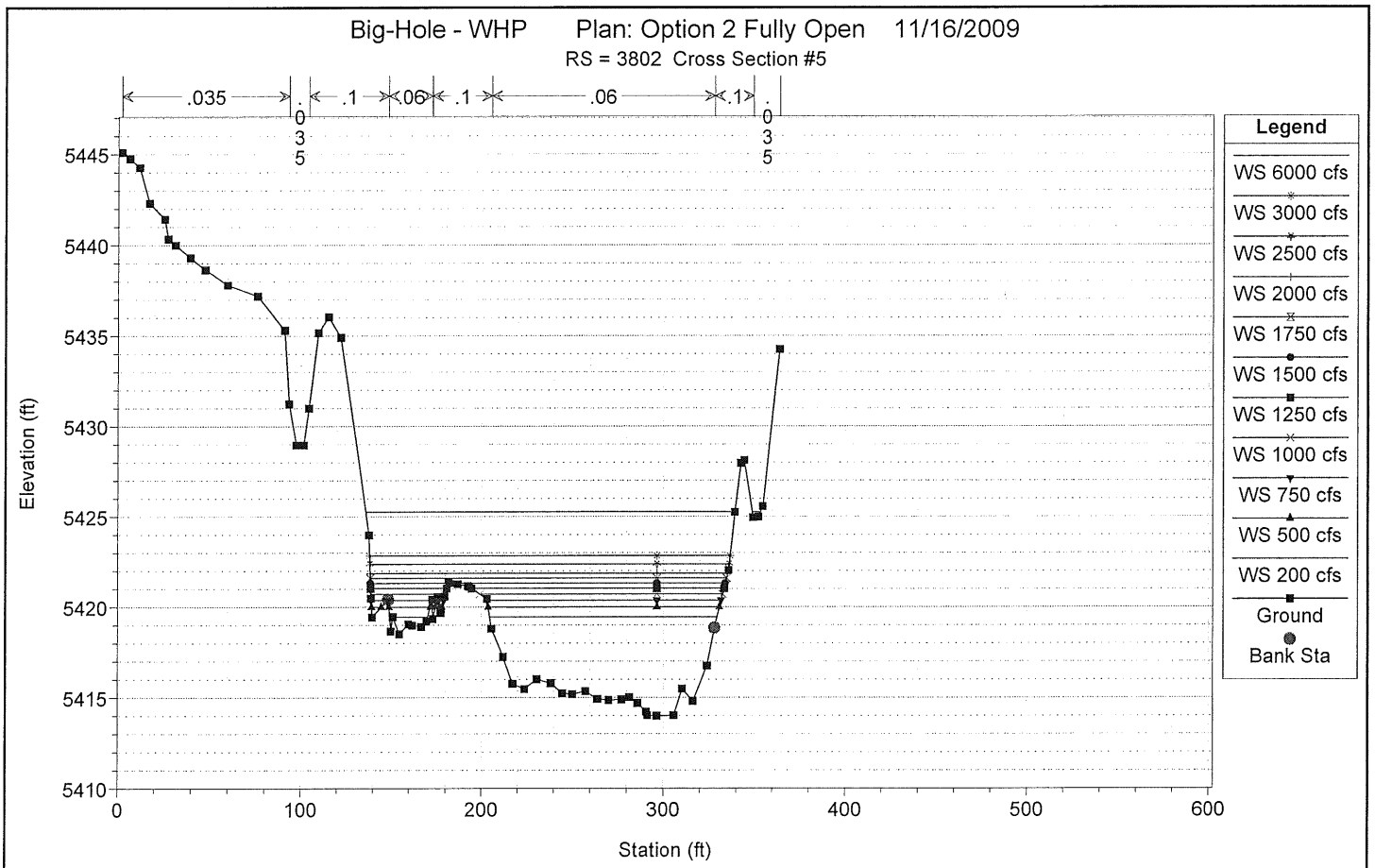


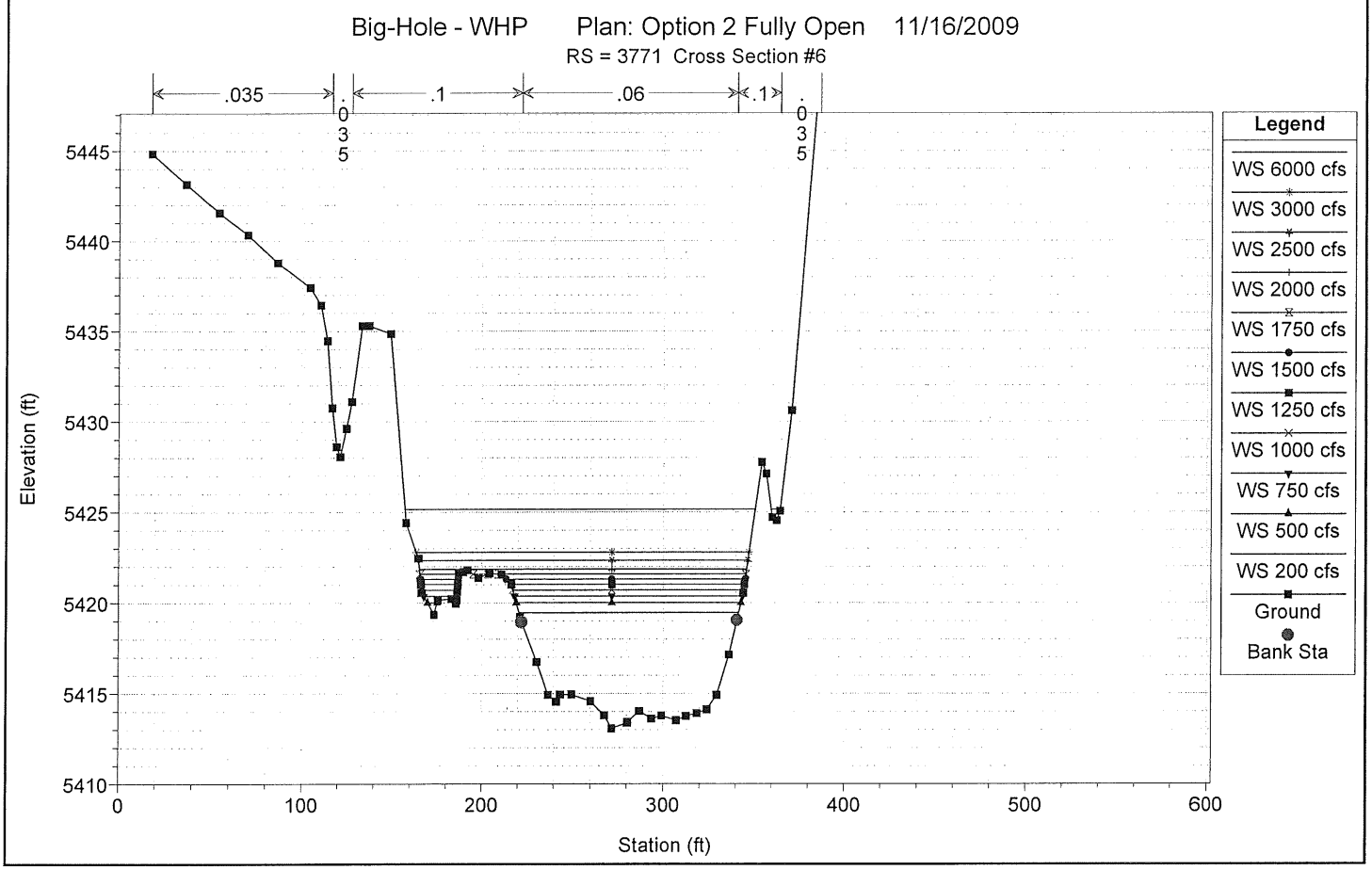
Big-Hole - WHP Plan: Option 2 Fully Open 11/16/2009

RS = 3955 Cross Section #4

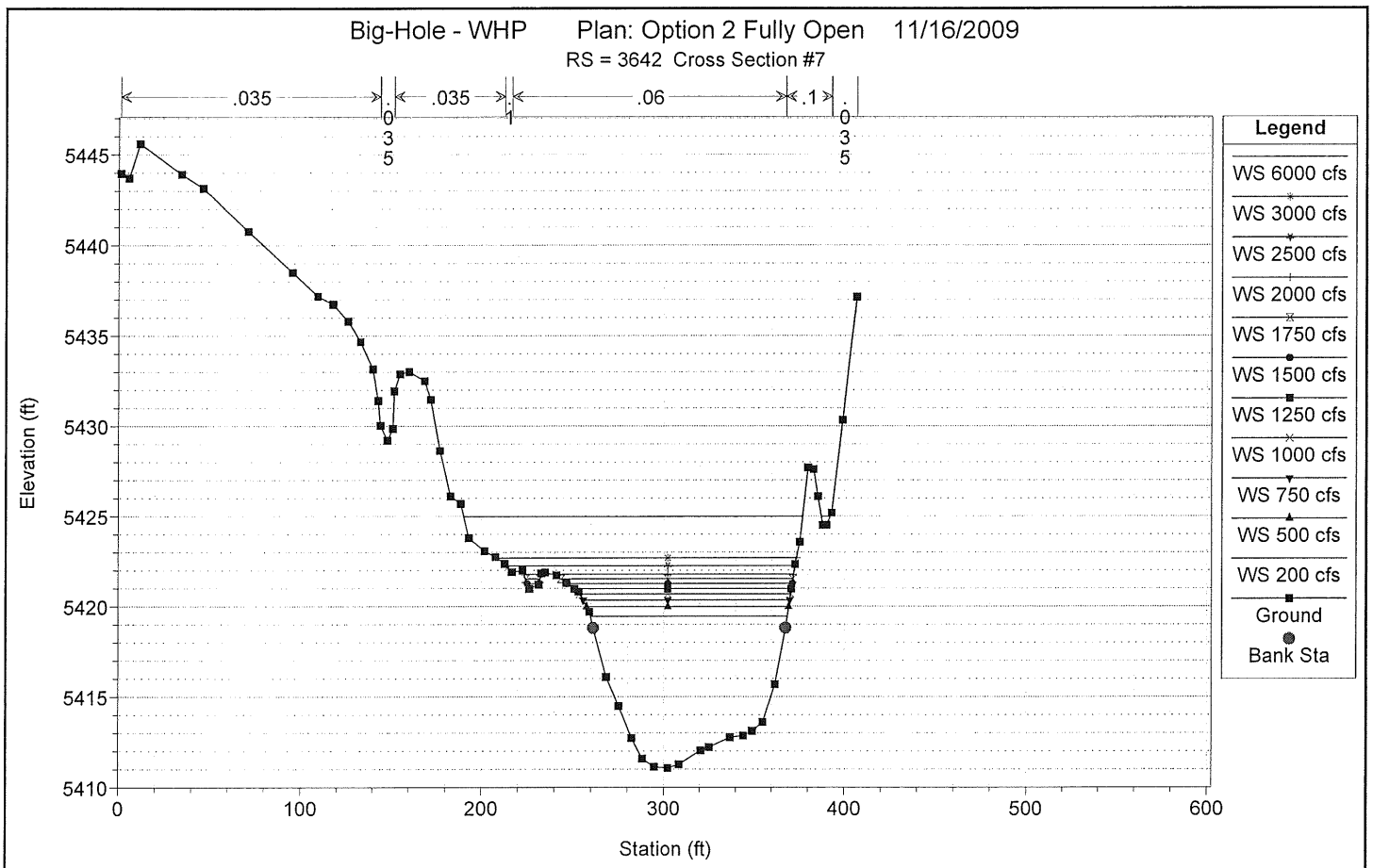


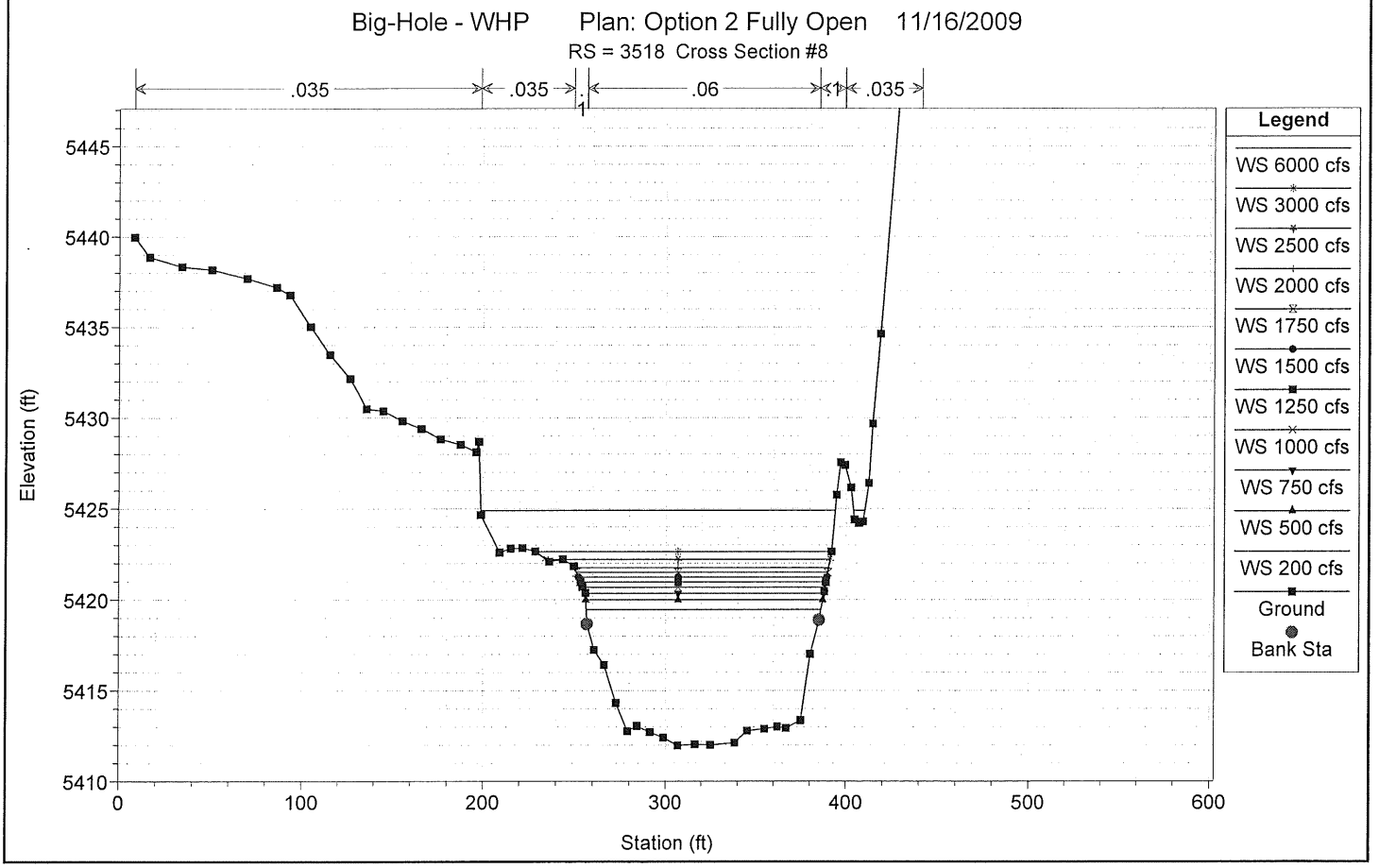
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



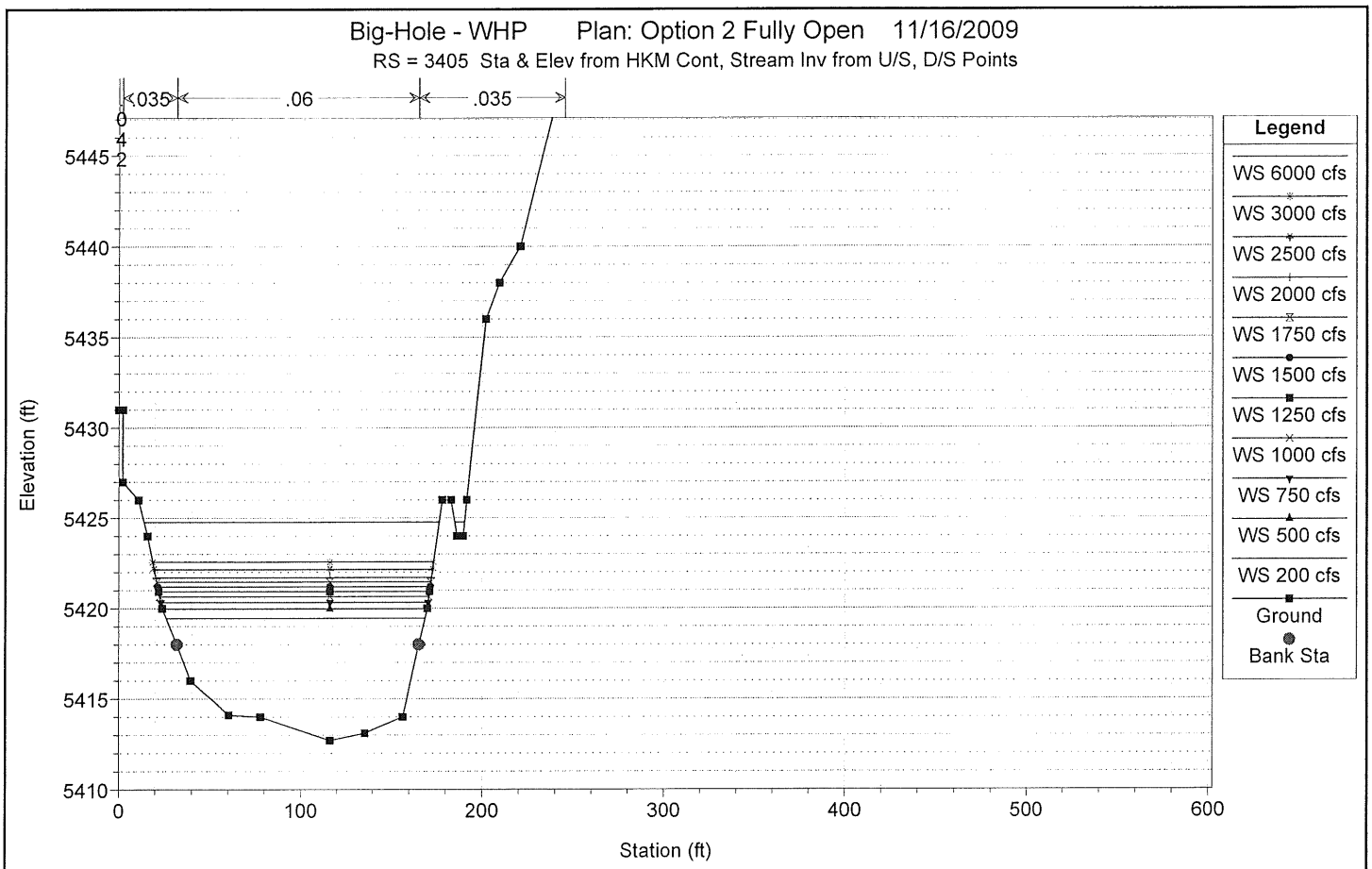


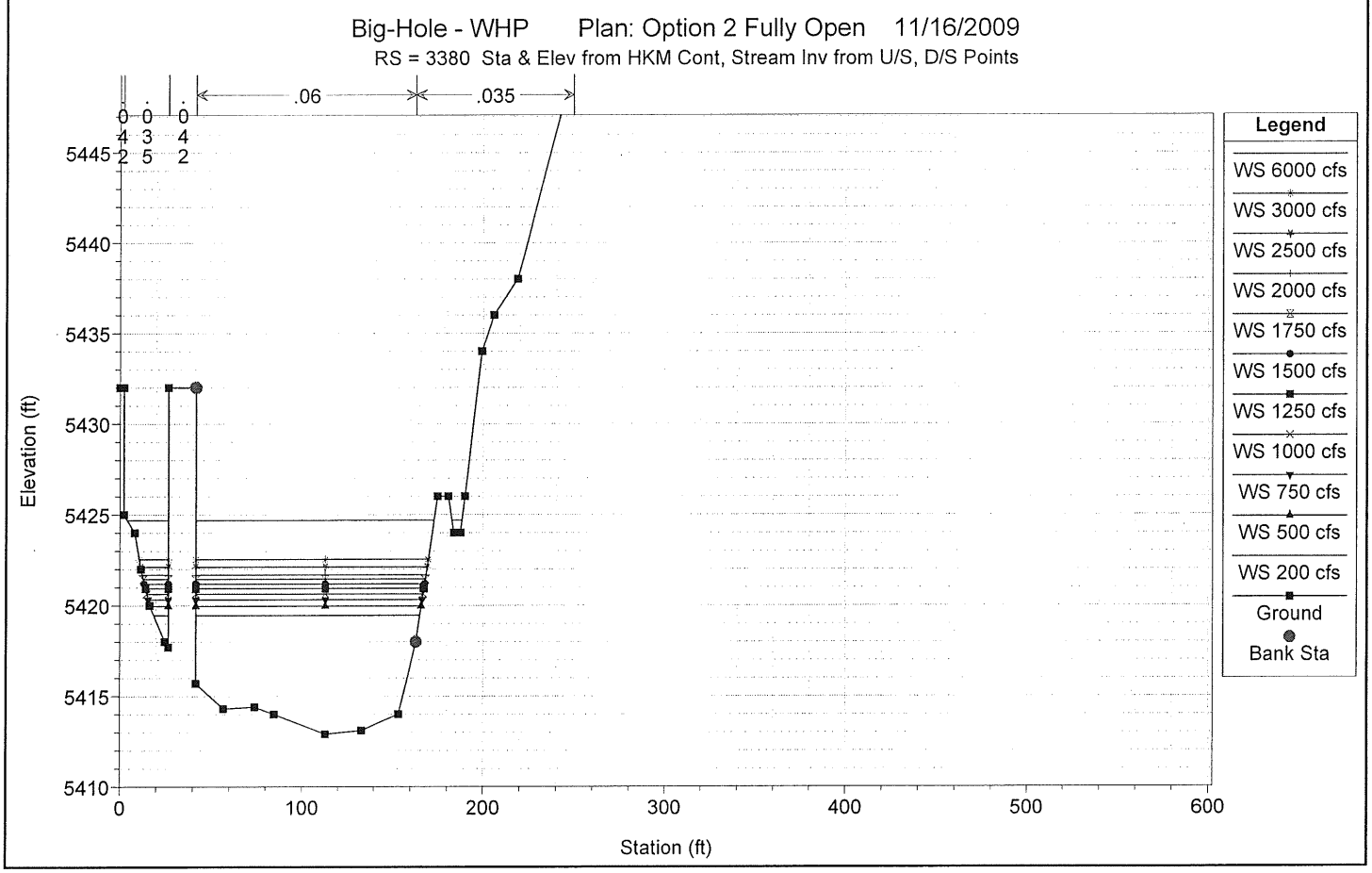
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



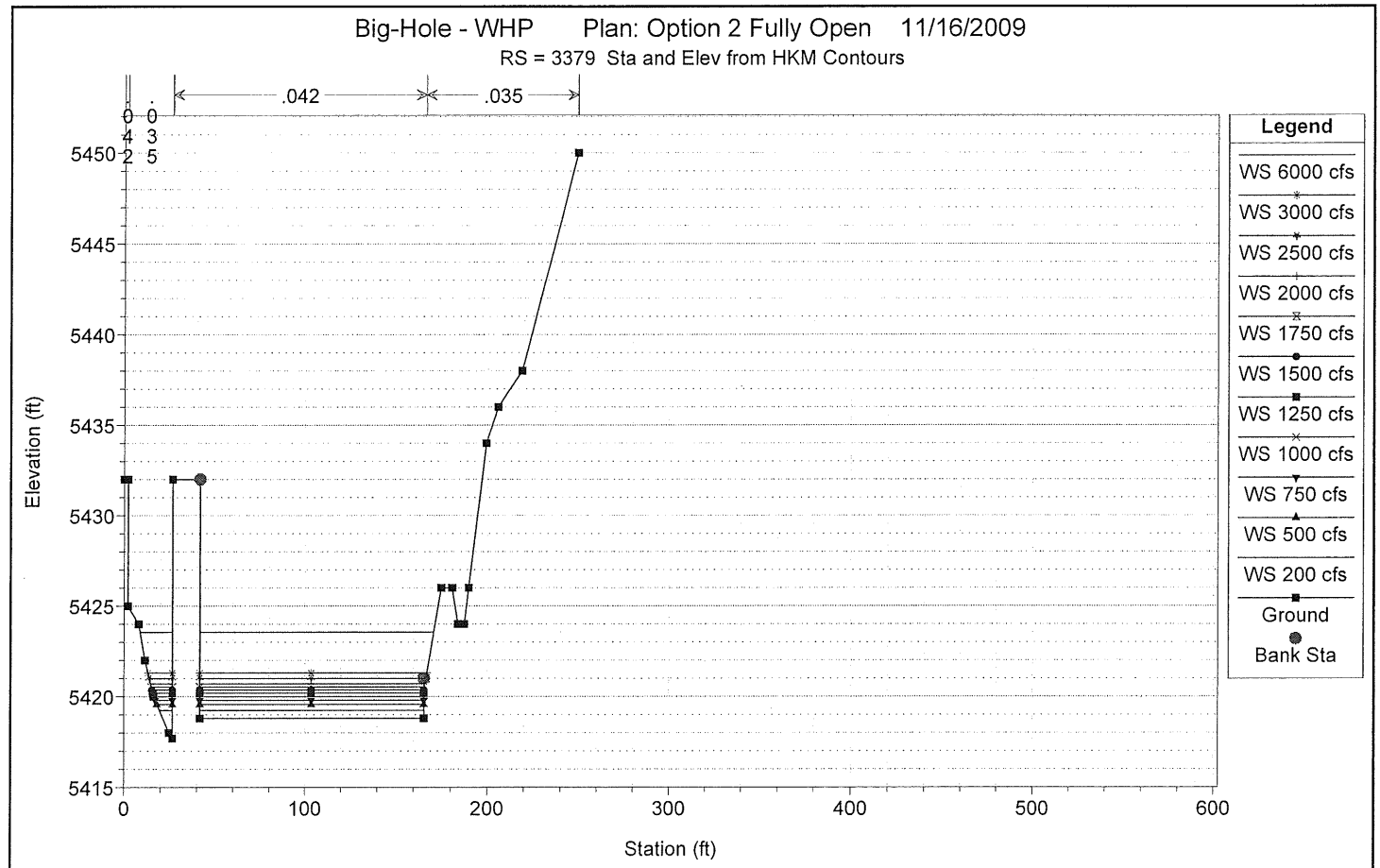


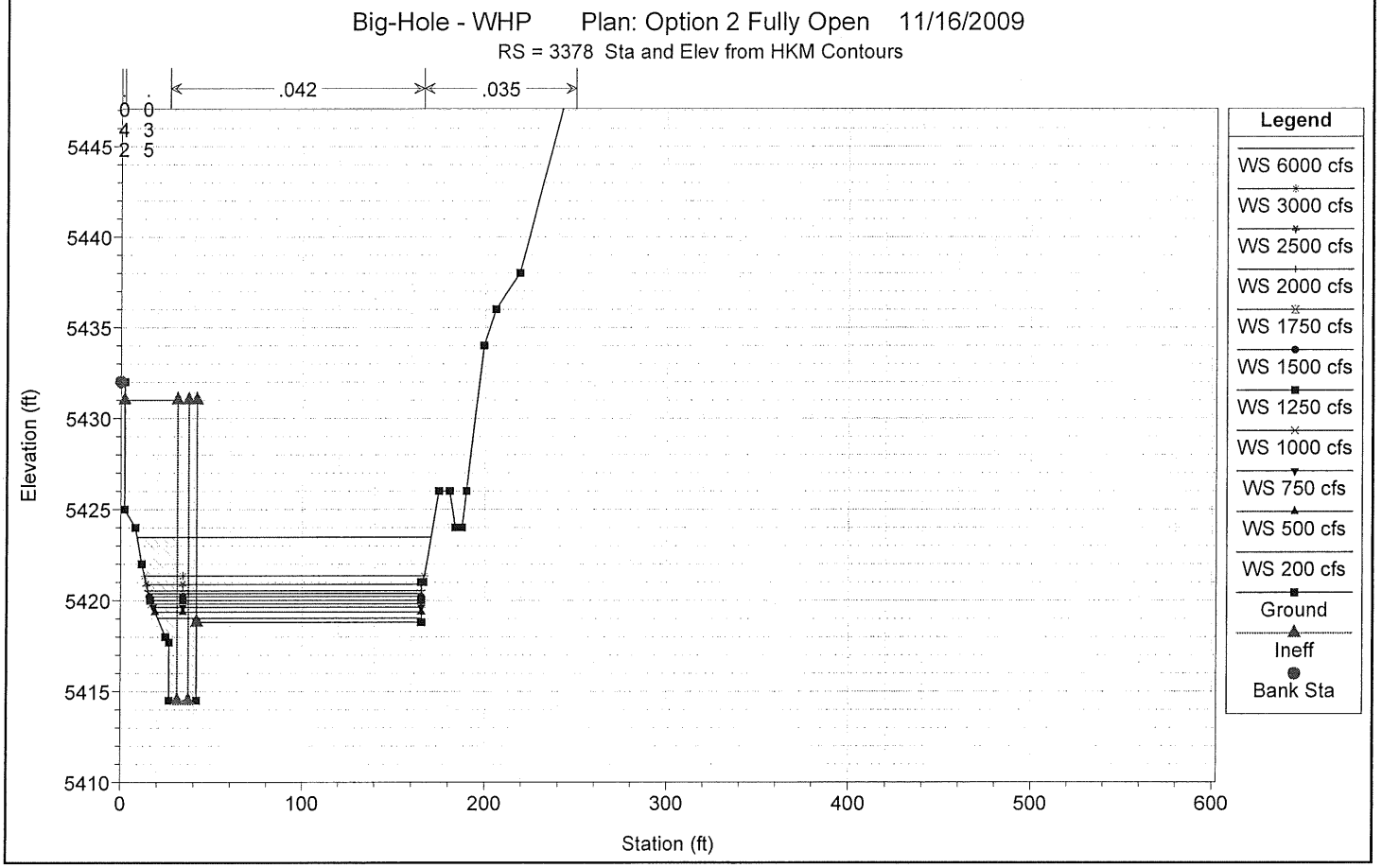
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



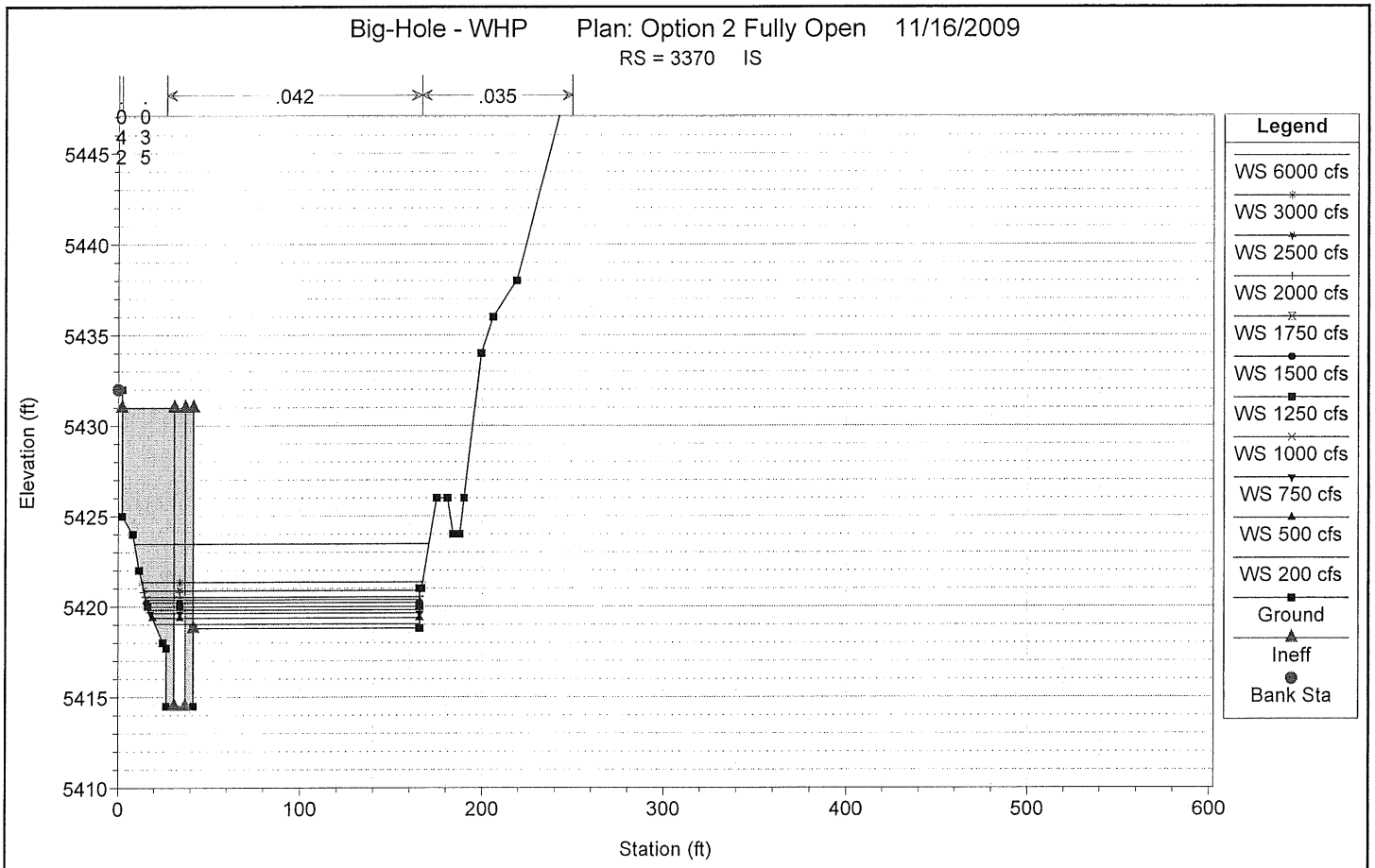


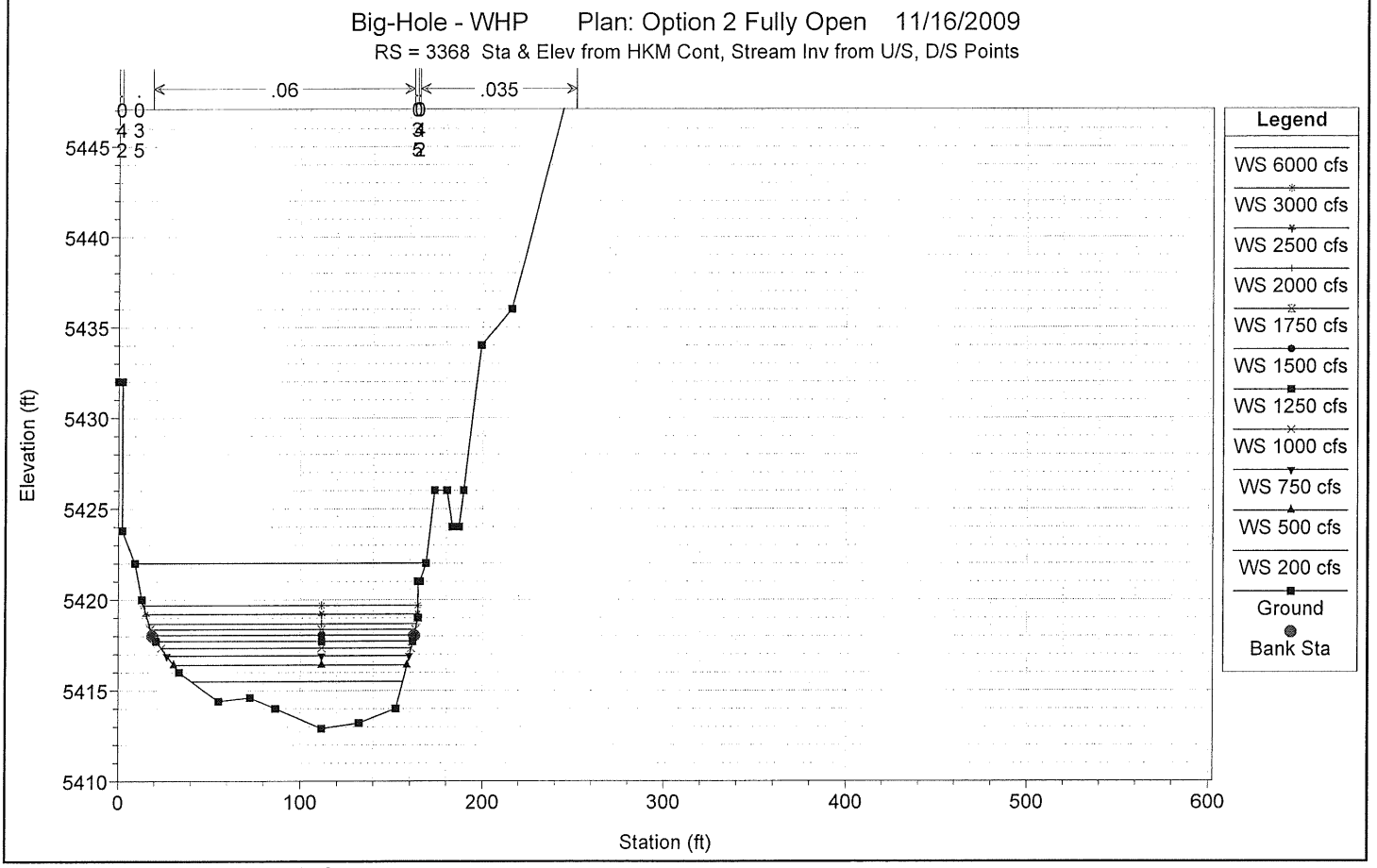
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



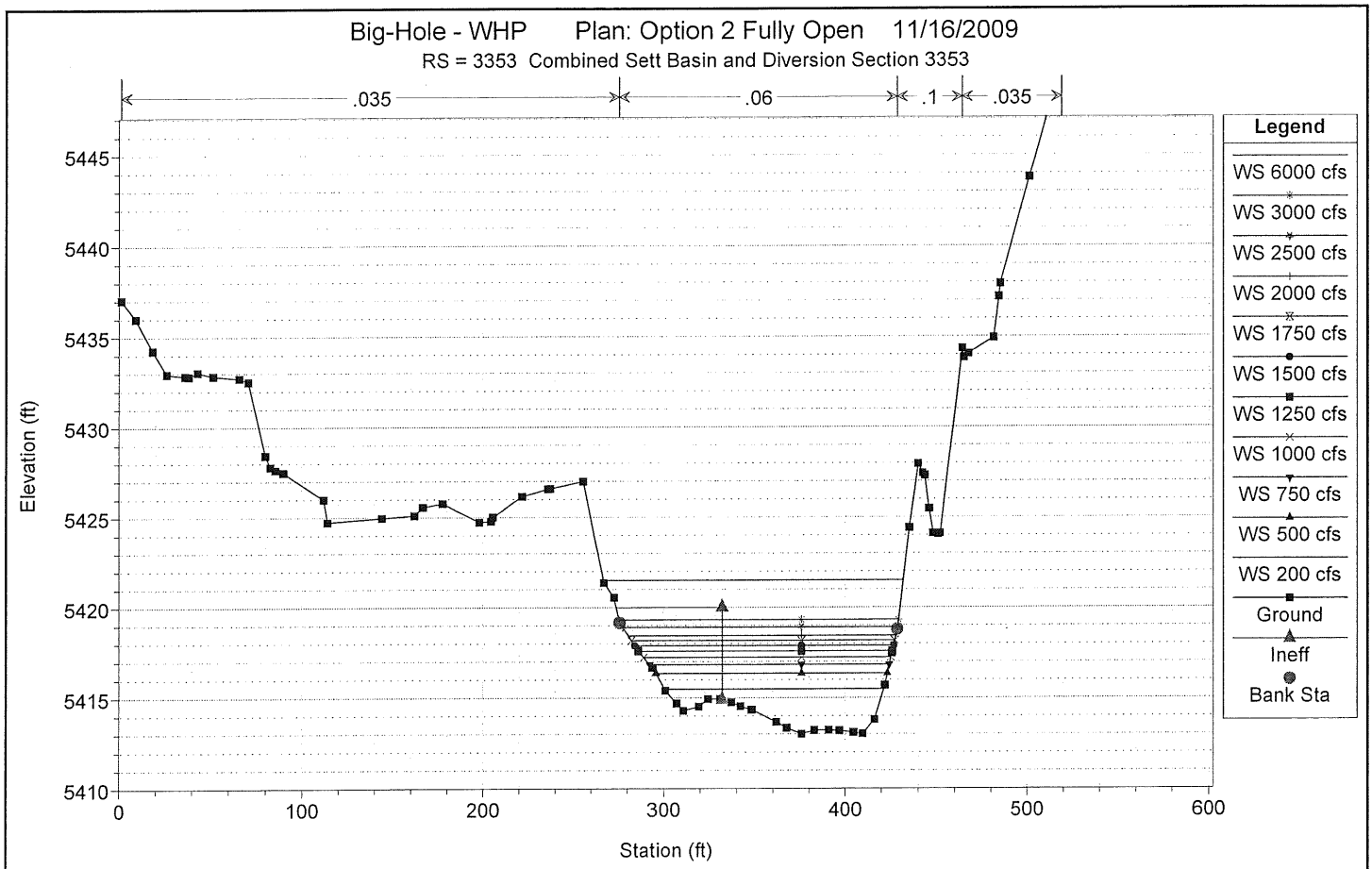


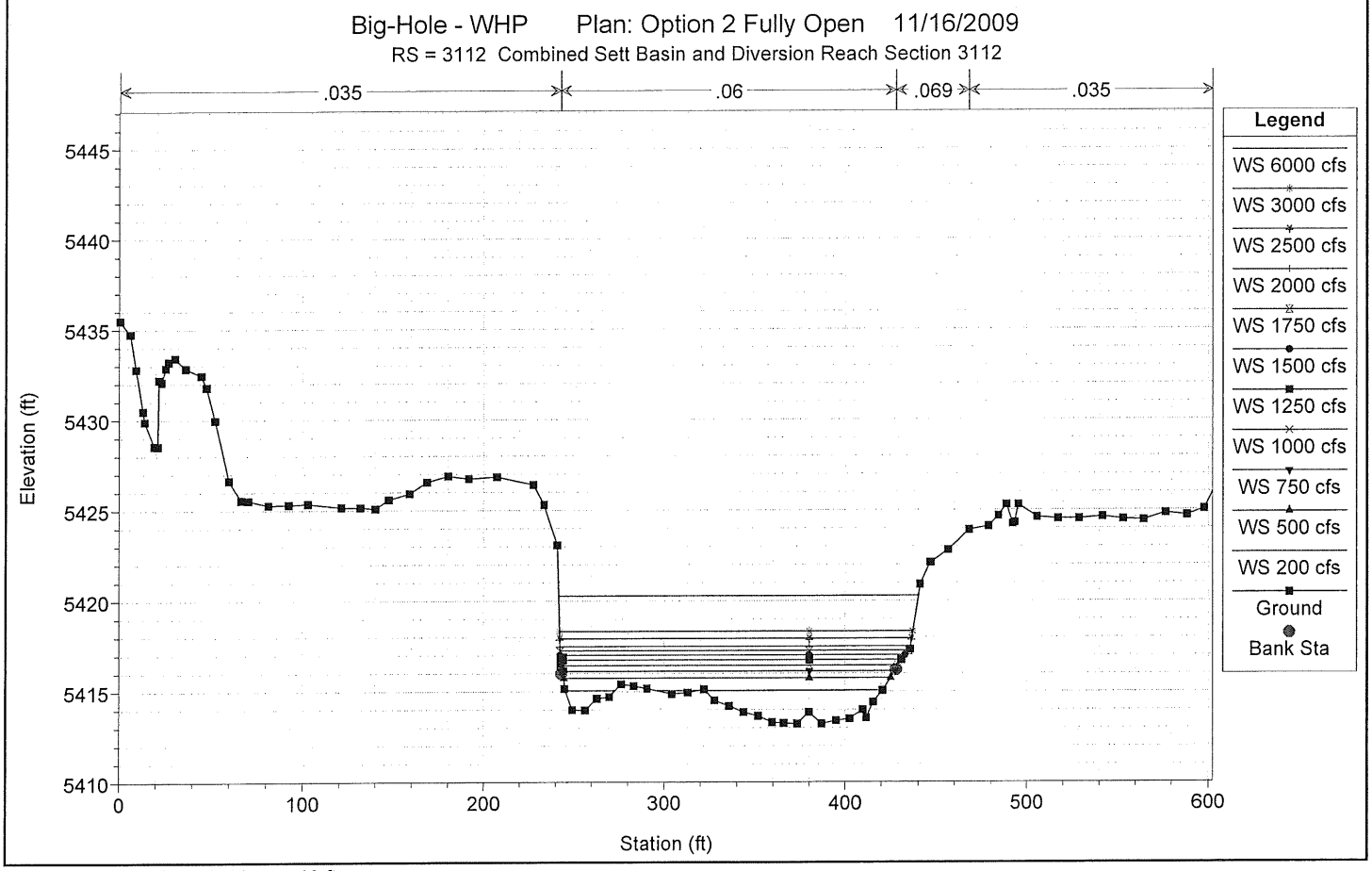
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



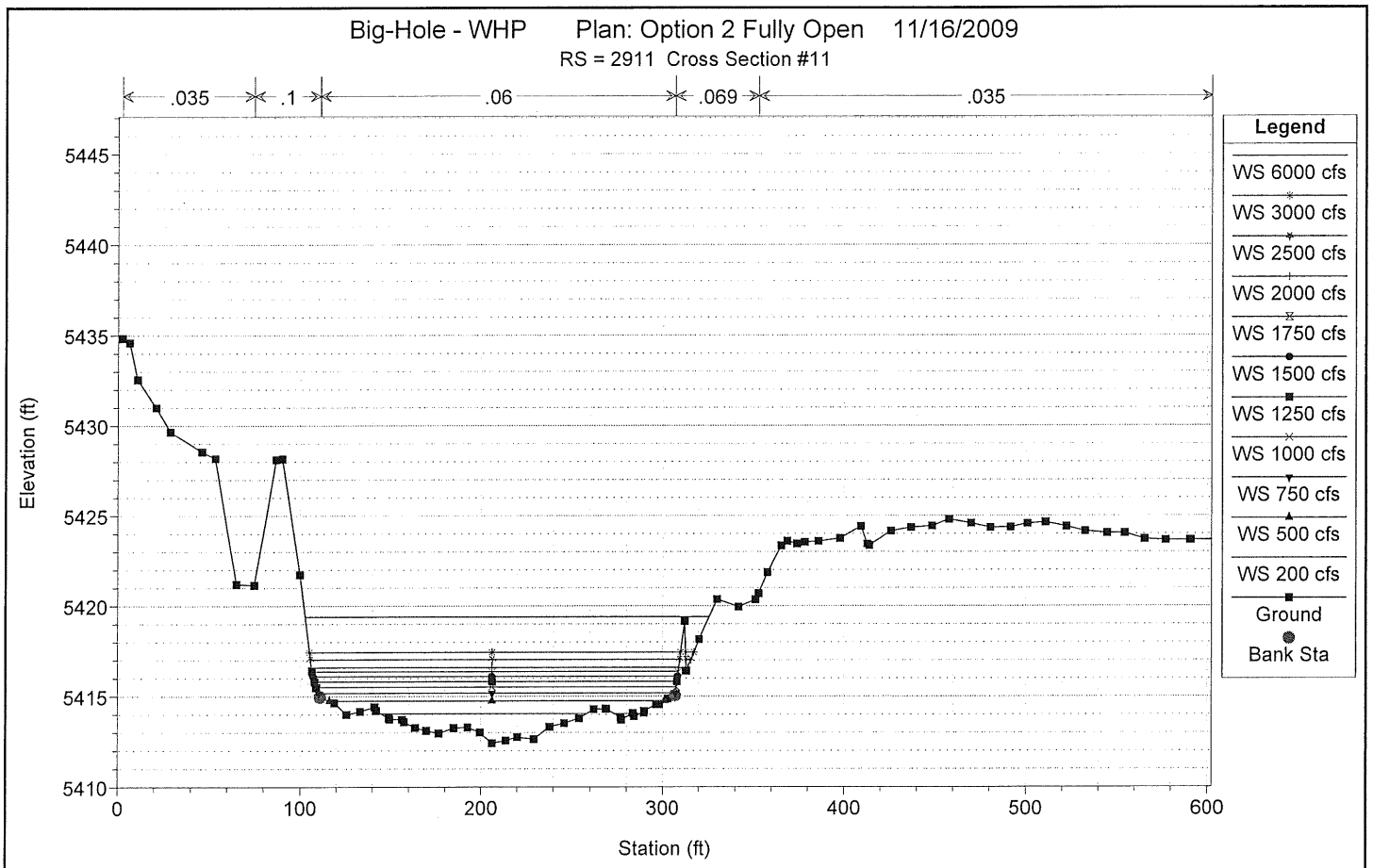


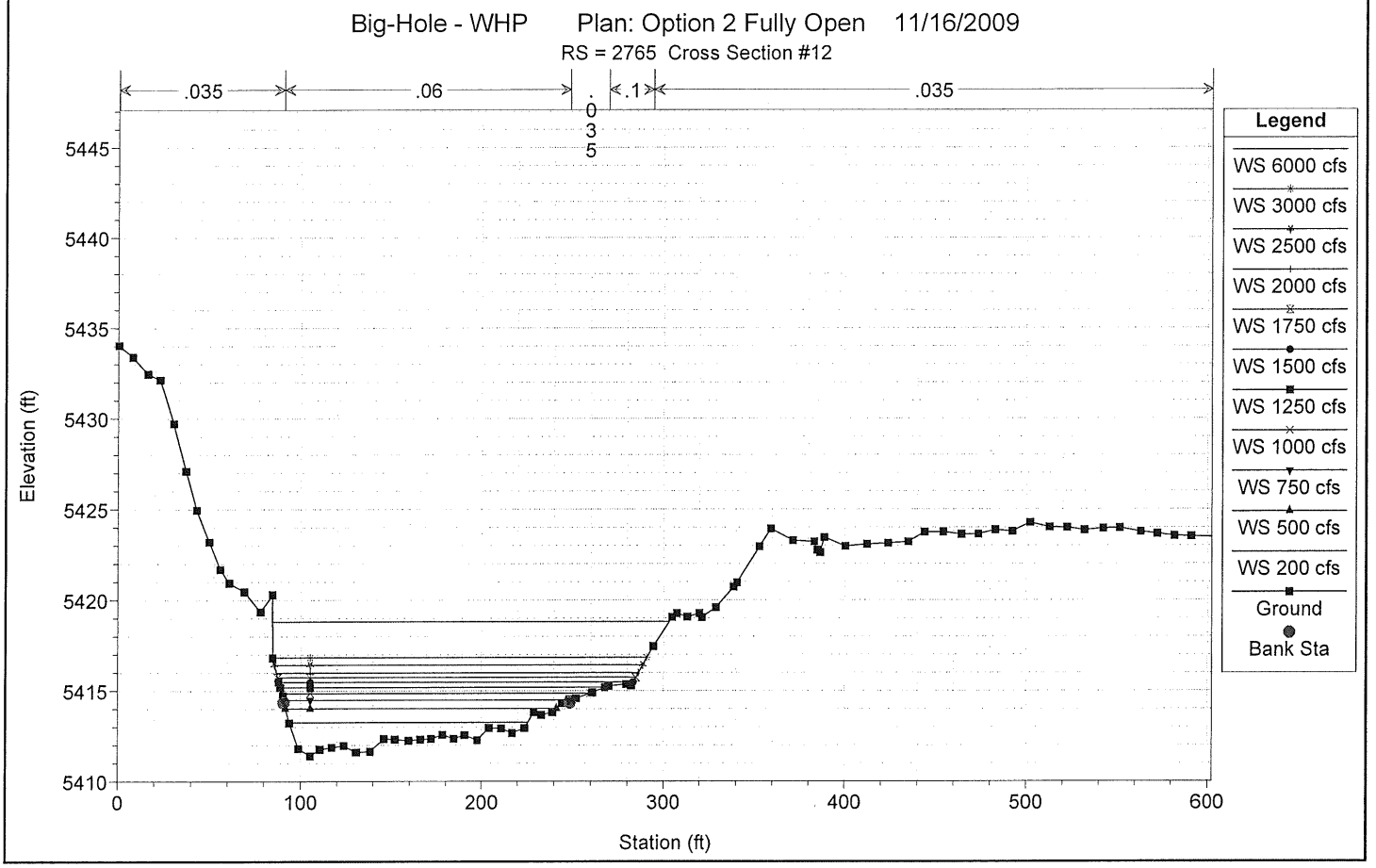
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



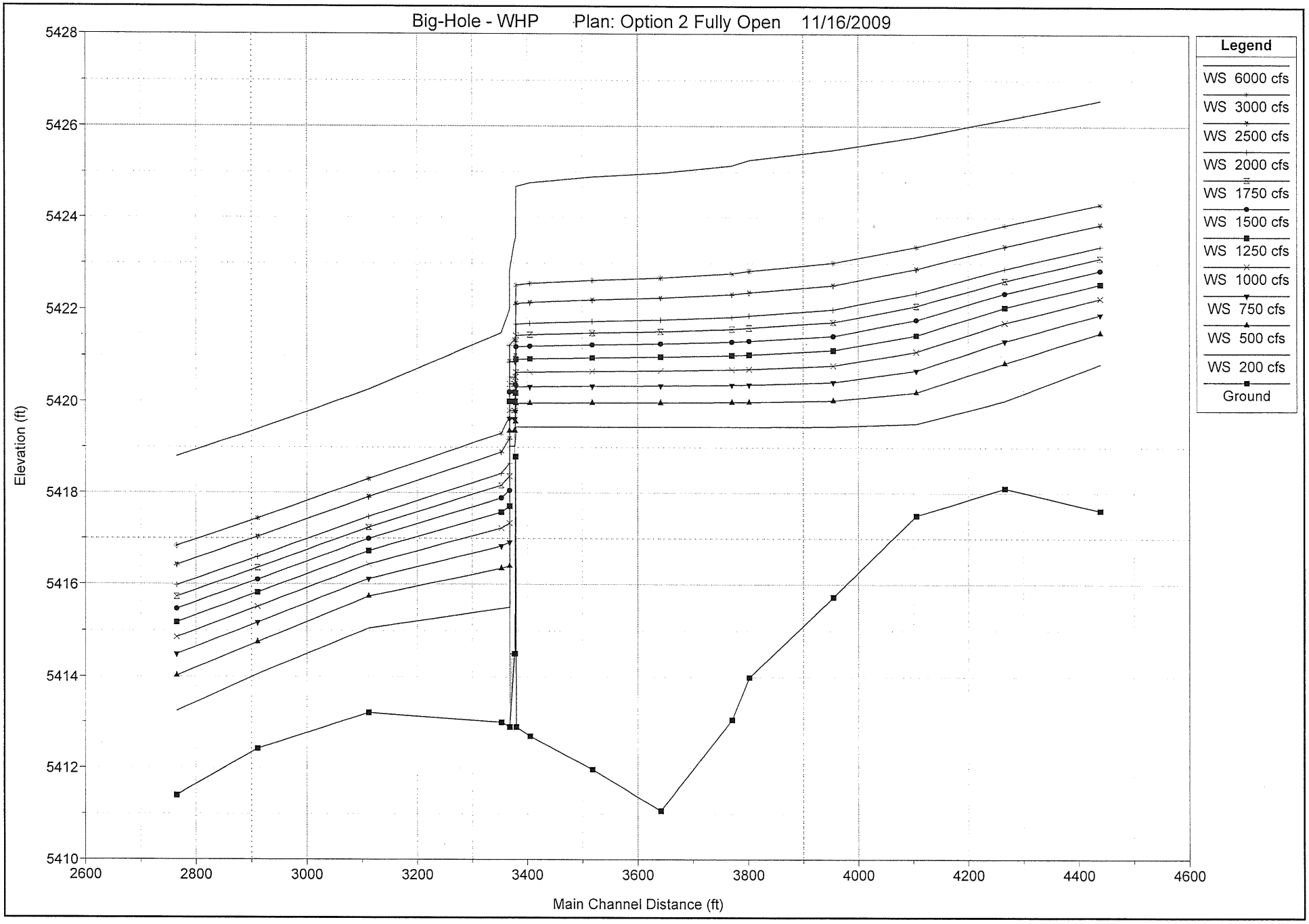


1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft


Big-Hole - WHP Plan: Option 2 Fully Open 11/16/2009
Elevation (ft)
5428
5426
5424
5422
5420
5418
5416
5414
5412
5410
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
Main Channel Distance (ft)
Legend
WS 6000 cfs
WS 3000 cfs
WS 2500 cfs
WS 2000 cfs
WS 1750 cfs
WS 1500 cfs
WS 1250 cfs
WS 1000 cfs
WS 750 cfs
WS 500 cfs
WS 200 cfs
Ground

14/14

PROJECT: BIG HOLE - WHP OPTION 2

PLAN: OPTION 2 HALF OPEN (.p18)

GEOMETRY: OPTION 2 HALF OPEN (.g18)

FLOW: INTAKE STRUCTURE FLOWS (.f08)

HEC-RAS Plan: Op 2 Half River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	200 cfs	200	5417.62	5420.8	5420.2	5420.87	0.005113	1.6	121.4	134.1	0.31
Upstream Chl	4439	500 cfs	500	5417.62	5421.5	5420.7	5421.57	0.005628	2.1	243.7	208.8	0.33
Upstream Chl	4439	750 cfs	750	5417.62	5421.9	5420.9	5421.98	0.004867	2.3	326.3	212.2	0.33
Upstream Chl	4439	1000 cfs	1000	5417.62	5422.2	5421.2	5422.34	0.004415	2.5	400.2	214.4	0.32
Upstream Chl	4439	1250 cfs	1250	5417.62	5422.6	5421.4	5422.67	0.004108	2.7	468.0	215.9	0.32
Upstream Chl	4439	1500 cfs	1500	5417.62	5422.8	5421.5	5422.97	0.003888	2.8	531.5	217.2	0.32
Upstream Chl	4439	1750 cfs	1750	5417.62	5423.1	5421.6	5423.25	0.003753	3.0	589.9	218.5	0.32
Upstream Chl	4439	2000 cfs	2000	5417.62	5423.4	5421.7	5423.52	0.003641	3.1	645.7	220.1	0.32
Upstream Chl	4439	2500 cfs	2500	5417.62	5423.9	5422.0	5424.03	0.003437	3.3	753.3	223.9	0.31
Upstream Chl	4439	3000 cfs	3000	5417.62	5424.3	5422.2	5424.50	0.003272	3.5	857.7	233.6	0.31
Upstream Chl	4439	6000 cfs	6000	5417.62	5426.6	5423.3	5426.90	0.002599	4.3	1414.9	251.7	0.30
Upstream Chl	4267	200 cfs	200	5418.11	5420.0	5419.2	5420.06	0.004281	1.4	138.7	164.8	0.28
Upstream Chl	4267	500 cfs	500	5418.11	5420.8	5419.7	5420.89	0.002908	1.7	295.5	206.7	0.25
Upstream Chl	4267	750 cfs	750	5418.11	5421.3	5420.0	5421.38	0.002538	1.9	395.6	212.0	0.24
Upstream Chl	4267	1000 cfs	1000	5418.11	5421.7	5420.2	5421.78	0.002388	2.1	480.0	214.8	0.24
Upstream Chl	4267	1250 cfs	1250	5418.11	5422.0	5420.4	5422.13	0.002362	2.3	551.9	216.7	0.25
Upstream Chl	4267	1500 cfs	1500	5418.11	5422.4	5420.6	5422.45	0.002338	2.4	619.2	218.3	0.25
Upstream Chl	4267	1750 cfs	1750	5418.11	5422.6	5420.7	5422.74	0.002354	2.6	679.3	219.8	0.26
Upstream Chl	4267	2000 cfs	2000	5418.11	5422.9	5420.8	5423.01	0.002359	2.7	737.2	221.4	0.26
Upstream Chl	4267	2500 cfs	2500	5418.11	5423.4	5421.1	5423.53	0.002343	3.0	848.0	223.2	0.27
Upstream Chl	4267	3000 cfs	3000	5418.11	5423.9	5421.3	5424.02	0.002317	3.2	952.8	224.7	0.27
Upstream Chl	4267	6000 cfs	6000	5418.11	5426.2	5422.4	5426.48	0.002198	4.1	1493.4	236.0	0.28
Upstream Chl	4106	200 cfs	200	5417.51	5419.5	5418.5	5419.56	0.002361	1.5	135.0	98.5	0.22
Upstream Chl	4106	500 cfs	500	5417.51	5420.2	5419.0	5420.29	0.004818	2.3	213.5	134.3	0.33
Upstream Chl	4106	750 cfs	750	5417.51	5420.7	5419.3	5420.79	0.005708	2.6	285.7	171.8	0.36
Upstream Chl	4106	1000 cfs	1000	5417.51	5421.1	5419.6	5421.21	0.005716	2.8	362.7	202.7	0.36
Upstream Chl	4106	1250 cfs	1250	5417.51	5421.5	5419.9	5421.58	0.005260	2.9	438.3	219.0	0.35
Upstream Chl	4106	1500 cfs	1500	5417.51	5421.8	5420.2	5421.92	0.004877	2.9	515.0	235.8	0.35
Upstream Chl	4106	1750 cfs	1750	5417.51	5422.1	5420.4	5422.23	0.004325	3.0	586.8	237.1	0.33
Upstream Chl	4106	2000 cfs	2000	5417.51	5422.4	5420.6	5422.53	0.003931	3.1	655.1	238.0	0.32
Upstream Chl	4106	2500 cfs	2500	5417.51	5422.9	5420.9	5423.08	0.003409	3.2	783.8	239.8	0.31
Upstream Chl	4106	3000 cfs	3000	5417.51	5423.4	5421.2	5423.59	0.003083	3.4	903.5	241.6	0.30
Upstream Chl	4106	6000 cfs	6000	5417.51	5425.9	5422.3	5426.11	0.002350	4.1	1520.3	263.7	0.29
Upstream Chl	3955	200 cfs	200	5415.73	5419.5	5417.0	5419.47	0.000240	0.7	305.3	146.6	0.08
Upstream Chl	3955	500 cfs	500	5415.73	5420.0	5417.7	5420.05	0.000701	1.3	390.4	155.4	0.14
Upstream Chl	3955	750 cfs	750	5415.73	5420.4	5418.1	5420.47	0.000998	1.7	454.5	164.5	0.17
Upstream Chl	3955	1000 cfs	1000	5415.73	5420.8	5418.4	5420.85	0.001211	1.9	515.6	169.3	0.19
Upstream Chl	3955	1250 cfs	1250	5415.73	5421.1	5418.6	5421.21	0.001370	2.2	573.7	174.4	0.21
Upstream Chl	3955	1500 cfs	1500	5415.73	5421.4	5418.8	5421.54	0.001489	2.4	629.7	179.3	0.22
Upstream Chl	3955	1750 cfs	1750	5415.73	5421.7	5419.0	5421.85	0.001578	2.6	684.3	183.7	0.23
Upstream Chl	3955	2000 cfs	2000	5415.73	5422.0	5419.1	5422.15	0.001646	2.7	737.8	189.2	0.24
Upstream Chl	3955	2500 cfs	2500	5415.73	5422.6	5419.4	5422.72	0.001742	3.0	843.5	204.5	0.26
Upstream Chl	3955	3000 cfs	3000	5415.73	5423.1	5419.7	5423.24	0.001780	3.2	959.8	239.6	0.28
Upstream Chl	3955	6000 cfs	6000	5415.73	5425.6	5421.1	5425.82	0.001571	3.9	1601.2	270.9	0.27
Upstream Chl	3802	200 cfs	200	5413.99	5419.5	5415.4	5419.45	0.000041	0.4	508.3	146.2	0.04
Upstream Chl	3802	500 cfs	500	5413.99	5420.0	5415.9	5420.00	0.000166	0.9	590.5	158.3	0.08
Upstream Chl	3802	750 cfs	750	5413.99	5420.4	5416.2	5420.39	0.000283	1.2	651.8	167.2	0.10
Upstream Chl	3802	1000 cfs	1000	5413.99	5420.7	5416.5	5420.75	0.000395	1.4	710.9	174.4	0.12
Upstream Chl	3802	1250 cfs	1250	5413.99	5421.0	5416.7	5421.08	0.000499	1.7	767.9	180.8	0.14
Upstream Chl	3802	1500 cfs	1500	5413.99	5421.3	5416.9	5421.39	0.000595	1.9	824.0	194.4	0.15
Upstream Chl	3802	1750 cfs	1750	5413.99	5421.6	5417.1	5421.69	0.000680	2.0	880.4	196.2	0.16
Upstream Chl	3802	2000 cfs	2000	5413.99	5421.9	5417.3	5421.98	0.000756	2.2	934.7	196.9	0.17
Upstream Chl	3802	2500 cfs	2500	5413.99	5422.4	5417.6	5422.52	0.000886	2.5	1037.8	197.8	0.19
Upstream Chl	3802	3000 cfs	3000	5413.99	5422.9	5418.0	5423.03	0.000993	2.7	1134.9	198.5	0.20
Upstream Chl	3802	6000 cfs	6000	5413.99	5425.4	5419.7	5425.59	0.001392	3.8	1628.3	208.5	0.23
Upstream Chl	3771	200 cfs	200	5413.06	5419.4	5414.4	5419.45	0.000025	0.4	568.6	121.8	0.03
Upstream Chl	3771	500 cfs	500	5413.06	5420.0	5415.0	5420.00	0.000111	0.8	636.2	129.4	0.06
Upstream Chl	3771	750 cfs	750	5413.06	5420.4	5415.3	5420.38	0.000200	1.1	687.5	144.1	0.08
Upstream Chl	3771	1000 cfs	1000	5413.06	5420.7	5415.6	5420.73	0.000291	1.4	737.5	147.2	0.10
Upstream Chl	3771	1250 cfs	1250	5413.06	5421.0	5415.8	5421.06	0.000381	1.6	784.4	149.0	0.11
Upstream Chl	3771	1500 cfs	1500	5413.06	5421.3	5416.0	5421.37	0.000470	1.9	829.1	152.8	0.13
Upstream Chl	3771	1750 cfs	1750	5413.06	5421.6	5416.3	5421.67	0.000554	2.1	873.9	169.5	0.14
Upstream Chl	3771	2000 cfs	2000	5413.06	5421.9	5416.5	5421.95	0.000635	2.3	921.7	180.6	0.15
Upstream Chl	3771	2500 cfs	2500	5413.06	5422.4	5416.8	5422.49	0.000777	2.7	1014.2	181.7	0.17
Upstream Chl	3771	3000 cfs	3000	5413.06	5422.9	5417.2	5422.99	0.000900	3.0	1101.6	183.9	0.18
Upstream Chl	3771	6000 cfs	6000	5413.06	5425.2	5418.9	5425.54	0.001417	4.5	1556.9	199.0	0.24
Upstream Chl	3642	200 cfs	200	5411.07	5419.4	5412.4	5419.45	0.000013	0.3	667.0	108.9	0.02

HEC-RAS Plan: Op 2 Half River: Big Hole Reach: Upstream Chl (Continued)

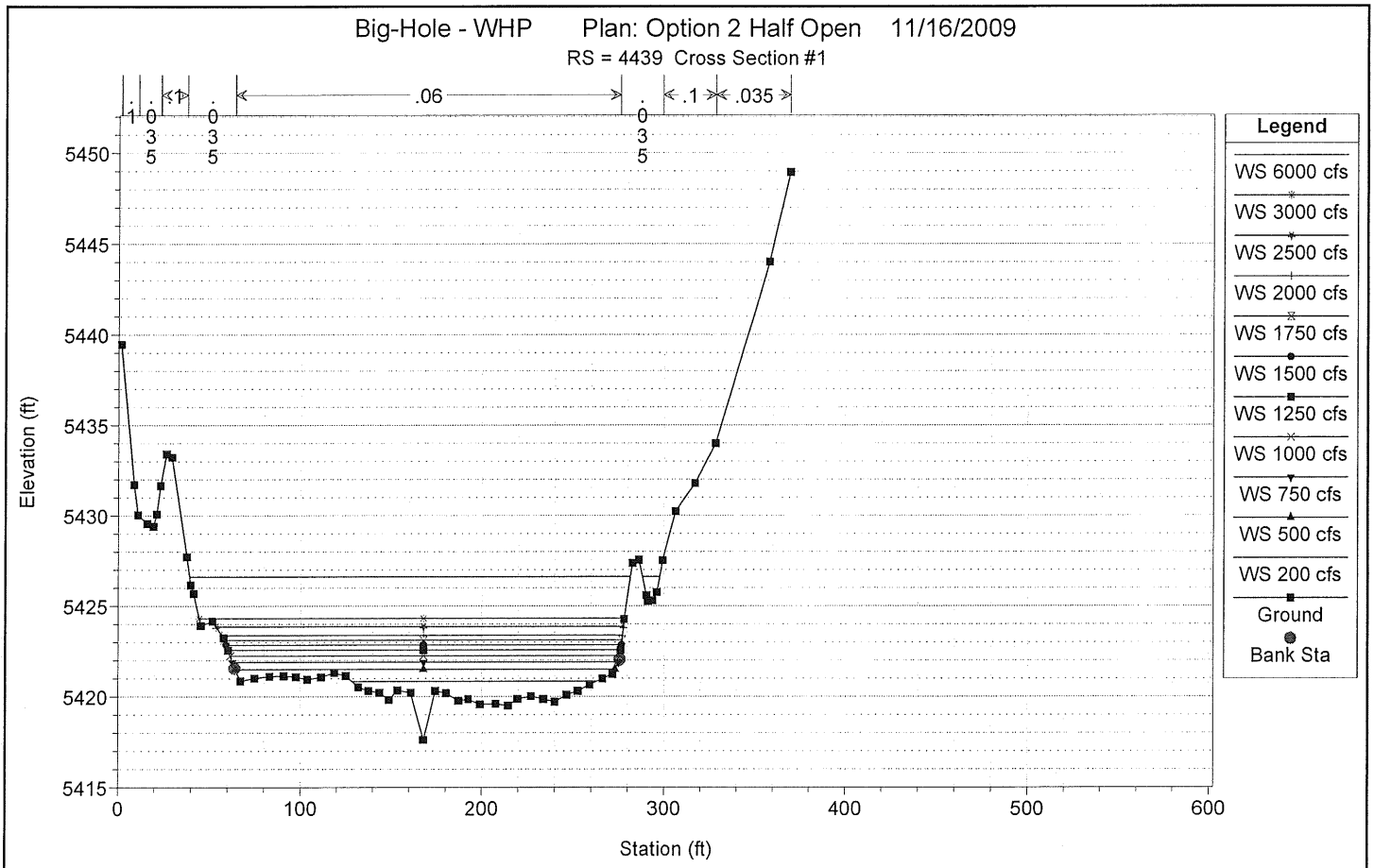
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3642	500 cfs	500	5411.07	5420.0	5413.2	5419.99	0.000062	0.7	725.5	111.8	0.05
Upstream Chl	3642	750 cfs	750	5411.07	5420.3	5413.6	5420.36	0.000117	1.0	766.9	114.2	0.06
Upstream Chl	3642	1000 cfs	1000	5411.07	5420.7	5413.9	5420.70	0.000179	1.3	805.5	116.5	0.08
Upstream Chl	3642	1250 cfs	1250	5411.07	5421.0	5414.2	5421.02	0.000244	1.5	841.7	120.4	0.09
Upstream Chl	3642	1500 cfs	1500	5411.07	5421.3	5414.4	5421.32	0.000311	1.7	878.0	130.9	0.11
Upstream Chl	3642	1750 cfs	1750	5411.07	5421.5	5414.7	5421.61	0.000378	2.0	914.6	136.5	0.12
Upstream Chl	3642	2000 cfs	2000	5411.07	5421.8	5414.9	5421.88	0.000444	2.2	951.0	144.1	0.13
Upstream Chl	3642	2500 cfs	2500	5411.07	5422.3	5415.4	5422.40	0.000569	2.5	1027.4	159.4	0.15
Upstream Chl	3642	3000 cfs	3000	5411.07	5422.8	5415.8	5422.89	0.000683	2.9	1102.7	166.7	0.16
Upstream Chl	3642	6000 cfs	6000	5411.07	5425.1	5417.7	5425.37	0.001166	4.3	1525.5	192.7	0.22
Upstream Chl	3518	200 cfs	200	5411.97	5419.4	5413.0	5419.45	0.000010	0.3	779.8	129.7	0.02
Upstream Chl	3518	500 cfs	500	5411.97	5420.0	5413.5	5419.98	0.000047	0.6	848.6	131.0	0.04
Upstream Chl	3518	750 cfs	750	5411.97	5420.3	5413.7	5420.35	0.000088	0.8	896.1	131.8	0.06
Upstream Chl	3518	1000 cfs	1000	5411.97	5420.7	5414.0	5420.68	0.000135	1.1	939.8	133.8	0.07
Upstream Chl	3518	1250 cfs	1250	5411.97	5421.0	5414.2	5420.99	0.000184	1.3	980.6	135.6	0.08
Upstream Chl	3518	1500 cfs	1500	5411.97	5421.3	5414.4	5421.28	0.000234	1.5	1019.1	137.3	0.09
Upstream Chl	3518	1750 cfs	1750	5411.97	5421.5	5414.7	5421.56	0.000285	1.7	1056.2	138.9	0.10
Upstream Chl	3518	2000 cfs	2000	5411.97	5421.8	5414.9	5421.83	0.000335	1.9	1092.0	140.4	0.11
Upstream Chl	3518	2500 cfs	2500	5411.97	5422.3	5415.2	5422.33	0.000434	2.2	1162.6	157.3	0.13
Upstream Chl	3518	3000 cfs	3000	5411.97	5422.7	5415.6	5422.81	0.000526	2.5	1235.9	169.8	0.14
Upstream Chl	3518	6000 cfs	6000	5411.97	5425.0	5417.3	5425.22	0.000916	3.8	1674.9	201.6	0.20
Upstream Chl	3405	200 cfs	200	5412.70	5419.4	5413.8	5419.45	0.000013	0.3	726.2	142.7	0.02
Upstream Chl	3405	500 cfs	500	5412.70	5420.0	5414.4	5419.97	0.000061	0.6	801.5	146.0	0.05
Upstream Chl	3405	750 cfs	750	5412.70	5420.3	5414.7	5420.34	0.000112	0.9	853.7	147.3	0.06
Upstream Chl	3405	1000 cfs	1000	5412.70	5420.6	5414.9	5420.67	0.000168	1.1	901.5	148.4	0.08
Upstream Chl	3405	1250 cfs	1250	5412.70	5420.9	5415.2	5420.97	0.000225	1.3	945.6	149.4	0.09
Upstream Chl	3405	1500 cfs	1500	5412.70	5421.2	5415.4	5421.26	0.000282	1.5	987.1	150.3	0.10
Upstream Chl	3405	1750 cfs	1750	5412.70	5421.5	5415.6	5421.53	0.000339	1.7	1026.6	151.2	0.11
Upstream Chl	3405	2000 cfs	2000	5412.70	5421.7	5415.8	5421.79	0.000394	1.9	1064.6	152.0	0.12
Upstream Chl	3405	2500 cfs	2500	5412.70	5422.2	5416.1	5422.28	0.000499	2.2	1136.7	153.6	0.14
Upstream Chl	3405	3000 cfs	3000	5412.70	5422.6	5416.4	5422.75	0.000596	2.5	1205.2	155.1	0.15
Upstream Chl	3405	6000 cfs	6000	5412.70	5424.9	5418.0	5425.11	0.001048	3.9	1563.8	168.7	0.21
Upstream Chl	3380	200 cfs	200	5412.90	5419.4	5414.0	5419.45	0.000016	0.3	673.1	131.7	0.02
Upstream Chl	3380	500 cfs	500	5412.90	5420.0	5414.6	5419.97	0.000073	0.7	742.3	134.6	0.05
Upstream Chl	3380	750 cfs	750	5412.90	5420.3	5414.9	5420.33	0.000136	1.0	790.2	136.1	0.07
Upstream Chl	3380	1000 cfs	1000	5412.90	5420.6	5415.1	5420.66	0.000204	1.2	834.0	137.3	0.08
Upstream Chl	3380	1250 cfs	1250	5412.90	5420.9	5415.3	5420.96	0.000276	1.4	874.4	138.5	0.10
Upstream Chl	3380	1500 cfs	1500	5412.90	5421.2	5415.6	5421.25	0.000348	1.7	912.4	139.5	0.11
Upstream Chl	3380	1750 cfs	1750	5412.90	5421.5	5415.8	5421.52	0.000420	1.9	948.6	140.5	0.12
Upstream Chl	3380	2000 cfs	2000	5412.90	5421.7	5415.9	5421.77	0.000490	2.1	983.4	141.5	0.13
Upstream Chl	3380	2500 cfs	2500	5412.90	5422.2	5416.3	5422.26	0.000626	2.4	1049.6	143.2	0.15
Upstream Chl	3380	3000 cfs	3000	5412.90	5422.6	5416.6	5422.73	0.000754	2.7	1112.4	144.6	0.16
Upstream Chl	3380	6000 cfs	6000	5412.90	5424.8	5418.2	5425.08	0.001378	4.3	1442.0	160.9	0.23
Upstream Chl	3379	200 cfs	200	5418.80	5419.2	5419.2	5419.43	0.026319	3.2	58.4	130.9	0.87
Upstream Chl	3379	500 cfs	500	5418.80	5419.6	5419.6	5419.94	0.026462	4.8	102.9	132.4	0.96
Upstream Chl	3379	750 cfs	750	5418.80	5419.8	5419.8	5420.29	0.023639	5.4	136.6	133.4	0.95
Upstream Chl	3379	1000 cfs	1000	5418.80	5420.1	5420.0	5420.61	0.018322	5.7	176.2	134.5	0.87
Upstream Chl	3379	1250 cfs	1250	5418.80	5420.4	5420.2	5420.91	0.016570	6.0	208.3	135.0	0.85
Upstream Chl	3379	1500 cfs	1500	5418.80	5420.6	5420.4	5421.19	0.015253	6.3	239.0	135.6	0.83
Upstream Chl	3379	1750 cfs	1750	5418.80	5420.8	5420.5	5421.46	0.014171	6.5	268.8	136.1	0.82
Upstream Chl	3379	2000 cfs	2000	5418.80	5421.0	5420.7	5421.71	0.013298	6.8	297.6	137.6	0.80
Upstream Chl	3379	2500 cfs	2500	5418.80	5421.4	5421.0	5422.19	0.011800	7.1	354.5	139.3	0.78
Upstream Chl	3379	3000 cfs	3000	5418.80	5421.8	5421.3	5422.65	0.010630	7.4	410.2	140.9	0.75
Upstream Chl	3379	6000 cfs	6000	5418.80	5423.8	5422.7	5424.99	0.007673	8.8	701.6	148.0	0.69
Upstream Chl	3378	200 cfs	200	5414.50	5419.1	5419.0	5419.24	0.024090	3.3	60.6	145.3	0.85
Upstream Chl	3378	500 cfs	500	5414.50	5419.6	5419.4	5419.83	0.011959	3.9	129.8	147.5	0.68
Upstream Chl	3378	750 cfs	750	5414.50	5419.9	5419.6	5420.22	0.010752	4.4	171.1	148.9	0.67
Upstream Chl	3378	1000 cfs	1000	5414.50	5420.2	5419.8	5420.56	0.010253	4.8	206.4	149.7	0.68
Upstream Chl	3378	1250 cfs	1250	5414.50	5420.4	5420.0	5420.86	0.010152	5.3	236.9	150.2	0.69
Upstream Chl	3378	1500 cfs	1500	5414.50	5420.6	5420.2	5421.14	0.009995	5.6	265.7	150.8	0.70
Upstream Chl	3378	1750 cfs	1750	5414.50	5420.9	5420.4	5421.41	0.009801	6.0	293.3	151.3	0.70
Upstream Chl	3378	2000 cfs	2000	5414.50	5421.1	5420.5	5421.67	0.009682	6.2	320.2	152.9	0.70
Upstream Chl	3378	2500 cfs	2500	5414.50	5421.5	5420.9	5422.16	0.009172	6.7	372.7	154.5	0.70
Upstream Chl	3378	3000 cfs	3000	5414.50	5421.8	5421.2	5422.63	0.008733	7.1	422.7	156.1	0.70
Upstream Chl	3378	6000 cfs	6000	5414.50	5423.8	5422.7	5424.97	0.007402	8.8	678.9	162.8	0.70
Upstream Chl	3370		Inl Struct									

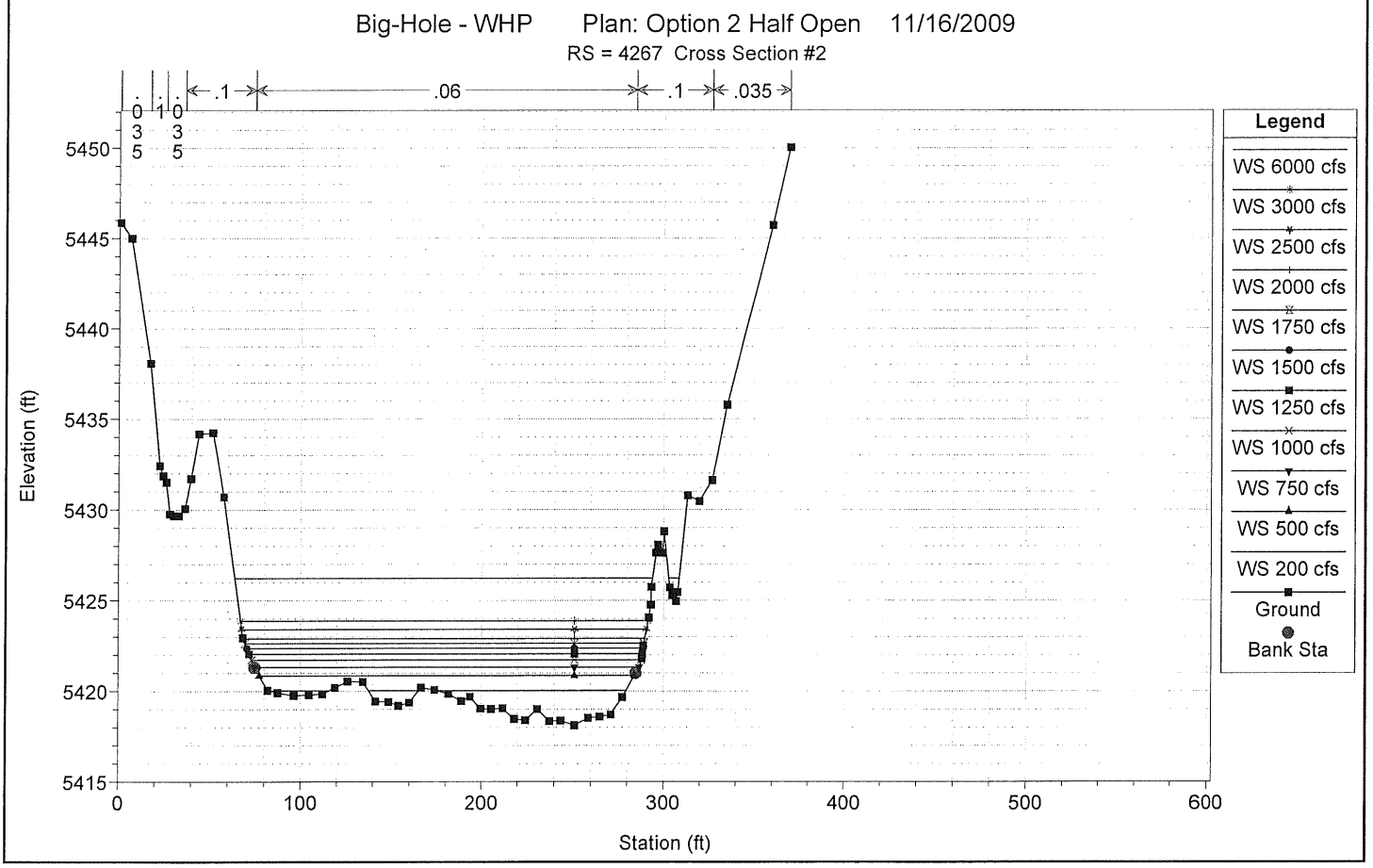
HEC-RAS Plan: Op 2 Half River: Big Hole Reach: Upstream Chl (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3368	200 cfs	200	5412.90	5415.5	5414.0	5415.52	0.001023	1.1	185.0	115.7	0.15
Upstream Chl	3368	500 cfs	500	5412.90	5416.4	5414.6	5416.44	0.001545	1.7	294.9	127.6	0.20
Upstream Chl	3368	750 cfs	750	5412.90	5416.9	5414.9	5416.98	0.001860	2.1	361.4	132.7	0.22
Upstream Chl	3368	1000 cfs	1000	5412.90	5417.3	5415.2	5417.42	0.002112	2.4	418.7	136.9	0.24
Upstream Chl	3368	1250 cfs	1250	5412.90	5417.7	5415.4	5417.82	0.002313	2.7	471.0	140.6	0.26
Upstream Chl	3368	1500 cfs	1500	5412.90	5418.1	5415.6	5418.18	0.002469	2.9	519.5	143.8	0.27
Upstream Chl	3368	1750 cfs	1750	5412.90	5418.4	5415.8	5418.52	0.002548	3.1	564.7	145.3	0.28
Upstream Chl	3368	2000 cfs	2000	5412.90	5418.7	5416.0	5418.83	0.002620	3.3	607.3	146.8	0.28
Upstream Chl	3368	2500 cfs	2500	5412.90	5419.2	5416.4	5419.40	0.002745	3.7	686.3	149.0	0.30
Upstream Chl	3368	3000 cfs	3000	5412.90	5419.7	5416.7	5419.92	0.002855	4.0	758.4	150.4	0.31
Upstream Chl	3368	6000 cfs	6000	5412.90	5422.0	5418.2	5422.44	0.003271	5.4	1115.6	159.5	0.35
Upstream Chl	3353	200 cfs	200	5413.00	5415.5	5414.0	5415.50	0.001155	1.2	160.8	120.9	0.16
Upstream Chl	3353	500 cfs	500	5413.00	5416.3	5414.6	5416.42	0.001985	2.1	239.2	127.7	0.23
Upstream Chl	3353	750 cfs	750	5413.00	5416.8	5415.0	5416.94	0.002572	2.6	283.7	131.8	0.27
Upstream Chl	3353	1000 cfs	1000	5413.00	5417.2	5415.2	5417.38	0.003087	3.1	320.5	136.0	0.30
Upstream Chl	3353	1250 cfs	1250	5413.00	5417.6	5415.5	5417.77	0.003540	3.5	352.9	139.7	0.32
Upstream Chl	3353	1500 cfs	1500	5413.00	5417.9	5415.7	5418.13	0.003952	3.9	382.1	142.6	0.34
Upstream Chl	3353	1750 cfs	1750	5413.00	5418.2	5416.0	5418.45	0.004334	4.3	408.9	145.0	0.36
Upstream Chl	3353	2000 cfs	2000	5413.00	5418.4	5416.2	5418.76	0.004692	4.6	433.7	147.3	0.38
Upstream Chl	3353	2500 cfs	2500	5413.00	5418.9	5416.6	5419.32	0.005335	5.2	478.9	151.3	0.41
Upstream Chl	3353	3000 cfs	3000	5413.00	5419.3	5417.0	5419.83	0.005881	5.8	519.0	153.8	0.44
Upstream Chl	3353	6000 cfs	6000	5413.00	5421.5	5418.9	5422.33	0.009556	7.3	825.0	165.1	0.56
Upstream Chl	3112	200 cfs	200	5413.21	5415.1	5414.1	5415.08	0.002991	1.3	148.5	149.3	0.24
Upstream Chl	3112	500 cfs	500	5413.21	5415.7	5414.6	5415.79	0.003448	1.9	266.2	180.5	0.27
Upstream Chl	3112	750 cfs	750	5413.21	5416.1	5414.9	5416.20	0.003657	2.2	336.0	183.5	0.29
Upstream Chl	3112	1000 cfs	1000	5413.21	5416.4	5415.2	5416.54	0.003851	2.5	394.4	186.0	0.31
Upstream Chl	3112	1250 cfs	1250	5413.21	5416.7	5415.4	5416.85	0.003955	2.8	448.7	187.9	0.32
Upstream Chl	3112	1500 cfs	1500	5413.21	5417.0	5415.5	5417.14	0.004025	3.0	499.3	190.3	0.32
Upstream Chl	3112	1750 cfs	1750	5413.21	5417.2	5415.7	5417.40	0.004071	3.2	546.9	192.5	0.33
Upstream Chl	3112	2000 cfs	2000	5413.21	5417.5	5415.8	5417.66	0.004108	3.4	592.2	193.4	0.34
Upstream Chl	3112	2500 cfs	2500	5413.21	5417.9	5416.1	5418.13	0.004166	3.7	676.3	194.2	0.35
Upstream Chl	3112	3000 cfs	3000	5413.21	5418.3	5416.3	5418.56	0.004211	4.0	753.9	194.9	0.35
Upstream Chl	3112	6000 cfs	6000	5413.21	5420.3	5417.5	5420.70	0.004410	5.4	1137.7	198.4	0.39
Upstream Chl	2911	200 cfs	200	5412.42	5414.1	5413.6	5414.11	0.008912	2.0	101.6	131.3	0.39
Upstream Chl	2911	500 cfs	500	5412.42	5414.7	5414.0	5414.83	0.007006	2.3	216.9	184.7	0.37
Upstream Chl	2911	750 cfs	750	5412.42	5415.2	5414.3	5415.27	0.005922	2.5	298.0	197.0	0.36
Upstream Chl	2911	1000 cfs	1000	5412.42	5415.5	5414.5	5415.63	0.005343	2.7	365.9	198.8	0.35
Upstream Chl	2911	1250 cfs	1250	5412.42	5415.8	5414.7	5415.95	0.005018	2.9	427.0	200.0	0.35
Upstream Chl	2911	1500 cfs	1500	5412.42	5416.1	5414.8	5416.25	0.004823	3.1	482.9	201.0	0.35
Upstream Chl	2911	1750 cfs	1750	5412.42	5416.4	5415.0	5416.52	0.004711	3.3	534.4	202.0	0.35
Upstream Chl	2911	2000 cfs	2000	5412.42	5416.6	5415.1	5416.78	0.004634	3.5	582.8	203.5	0.36
Upstream Chl	2911	2500 cfs	2500	5412.42	5417.0	5415.4	5417.25	0.004539	3.8	672.9	206.5	0.36
Upstream Chl	2911	3000 cfs	3000	5412.42	5417.4	5415.6	5417.69	0.004476	4.0	756.7	209.3	0.36
Upstream Chl	2911	6000 cfs	6000	5412.42	5419.4	5416.7	5419.81	0.004381	5.2	1179.3	223.0	0.39
Upstream Chl	2765	200 cfs	200	5411.40	5413.2	5412.6	5413.28	0.003899	1.5	130.4	131.7	0.27
Upstream Chl	2765	500 cfs	500	5411.40	5414.0	5413.0	5414.08	0.003899	2.1	237.9	149.6	0.29
Upstream Chl	2765	750 cfs	750	5411.40	5414.5	5413.2	5414.57	0.003904	2.4	309.6	159.6	0.30
Upstream Chl	2765	1000 cfs	1000	5411.40	5414.9	5413.5	5414.97	0.003904	2.7	370.4	169.8	0.31
Upstream Chl	2765	1250 cfs	1250	5411.40	5415.2	5413.7	5415.31	0.003904	3.0	426.9	178.7	0.32
Upstream Chl	2765	1500 cfs	1500	5411.40	5415.5	5413.9	5415.62	0.003902	3.2	481.2	195.0	0.33
Upstream Chl	2765	1750 cfs	1750	5411.40	5415.7	5414.0	5415.90	0.003904	3.4	532.6	197.2	0.33
Upstream Chl	2765	2000 cfs	2000	5411.40	5416.0	5414.2	5416.16	0.003902	3.5	581.2	199.2	0.33
Upstream Chl	2765	2500 cfs	2500	5411.40	5416.4	5414.5	5416.64	0.003908	3.8	671.0	202.9	0.34
Upstream Chl	2765	3000 cfs	3000	5411.40	5416.8	5414.8	5417.08	0.003901	4.1	754.8	206.2	0.35
Upstream Chl	2765	6000 cfs	6000	5411.40	5418.8	5416.1	5419.21	0.003907	5.3	1172.8	218.5	0.37

HEC-RAS Plan: Op 2 Half River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Q Total	Q Weir	Q Gates
			(ft)	(ft)	(cfs)	(cfs)	(cfs)
Upstream Chl	3370	200 cfs	5419.24	5419.07	200.00	107.29	92.71
Upstream Chl	3370	500 cfs	5419.83	5419.60	500.00	389.23	110.77
Upstream Chl	3370	750 cfs	5420.22	5419.92	750.00	626.98	123.02
Upstream Chl	3370	1000 cfs	5420.56	5420.19	1000.00	864.30	135.70
Upstream Chl	3370	1250 cfs	5420.86	5420.43	1250.00	1096.75	153.25
Upstream Chl	3370	1500 cfs	5421.14	5420.65	1500.00	1332.26	167.74
Upstream Chl	3370	1750 cfs	5421.41	5420.86	1750.00	1570.47	179.53
Upstream Chl	3370	2000 cfs	5421.67	5421.07	2000.00	1811.14	188.86
Upstream Chl	3370	2500 cfs	5422.16	5421.47	2500.00	2300.13	199.87
Upstream Chl	3370	3000 cfs	5422.63	5421.84	3000.00	2794.20	205.80
Upstream Chl	3370	6000 cfs	5424.97	5423.76	6000.00	5789.88	210.12

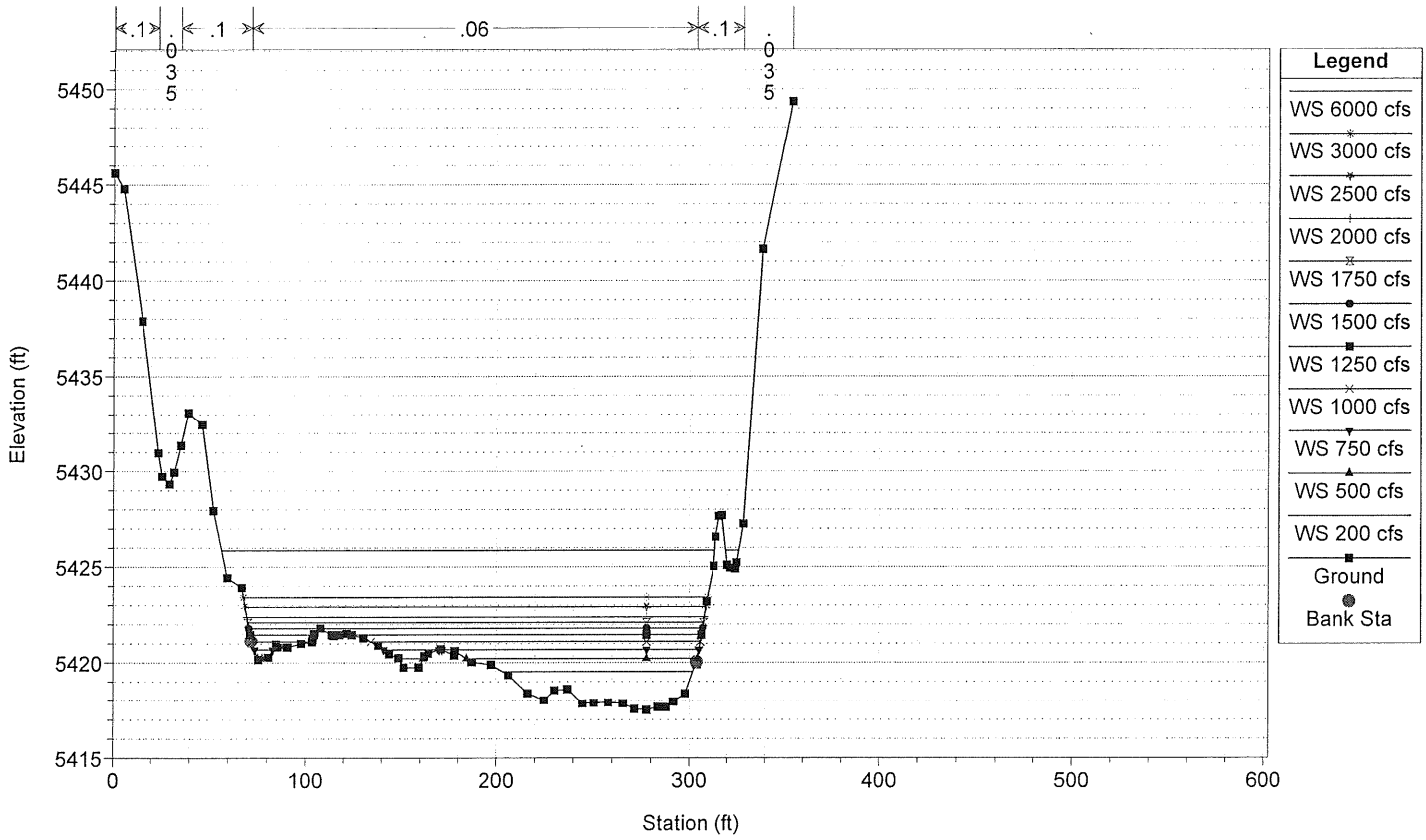




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

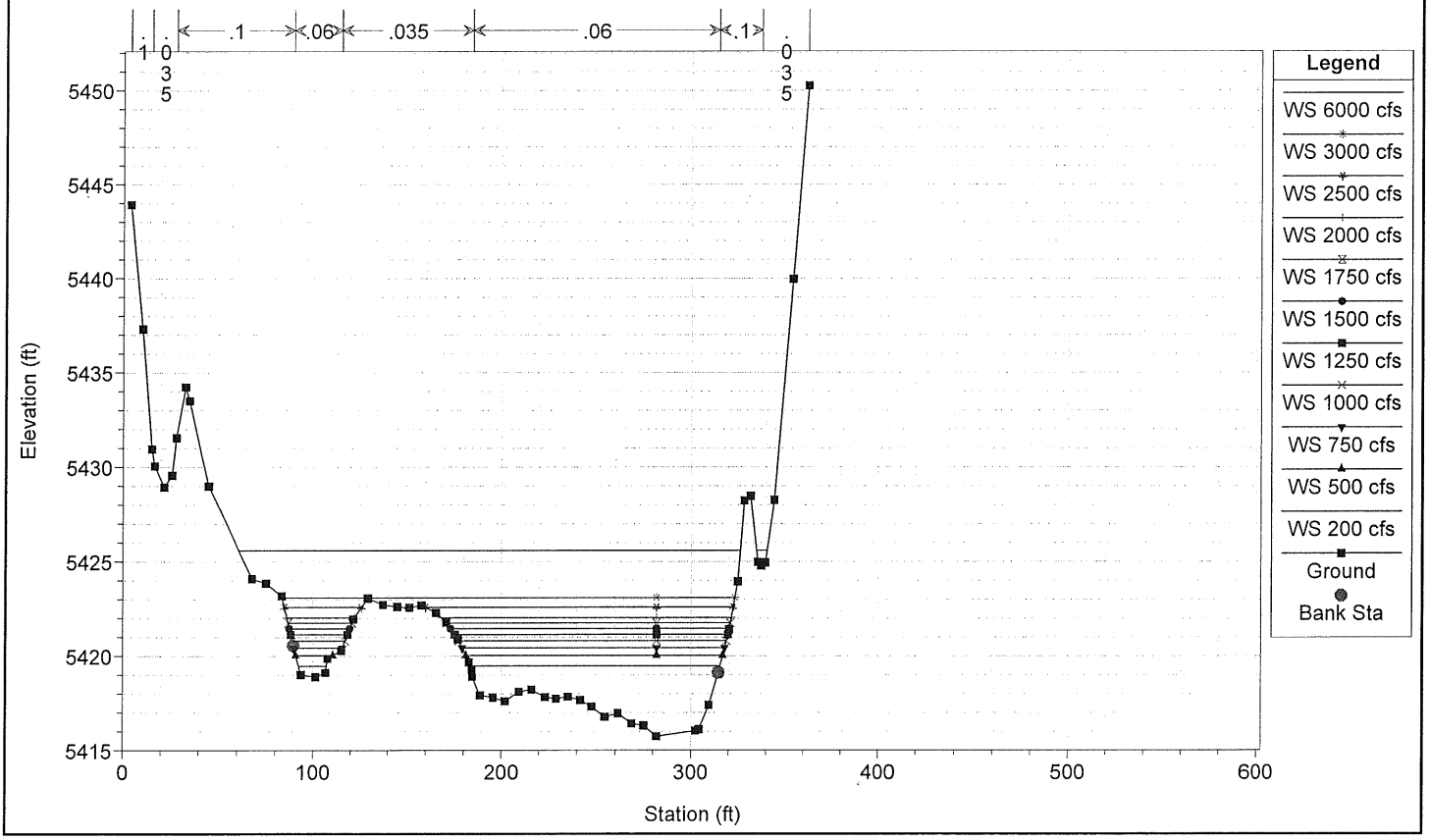
Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 4106 Cross Section #3

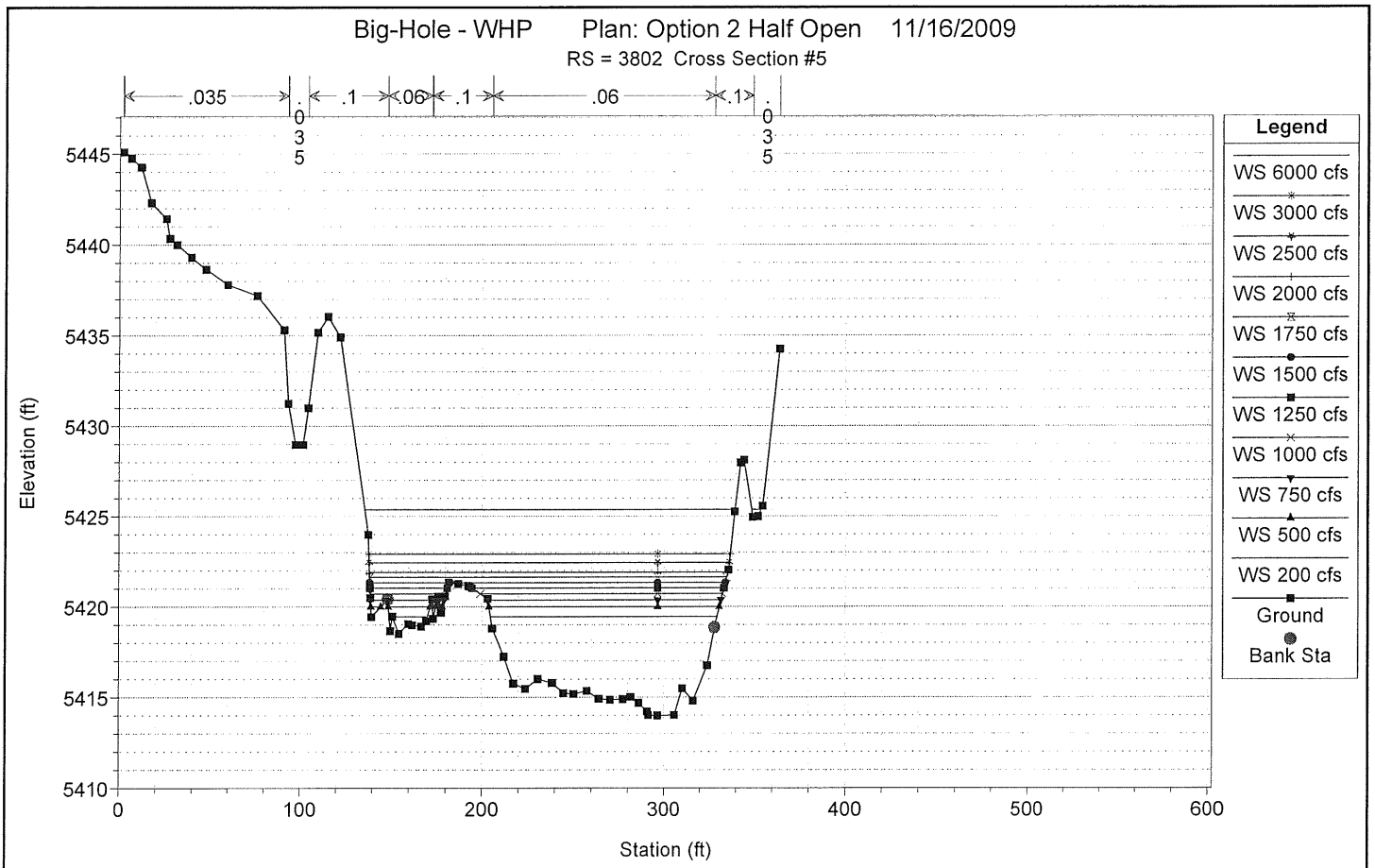


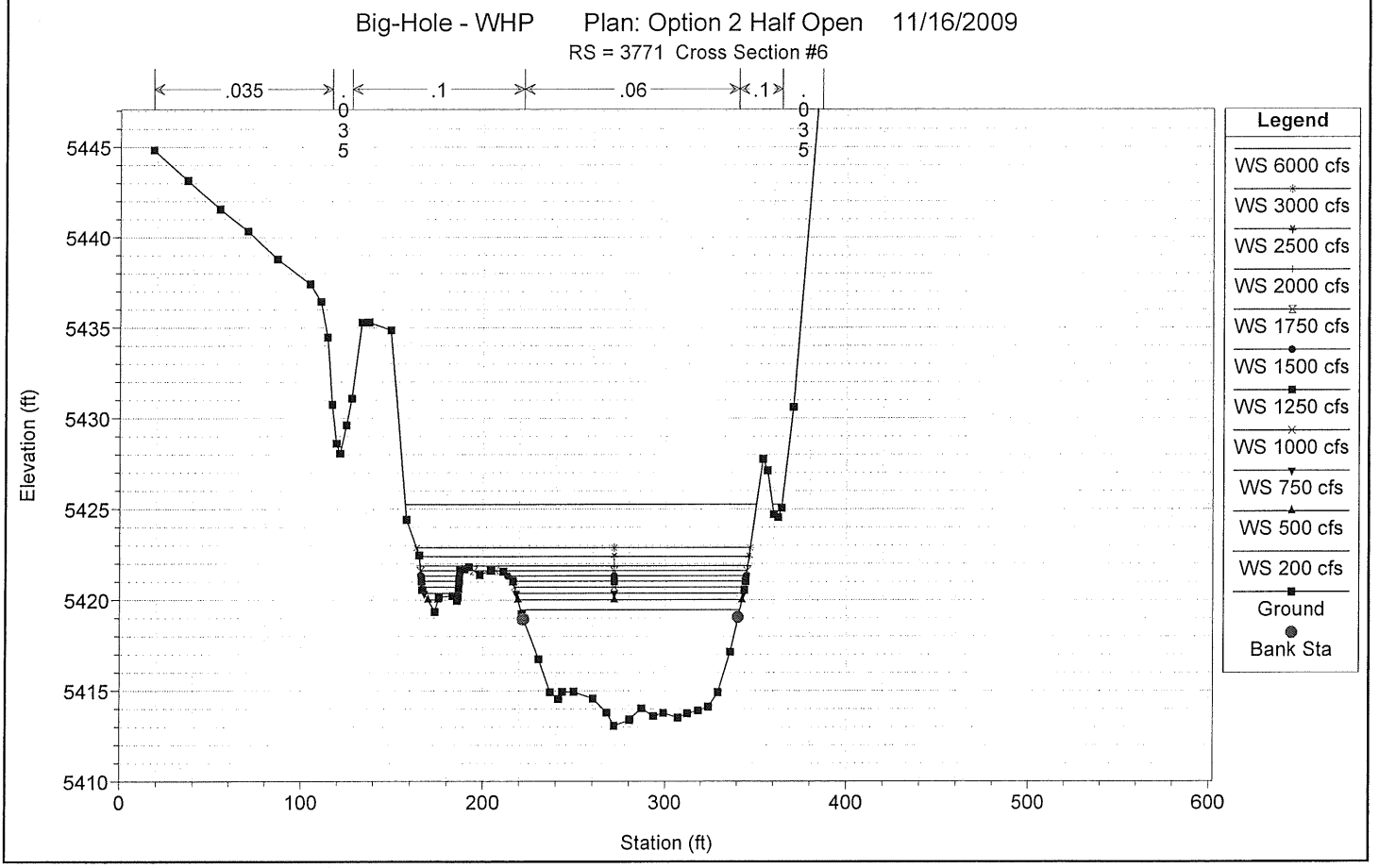
Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 3955 Cross Section #4

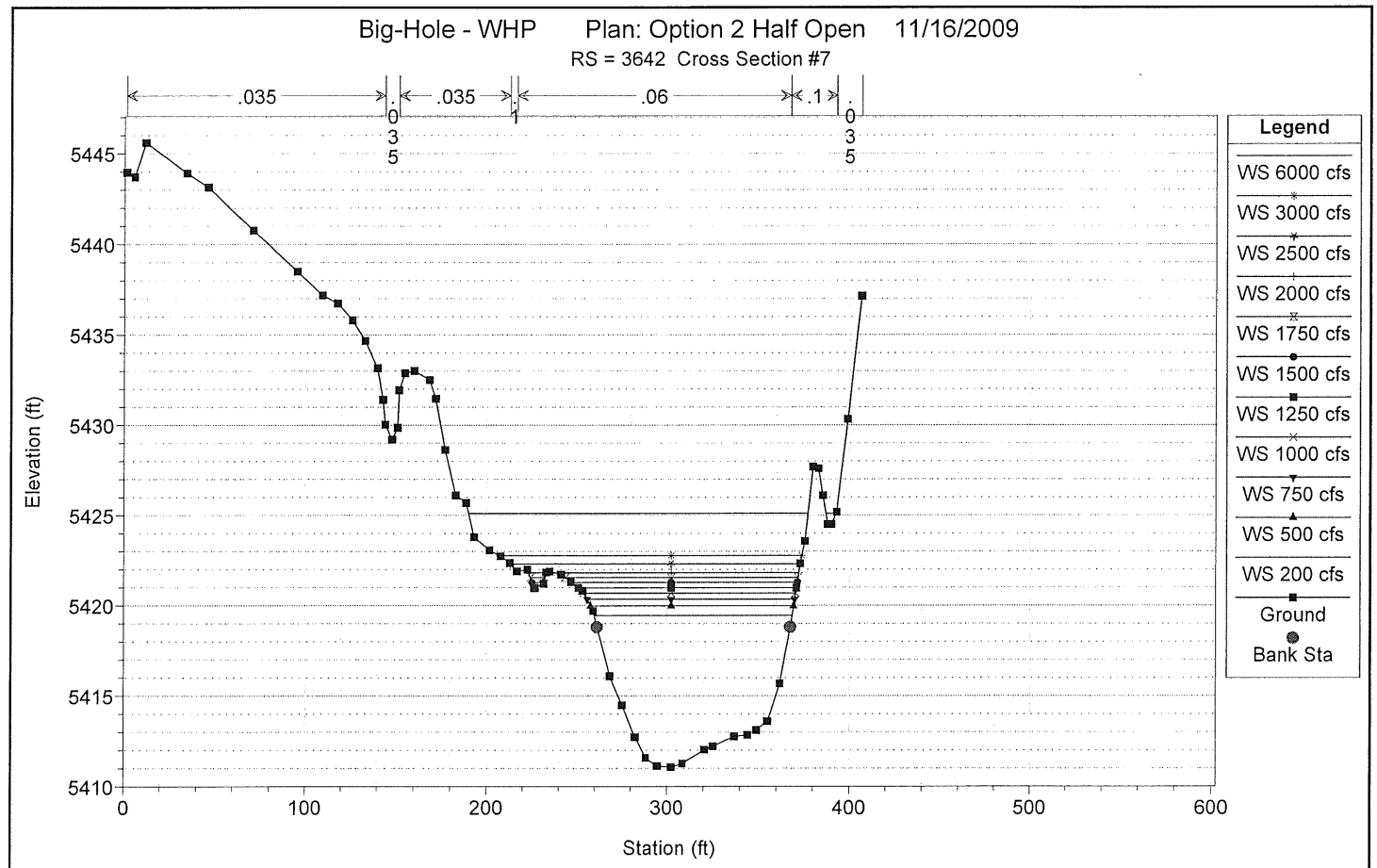


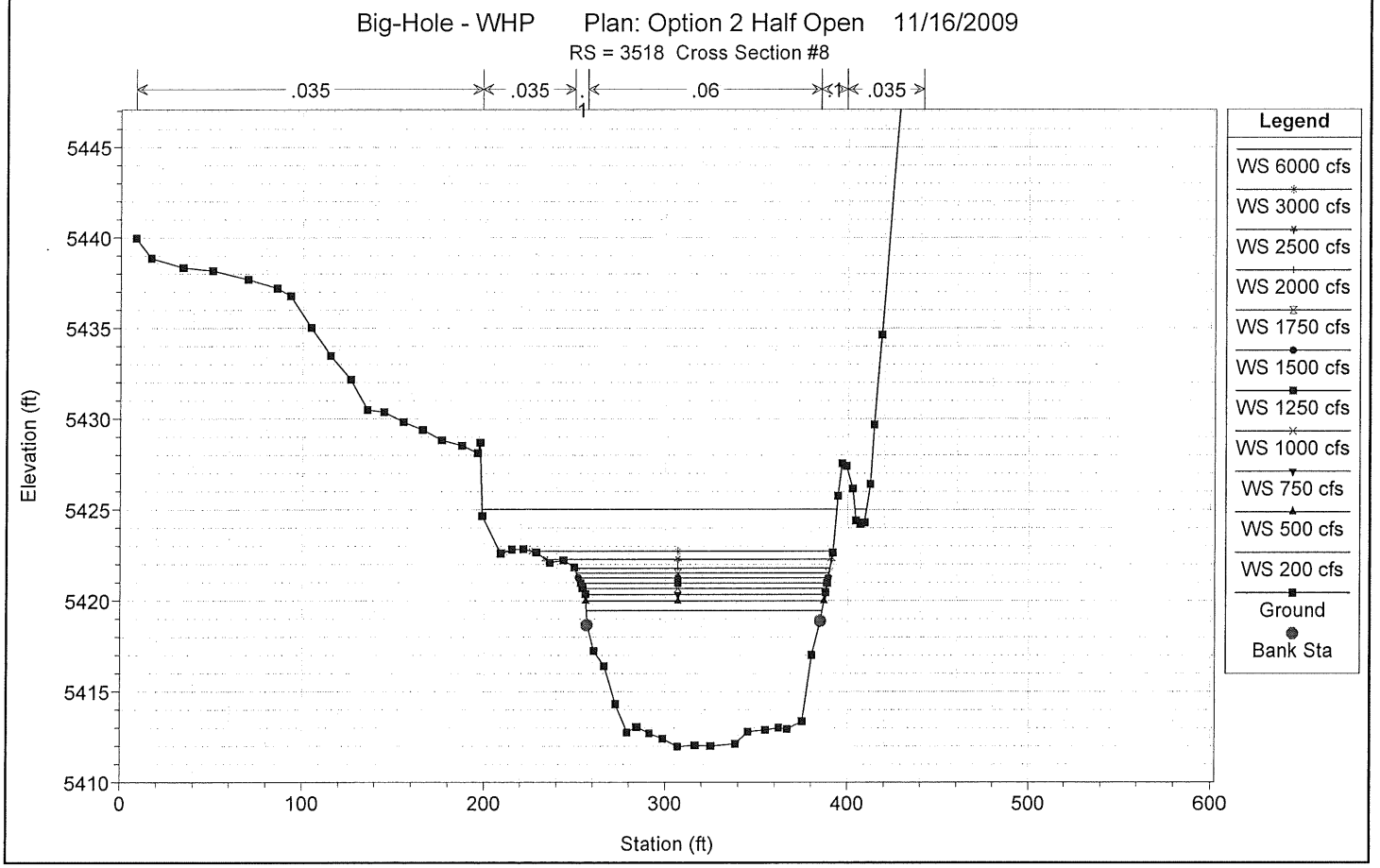
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



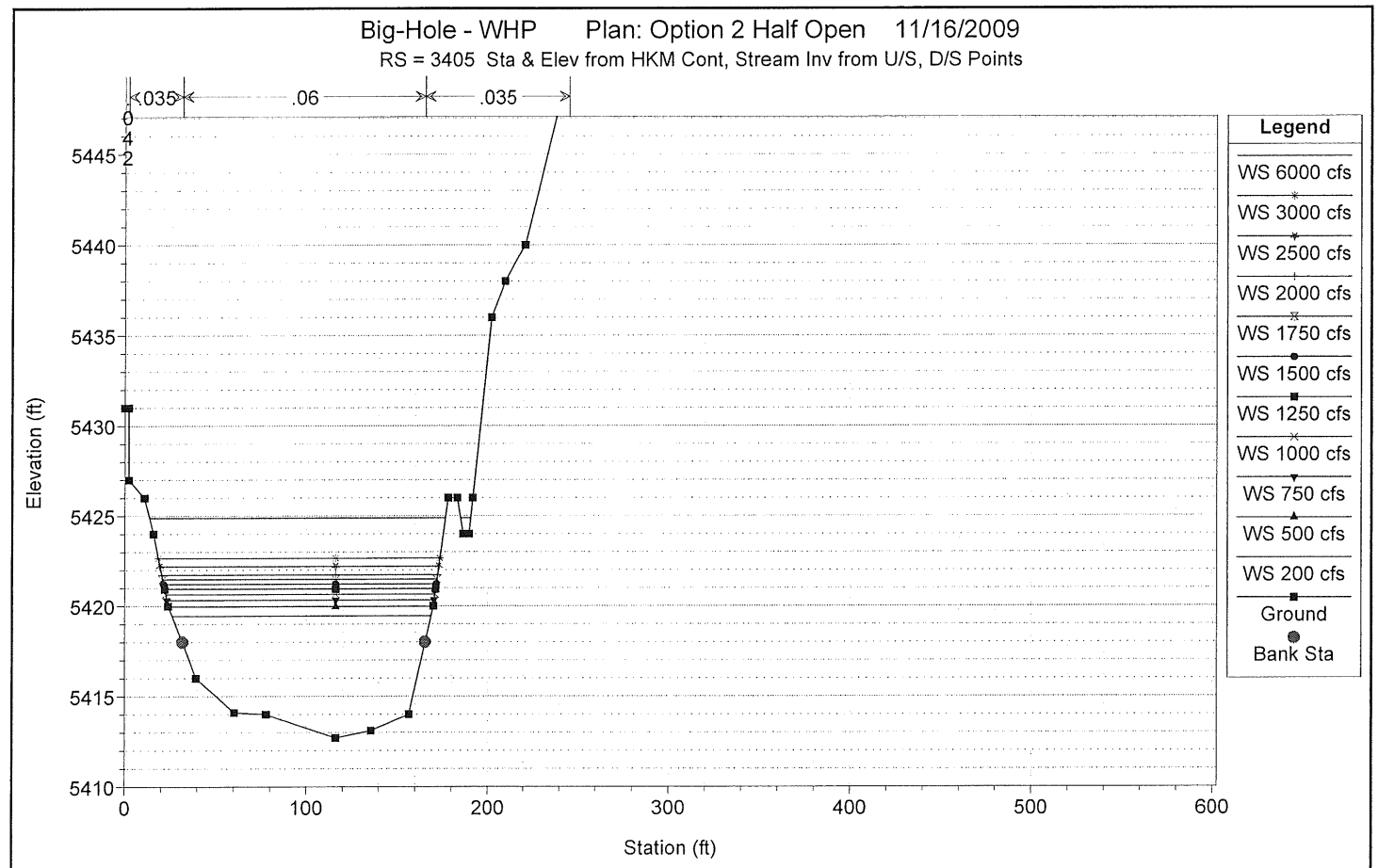


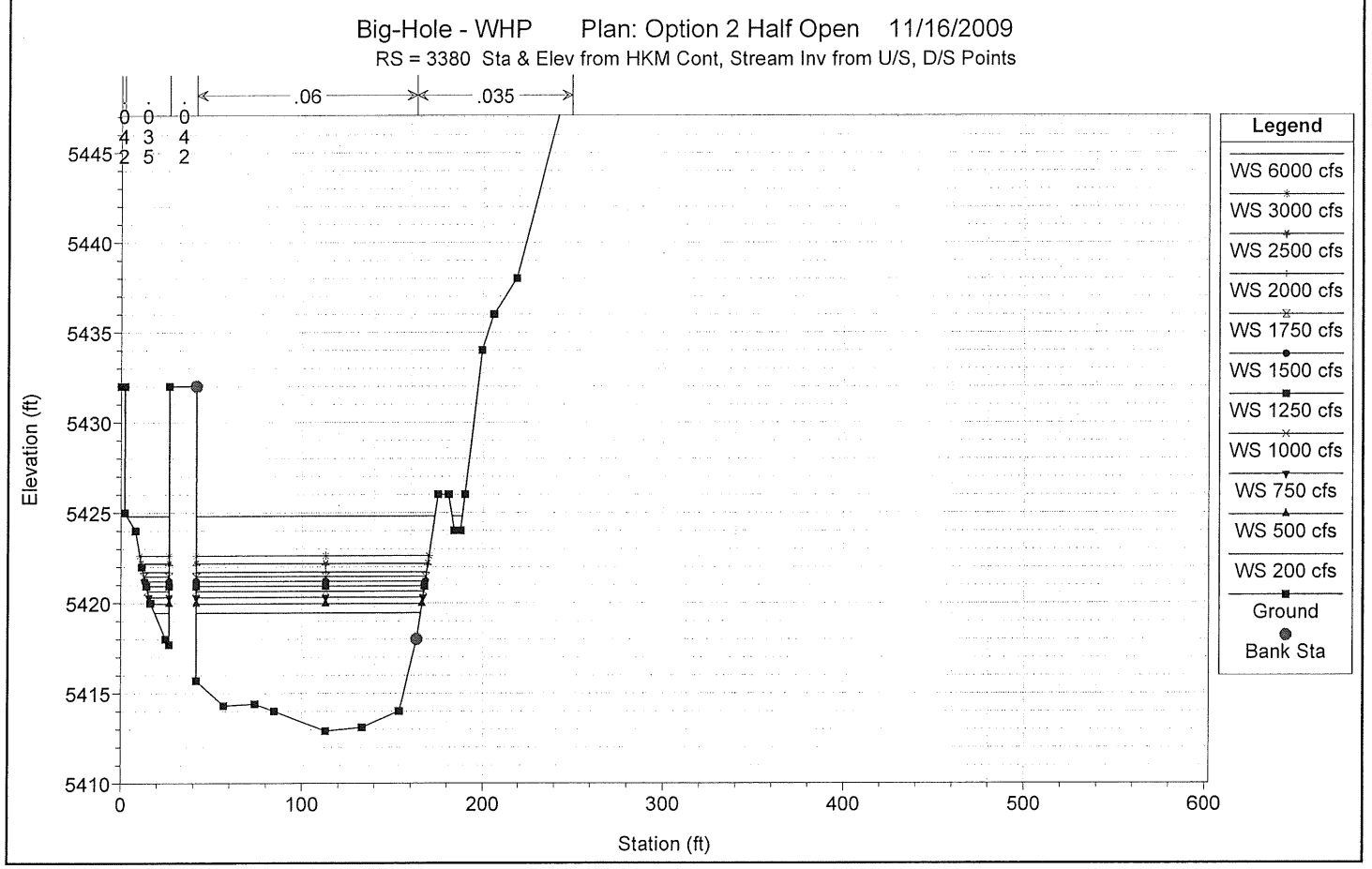
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



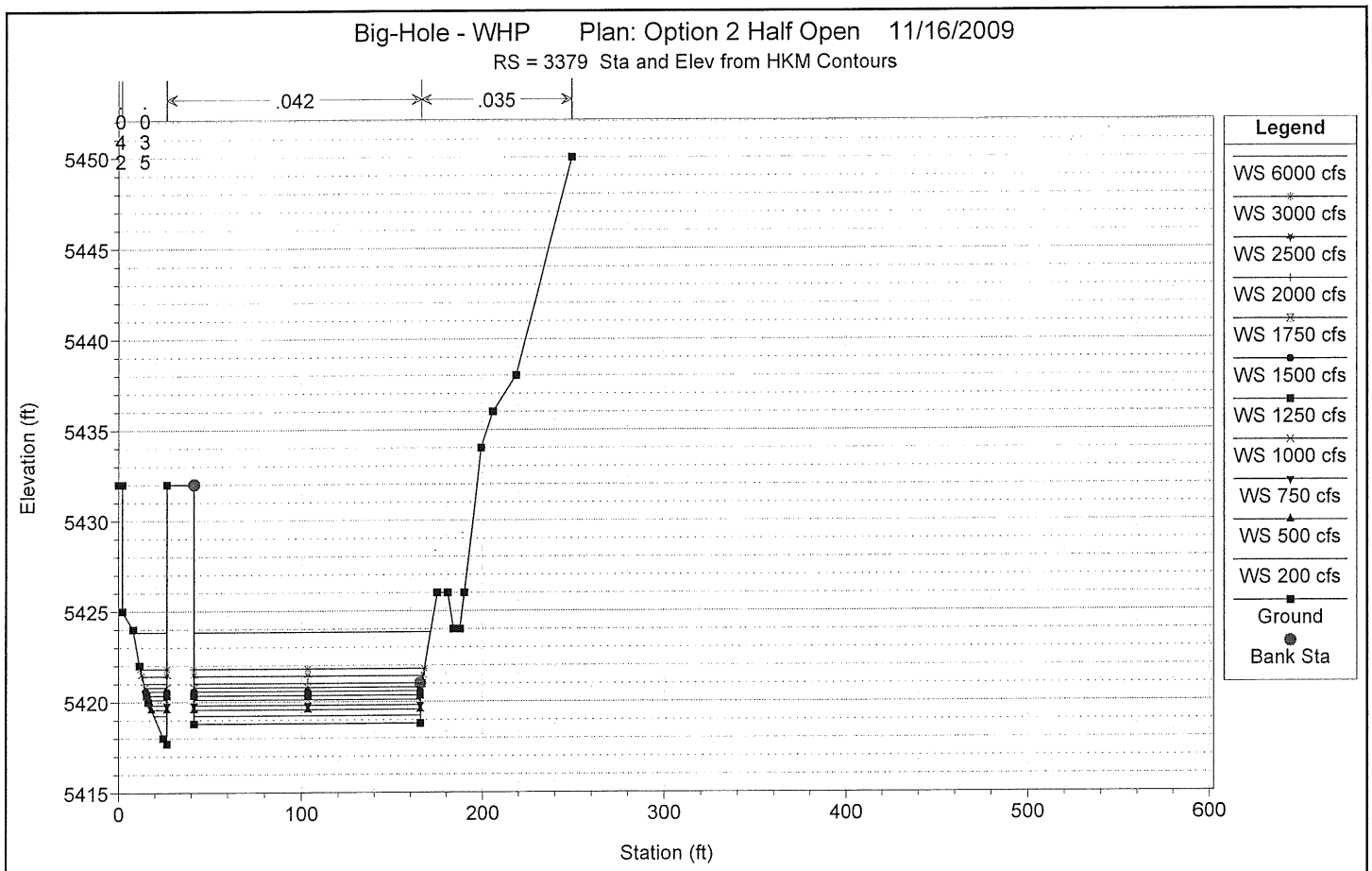


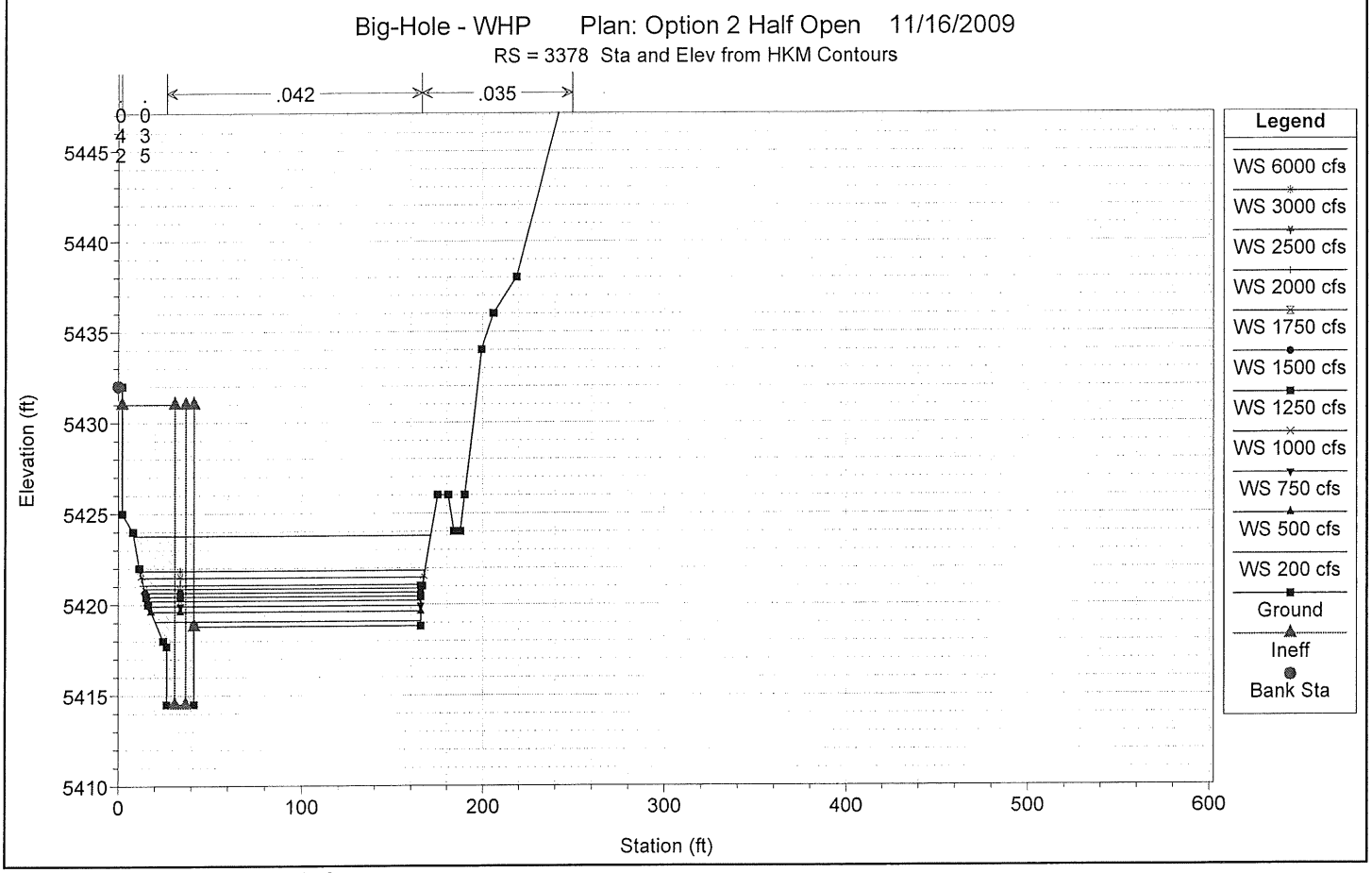
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft

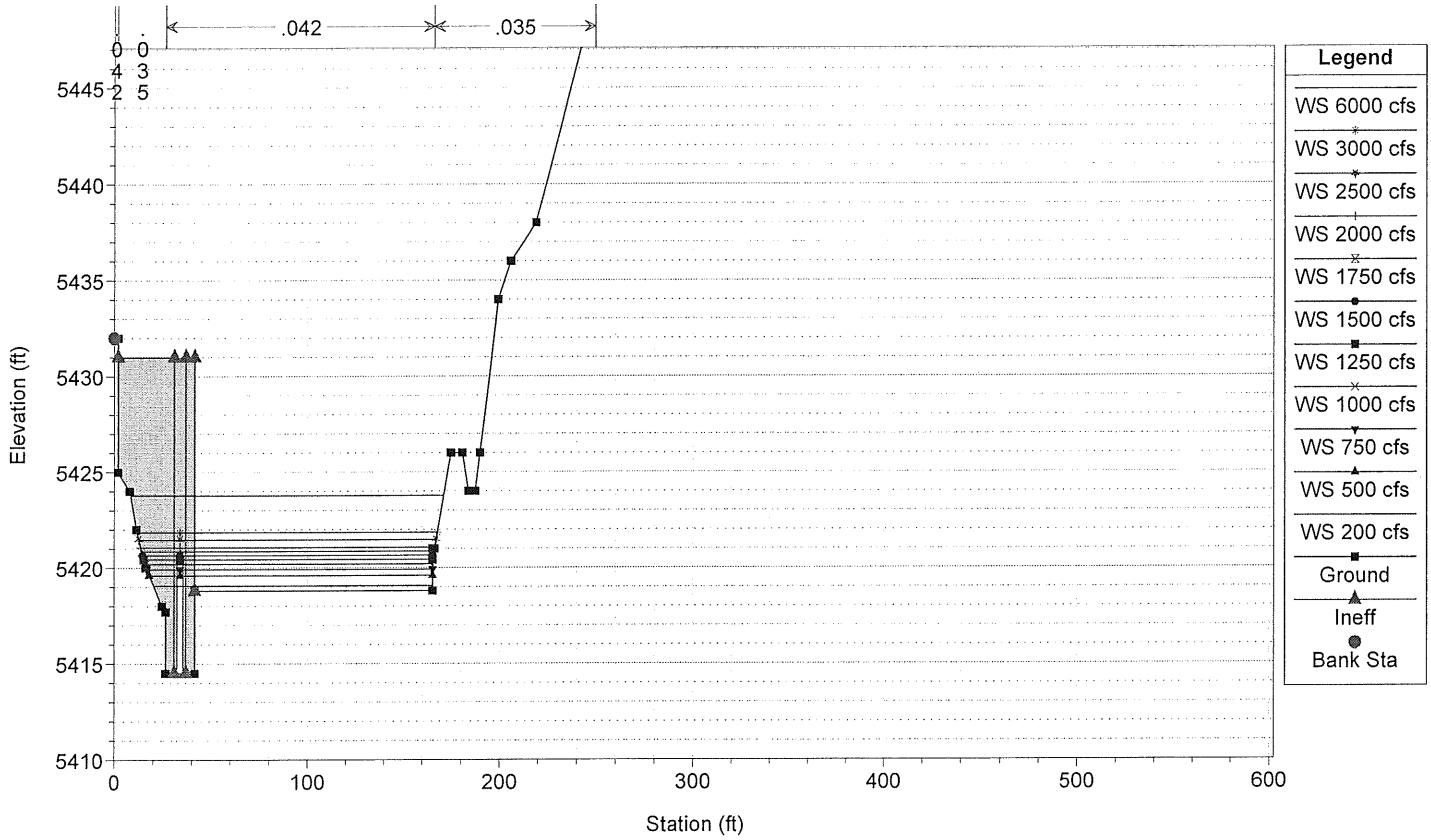




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

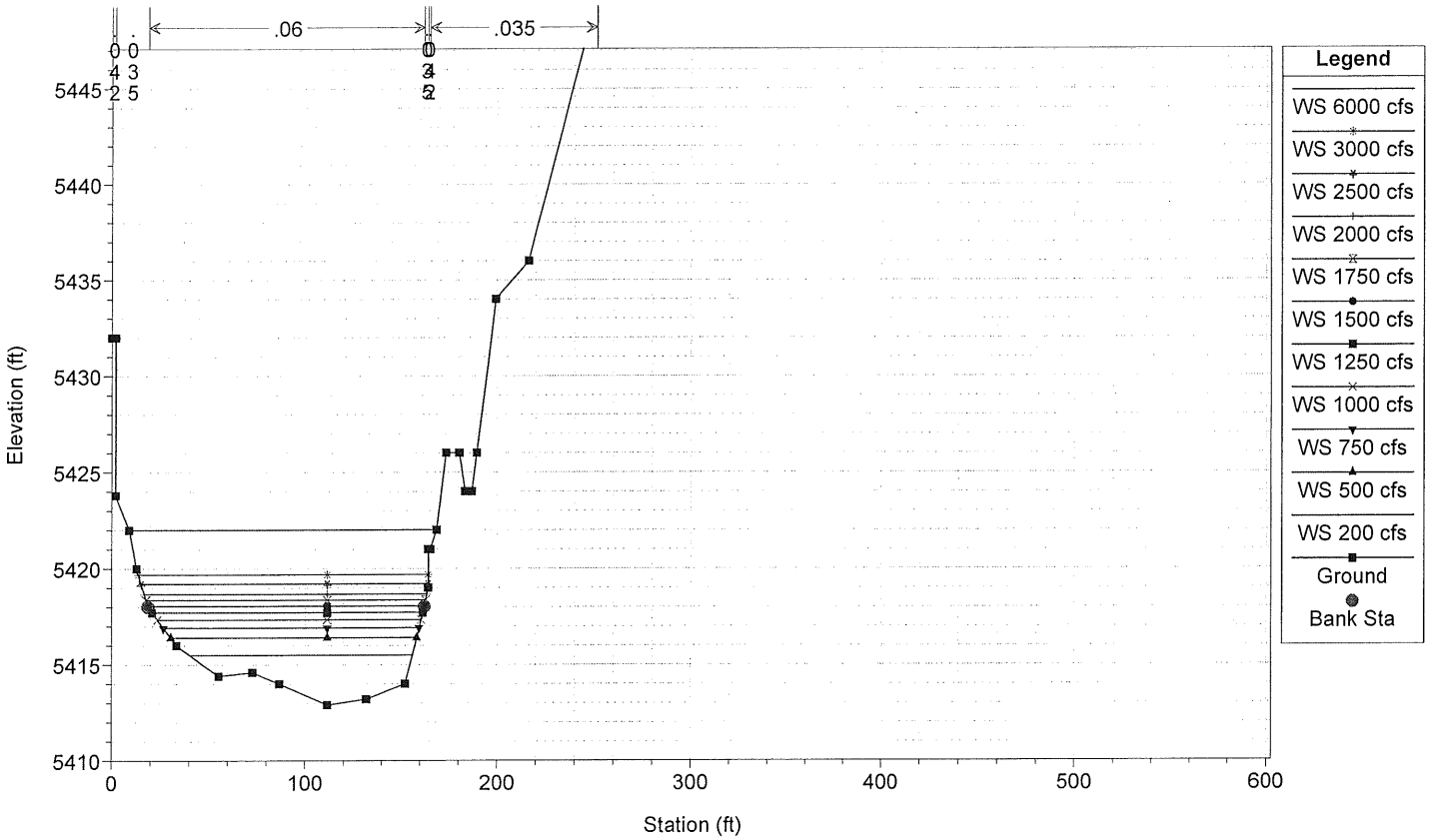
Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 3370 IS

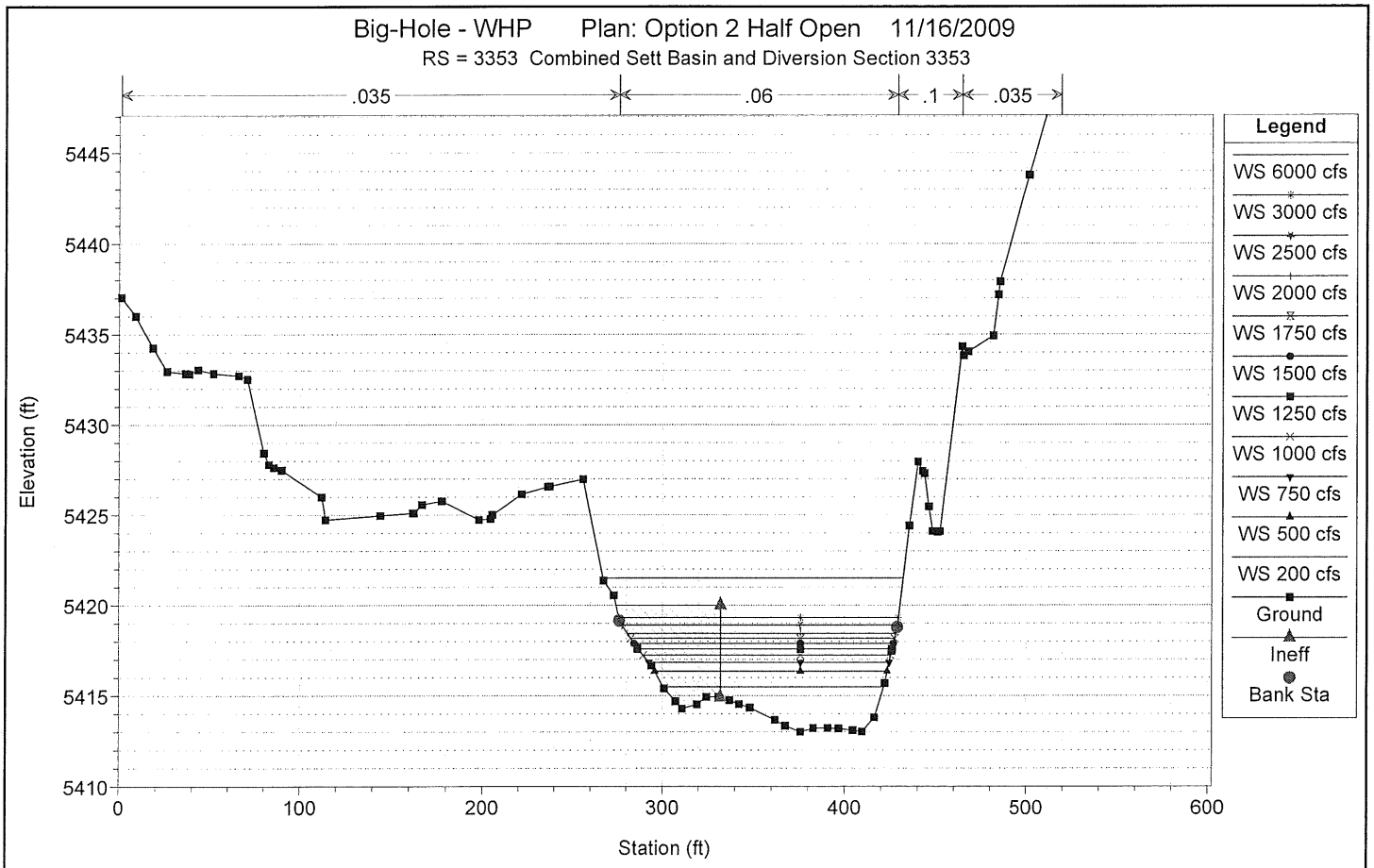


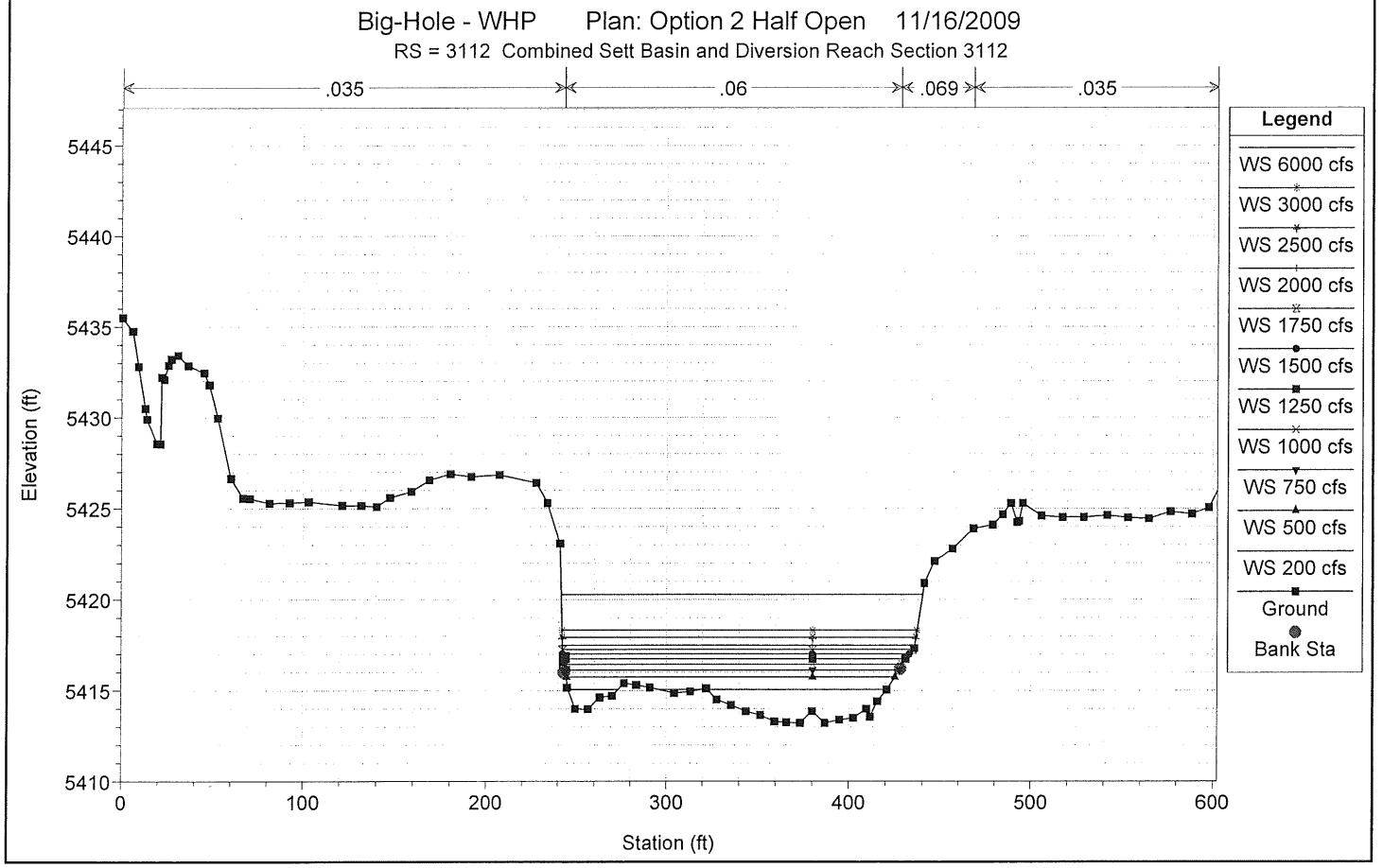
Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 3368 Sta & Elev from HKM Cont, Stream Inv from U/S, D/S Points



1 in Horiz. = 100 ft 1 in Vert. = 10 ft

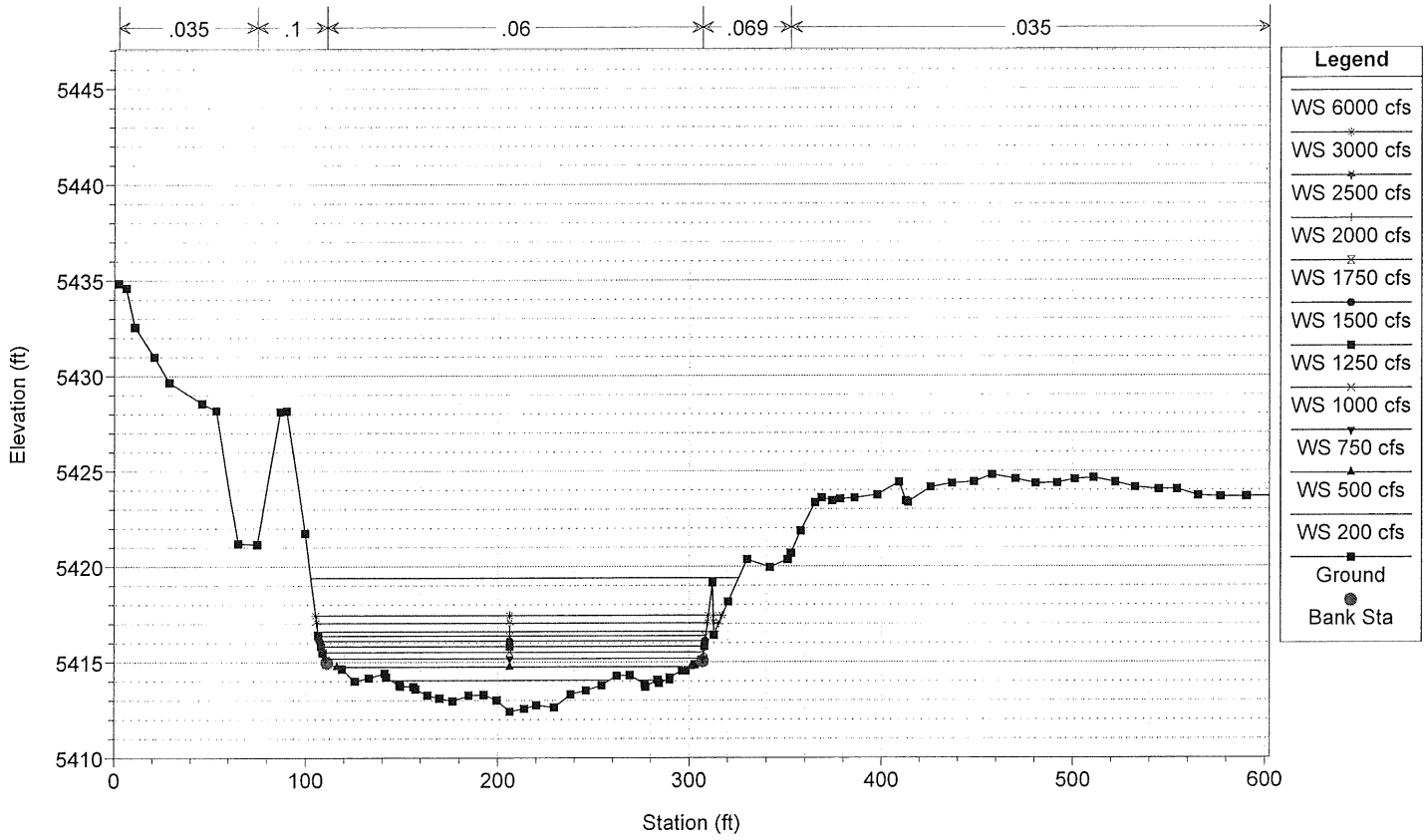




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

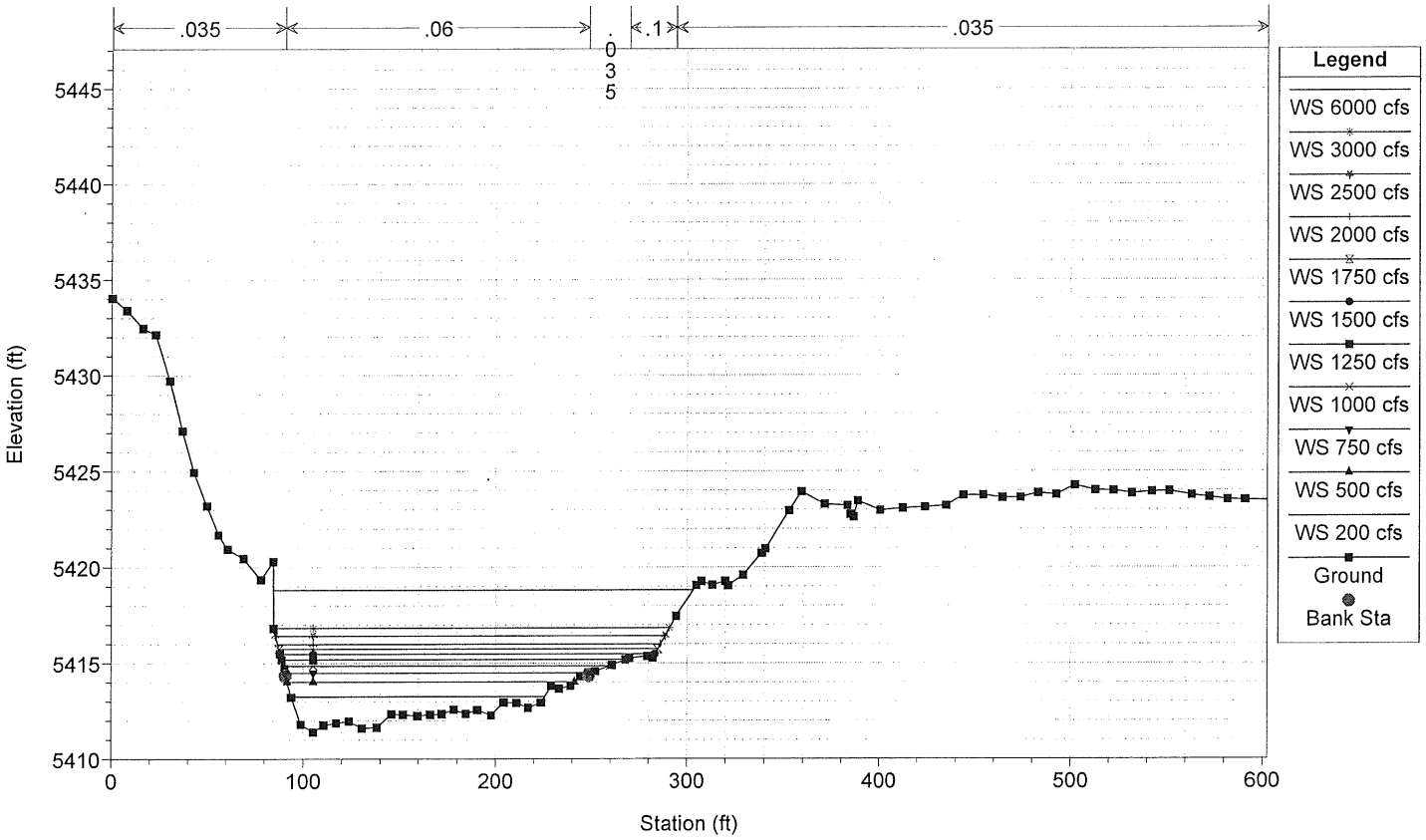
Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 2911 Cross Section #11

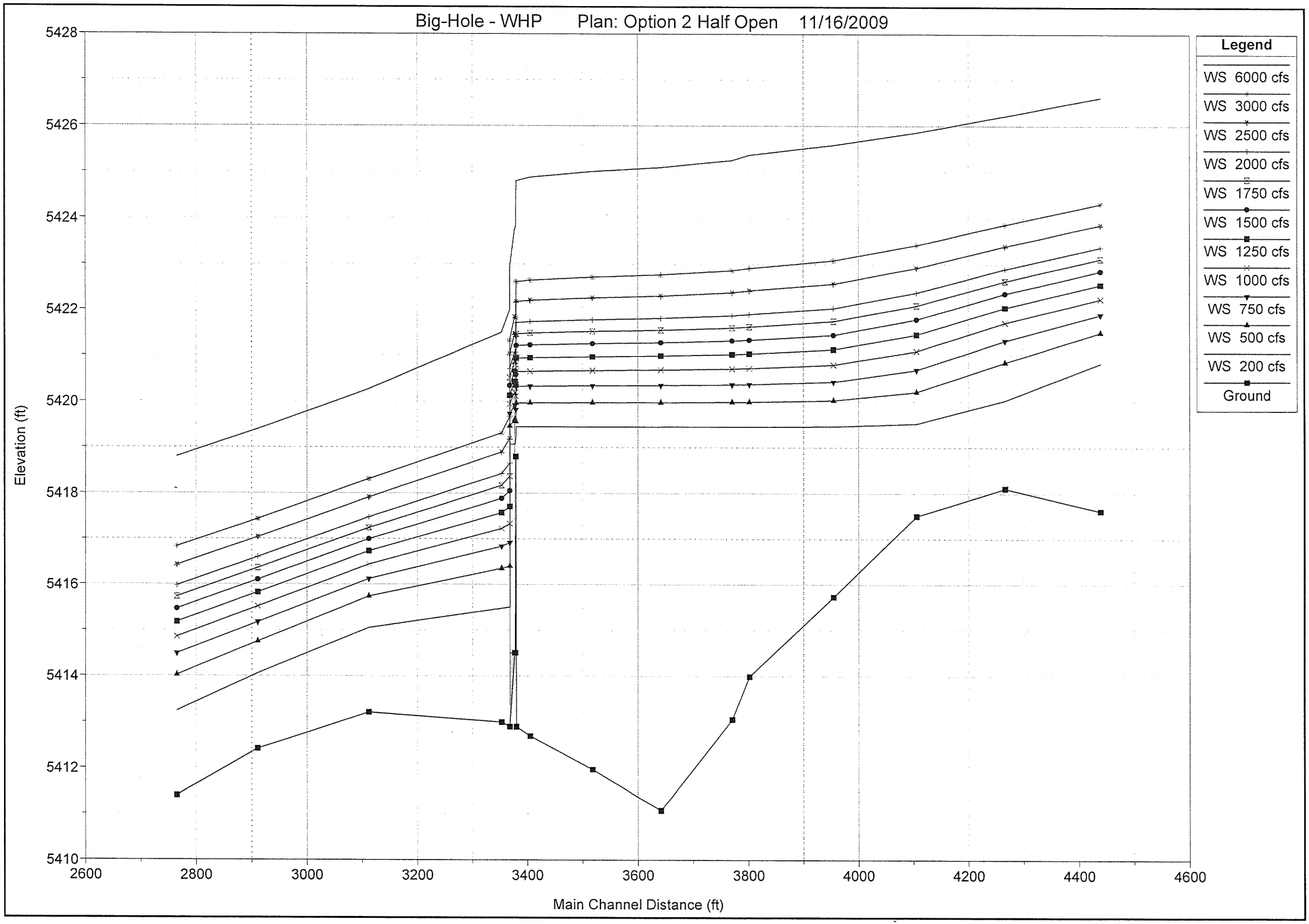


Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009

RS = 2765 Cross Section #12



1 in Horiz. = 100 ft 1 in Vert. = 10 ft


Big-Hole - WHP Plan: Option 2 Half Open 11/16/2009
Elevation (ft)
5428
5426
5424
5422
5420
5418
5416
5414
5412
5410
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
Main Channel Distance (ft)
Legend
WS 6000 cfs
WS 3000 cfs
WS 2500 cfs
WS 2000 cfs
WS 1750 cfs
WS 1500 cfs
WS 1250 cfs
WS 1000 cfs
WS 750 cfs
WS 500 cfs
WS 200 cfs
Ground

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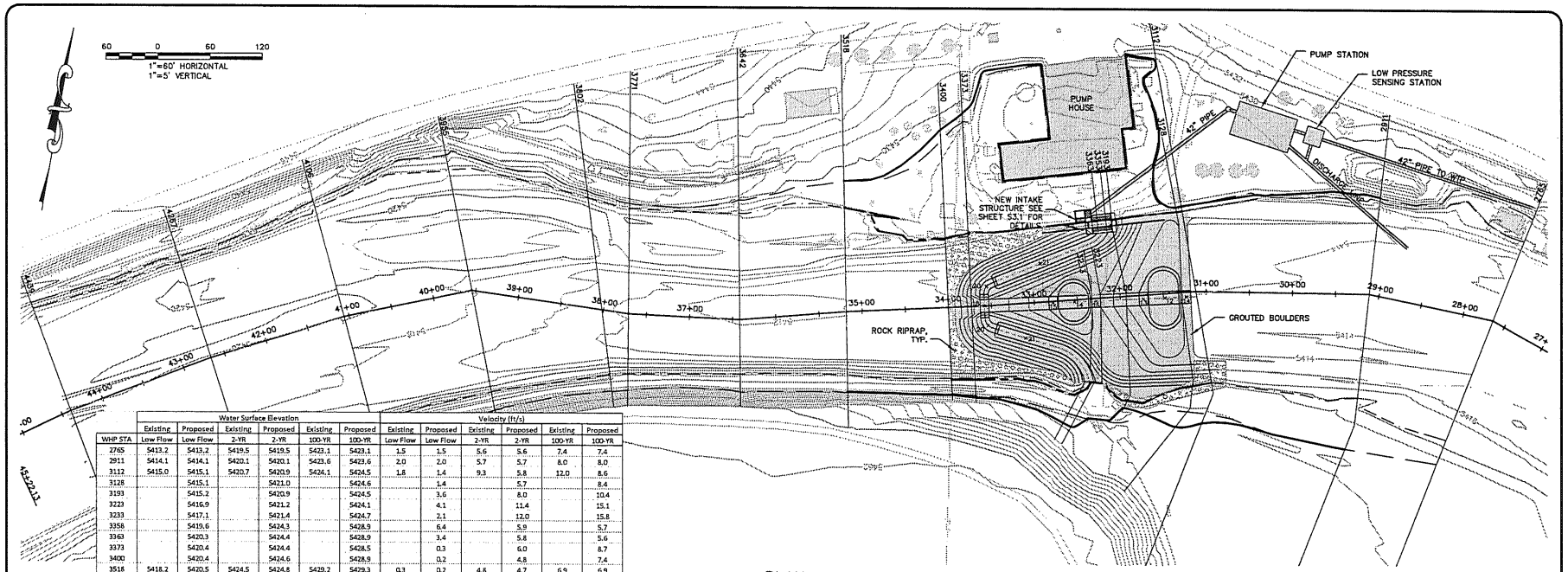
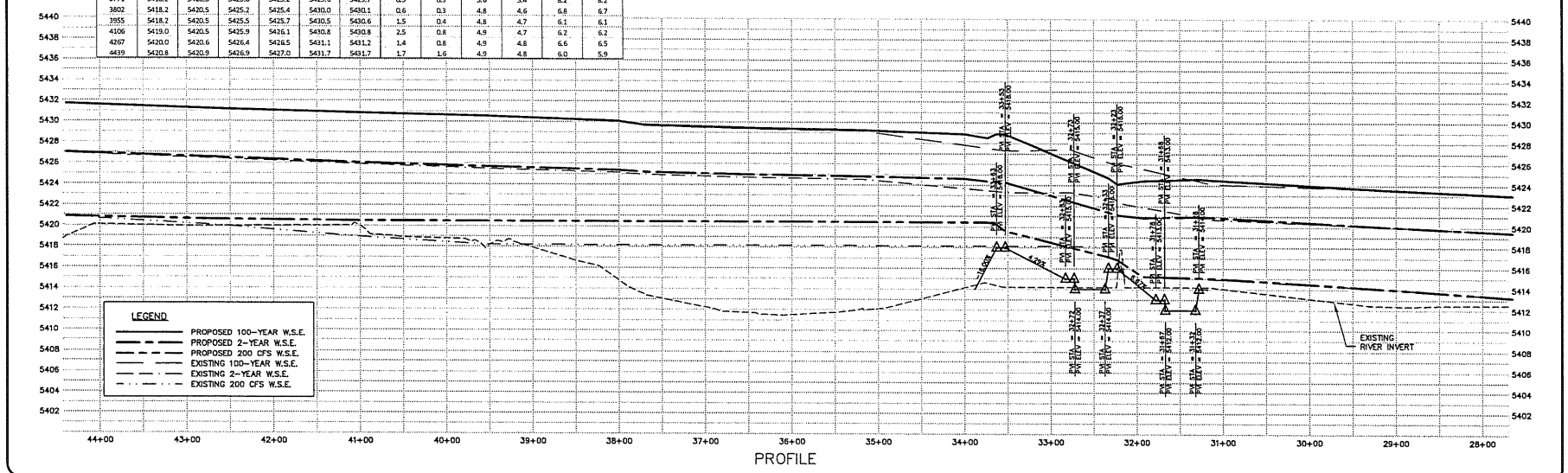


	Water Surface Elevation						Velocity (ft/s)					
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
WHP STA	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3128		5415.1		5421.0		5424.6		1.4		5.7		8.4
3193		5415.2		5420.9		5424.5		3.6		8.0		10.4
3223		5416.9		5421.2		5424.1		4.1		11.4		15.1
3233		5417.1		5421.4		5424.7		2.1		12.0		15.8
3358		5419.6		5424.3		5428.9		6.4		5.9		5.7
3361		5420.3		5424.4		5428.9		3.4		5.8		5.6
3373		5420.4		5424.4		5428.5		0.3		6.0		8.7
3400		5420.4		5424.6		5428.9		0.2		4.8		7.4
3518	5418.2	5420.5	5424.5	5424.8	5429.2	5429.3	0.3	0.2	4.8	4.7	6.9	6.9
3642	5418.2	5420.5	5424.7	5425.0	5429.3	5429.4	0.4	0.3	5.5	5.3	7.9	7.8
3771	5418.2	5420.5	5425.0	5425.2	5429.6	5429.7	0.5	0.3	5.6	5.4	8.2	8.2
3802	5418.2	5420.5	5425.2	5425.4	5430.0	5430.1	0.6	0.3	4.8	4.6	6.8	6.7
3955	5418.2	5420.5	5425.5	5425.7	5430.5	5430.6	1.5	0.4	4.8	4.7	6.1	6.1
4106	5419.0	5420.5	5425.9	5426.1	5430.8	5430.8	2.5	0.8	4.9	4.7	6.2	6.2
4267	5420.0	5420.6	5426.4	5426.5	5431.1	5431.2	1.4	0.8	4.9	4.6	6.6	6.5
4439	5420.8	5420.9	5426.9	5427.0	5431.7	5431.7	1.7	1.6	4.9	4.8	6.0	5.9

PLAN



PROFILE

No.	Revision	By	Date

WARNING
1/2
IF THIS BAR DOES NOT MEASURE 1/2" THE DRAWING IS NOT TO SCALE

BIG HOLE RIVER DIVERSION DAM
REPLACEMENT PROJECT

OPTION 3 PLAN AND PROFILE

WHPacific
12596 W Bayaud Ave., Suite 200
Lakewood, CO 80228
303.986.8550 Fax 303.457.9304
www.WHPacific.com

DOWL HKM
130 N. Main St.
Suite 100
P.O. Box 1148
Butte, MT 59701-2839
406.723.8213
406.723.5731 (FAX)
DOWLHKM.COM

Sheet No.
5

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Option 3

Project: Big Hole - WHP
Plan: plan05 (.p05)

Geometry: Big Hole - Proposed Option 3 (.g06)
Flow: Translated Flows - Option 3 (.f04)

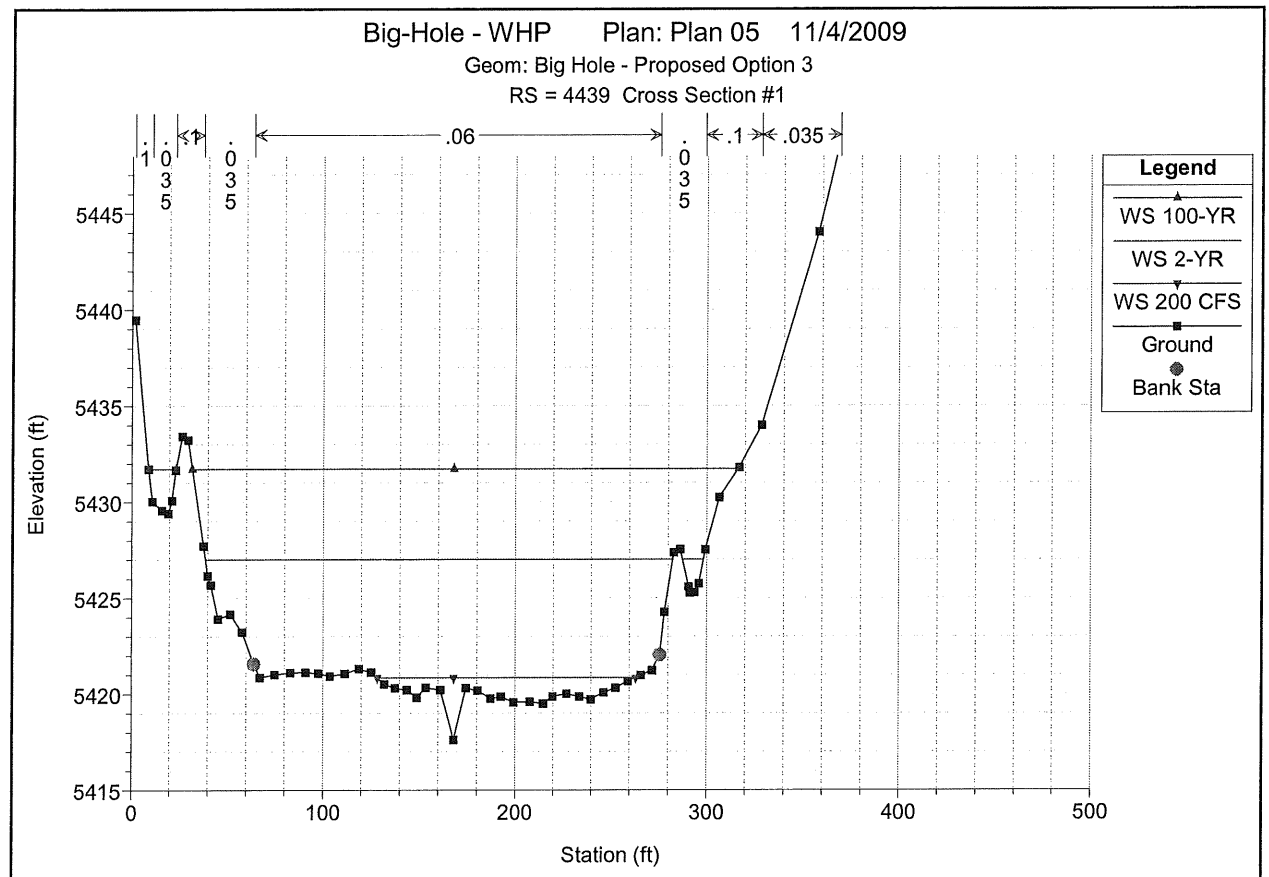
HEC-RAS Plan: Option 3 River: Big Hole Reach: Upstream Chl

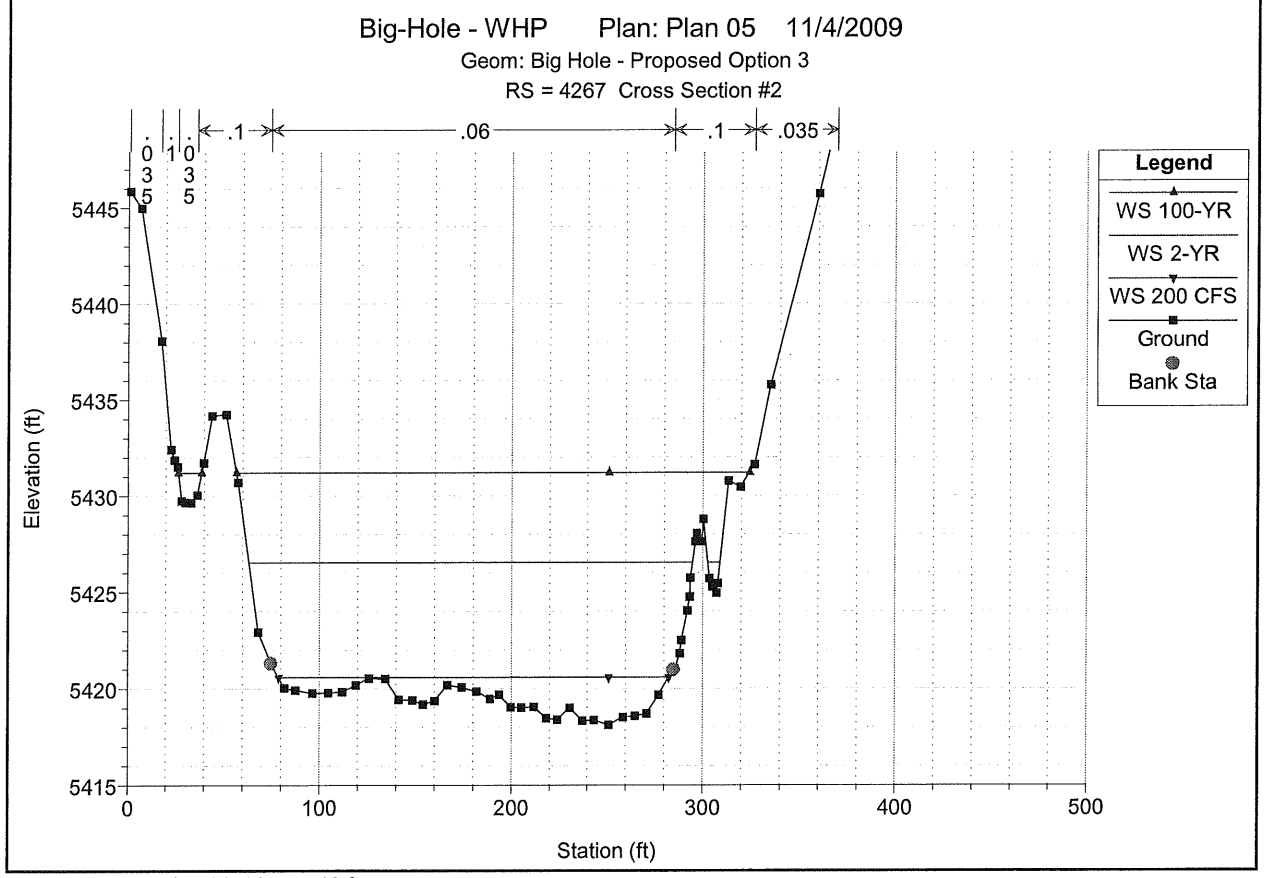
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	7239.00	5417.62	5427.02	5423.65	5427.38	0.003015	4.80	1518.48	254.56	0.33
Upstream Chl	4439	16712.00	5417.62	5431.71	5426.09	5432.27	0.002262	5.93	2806.25	299.26	0.31
Upstream Chl	4439	200.00	5417.62	5420.86	5420.24	5420.90	0.004596	1.59	125.73	135.18	0.29
Upstream Chl	4267	7239.00	5418.11	5426.54	5422.76	5426.88	0.002738	4.78	1569.23	237.52	0.32
Upstream Chl	4267	16712.00	5418.11	5431.20	5425.22	5431.84	0.002620	6.54	2750.71	279.63	0.34
Upstream Chl	4267	200.00	5418.11	5420.58	5419.22	5420.59	0.000898	0.83	241.23	203.69	0.13
Upstream Chl	4106	7239.00	5417.51	5426.07	5422.68	5426.42	0.003048	4.74	1577.56	264.92	0.33
Upstream Chl	4106	16712.00	5417.51	5430.84	5425.02	5431.41	0.002464	6.16	2904.54	292.87	0.32
Upstream Chl	4106	200.00	5417.51	5420.47	5418.52	5420.48	0.000538	0.80	251.22	153.88	0.11
Upstream Chl	3955	7239.00	5415.73	5425.70	5421.65	5426.03	0.002155	4.66	1633.01	271.81	0.32
Upstream Chl	3955	16712.00	5415.73	5430.55	5424.48	5431.09	0.001734	6.06	3056.16	316.04	0.31
Upstream Chl	3955	200.00	5415.73	5420.45	5417.01	5420.45	0.000069	0.44	458.70	164.84	0.05
Upstream Chl	3802	7239.00	5413.99	5425.38	5420.27	5425.71	0.002012	4.63	1632.48	208.68	0.28
Upstream Chl	3802	16712.00	5413.99	5430.09	5423.29	5430.76	0.002538	6.71	2681.14	238.25	0.33
Upstream Chl	3802	200.00	5413.99	5420.45	5415.38	5420.45	0.000019	0.30	665.22	168.66	0.03
Upstream Chl	3771	7239.00	5413.06	5425.21	5419.54	5425.63	0.002091	5.40	1549.17	198.77	0.29
Upstream Chl	3771	16712.00	5413.06	5429.72	5423.39	5430.65	0.002974	8.16	2499.96	223.23	0.37
Upstream Chl	3771	200.00	5413.06	5420.45	5414.36	5420.45	0.000013	0.29	699.80	145.11	0.02
Upstream Chl	3642	7239.00	5411.07	5424.97	5418.37	5425.38	0.001771	5.32	1501.85	191.54	0.27
Upstream Chl	3642	16712.00	5411.07	5429.44	5422.89	5430.27	0.002473	7.79	2440.10	224.55	0.34
Upstream Chl	3642	200.00	5411.07	5420.45	5412.44	5420.45	0.000008	0.26	778.45	114.92	0.02
Upstream Chl	3518	7239.00	5411.97	5424.83	5417.92	5425.16	0.001416	4.68	1640.03	200.93	0.24
Upstream Chl	3518	16712.00	5411.97	5429.27	5421.46	5429.95	0.001963	6.85	2590.42	246.07	0.30
Upstream Chl	3518	200.00	5411.97	5420.45	5412.99	5420.45	0.000006	0.22	910.61	132.37	0.01
Upstream Chl	3400	7239.00	5413.00	5424.63	5418.56	5424.98	0.001645	4.80	1526.88	162.79	0.26
Upstream Chl	3400	16712.00	5413.00	5428.91	5421.96	5429.69	0.002454	7.36	2465.11	296.78	0.34
Upstream Chl	3400	200.00	5413.00	5420.44	5413.98	5420.45	0.000007	0.23	875.13	148.97	0.02
Upstream Chl	3373	7239.00	5414.00	5424.38	5420.56	5424.92	0.001592	5.99	1248.83	172.95	0.37
Upstream Chl	3373	16712.00	5414.00	5428.53	5423.67	5429.60	0.001926	8.65	2208.98	321.91	0.43
Upstream Chl	3373	200.00	5414.00	5420.44	5415.50	5420.45	0.000012	0.33	615.19	153.58	0.03
Upstream Chl	3363	7239.00	5418.00	5424.37	5423.08	5424.89	0.004808	5.78	1253.20	341.04	0.53
Upstream Chl	3363	16712.00	5418.00	5428.93	5424.90	5429.40	0.001595	5.63	3110.76	461.69	0.35
Upstream Chl	3363	200.00	5418.00	5420.25	5419.58	5420.43	0.011571	3.41	58.67	68.48	0.65
Upstream Chl	3358	7239.00	5418.00	5424.29	5423.08	5424.83	0.005153	5.90	1227.07	340.59	0.55
Upstream Chl	3358	16712.00	5418.00	5428.91	5424.90	5429.38	0.001609	5.65	3101.52	461.55	0.35
Upstream Chl	3358	200.00	5418.00	5419.58	5419.58	5420.22	0.024420	6.41	31.20	24.48	1.00
Upstream Chl	3233	7239.00	5416.00	5421.41	5421.41	5423.65	0.016178	12.00	603.39	136.90	1.01
Upstream Chl	3233	16712.00	5416.00	5424.72	5424.72	5428.61	0.014235	15.84	1055.26	136.90	1.01
Upstream Chl	3233	200.00	5416.00	5417.14	5416.62	5417.21	0.003572	2.09	95.57	96.97	0.37
Upstream Chl	3223	7239.00	5416.00	5421.15	5421.15	5423.18	0.016584	11.44	632.70	157.90	1.01
Upstream Chl	3223	16712.00	5416.00	5424.14	5424.14	5427.69	0.014460	15.12	1105.32	157.90	1.01
Upstream Chl	3223	200.00	5416.00	5416.86	5416.86	5417.11	0.033288	4.03	49.64	100.67	1.01
Upstream Chl	3193	7239.00	5414.00	5420.89	5419.48	5421.87	0.006375	7.97	912.16	197.11	0.64
Upstream Chl	3193	16712.00	5414.00	5424.45	5422.32	5426.10	0.005270	10.37	1630.48	207.42	0.63
Upstream Chl	3193	200.00	5414.00	5415.23	5415.06	5415.44	0.015209	3.61	55.33	73.32	0.73
Upstream Chl	3128	7239.00	5414.00	5420.99	5417.98	5421.50	0.002226	5.71	1273.42	202.08	0.39
Upstream Chl	3128	16712.00	5414.00	5424.62	5420.63	5425.69	0.002674	8.35	2066.62	264.65	0.46
Upstream Chl	3128	200.00	5414.00	5415.09	5414.49	5415.12	0.001852	1.37	145.75	170.21	0.26
Upstream Chl	3112	7239.00	5413.21	5420.93	5417.93	5421.45	0.004482	5.80	1270.70	199.75	0.40
Upstream Chl	3112	16712.00	5413.21	5424.52	5420.59	5425.62	0.005461	8.55	2052.31	284.83	0.47
Upstream Chl	3112	200.00	5413.21	5415.05	5414.13	5415.08	0.002991	1.35	148.52	149.30	0.24
Upstream Chl	2911	7239.00	5412.42	5420.06	5417.13	5420.55	0.004377	5.65	1329.99	232.29	0.39
Upstream Chl	2911	16712.00	5412.42	5423.61	5419.76	5424.54	0.004844	7.97	2290.33	379.56	0.45
Upstream Chl	2911	200.00	5412.42	5414.05	5413.54	5414.11	0.008912	1.97	101.61	131.35	0.39
Upstream Chl	2765	7239.00	5411.40	5419.47	5416.55	5419.94	0.003904	5.62	1328.01	244.84	0.38
Upstream Chl	2765	16712.00	5411.40	5423.08	5419.21	5423.87	0.003906	7.43	2369.70	402.87	0.40

11/16/09

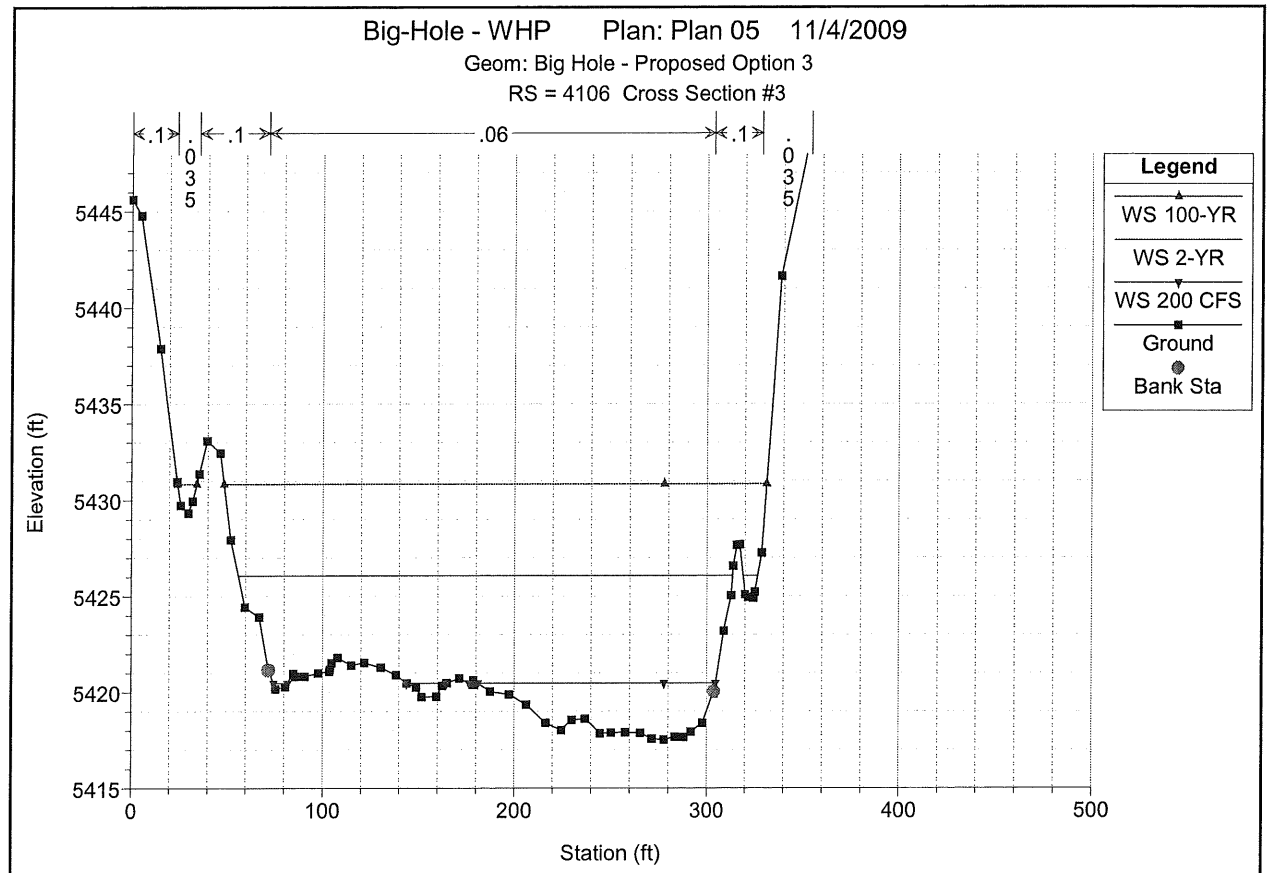
HEC-RAS Plan: Option 3 River: Big Hole Reach: Upstream Chl (Continued)

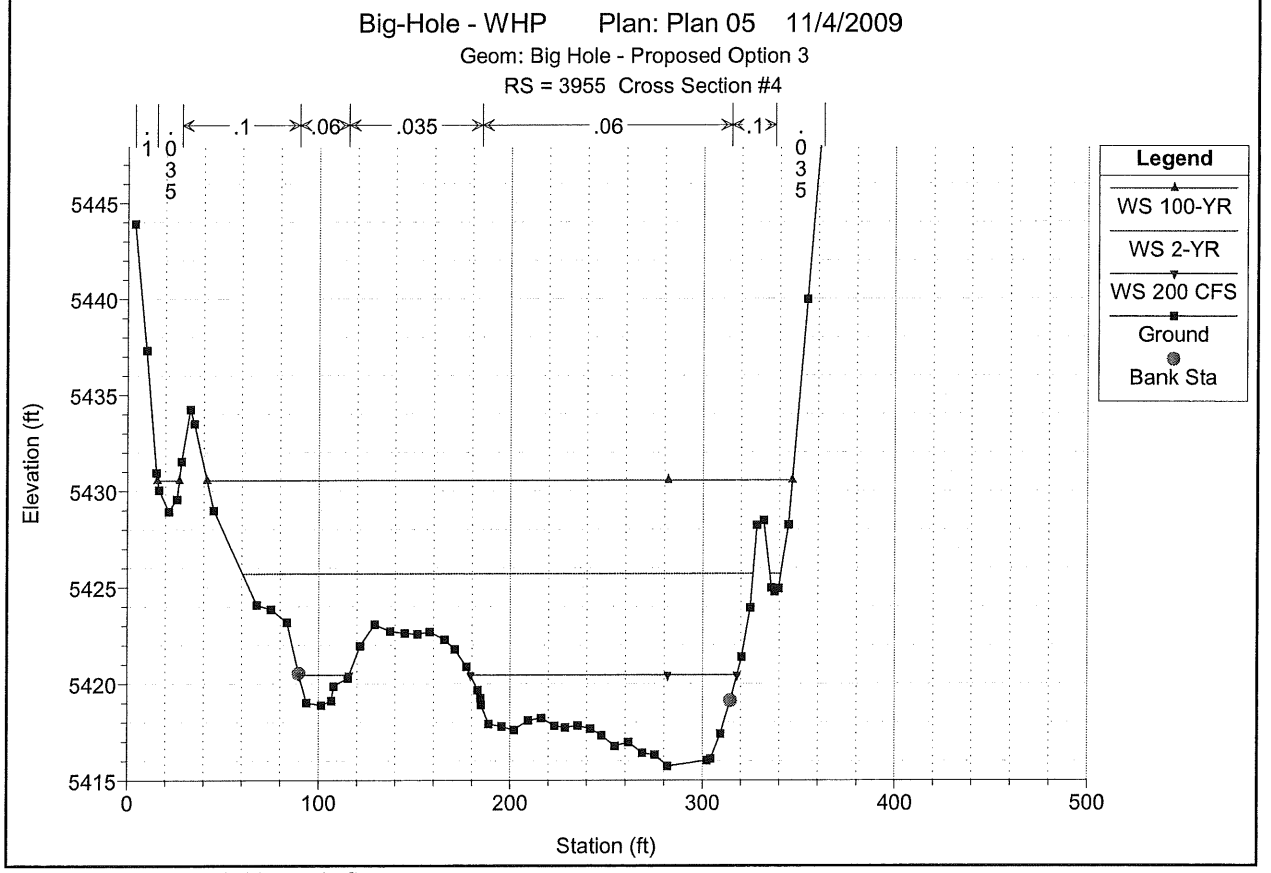
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	2765	200.00	5411.40	5413.24	5412.59	5413.28	0.003899	1.53	130.41	131.67	0.27



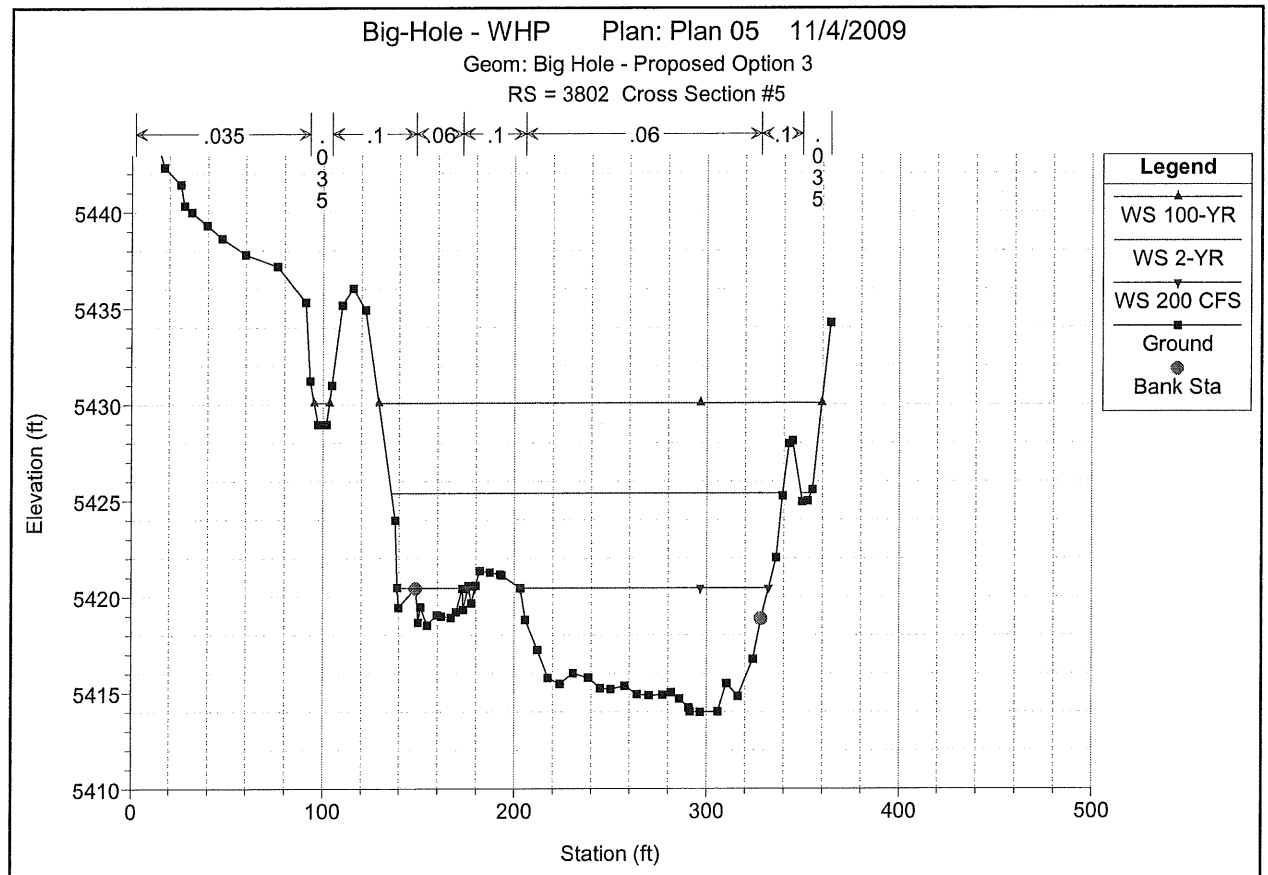


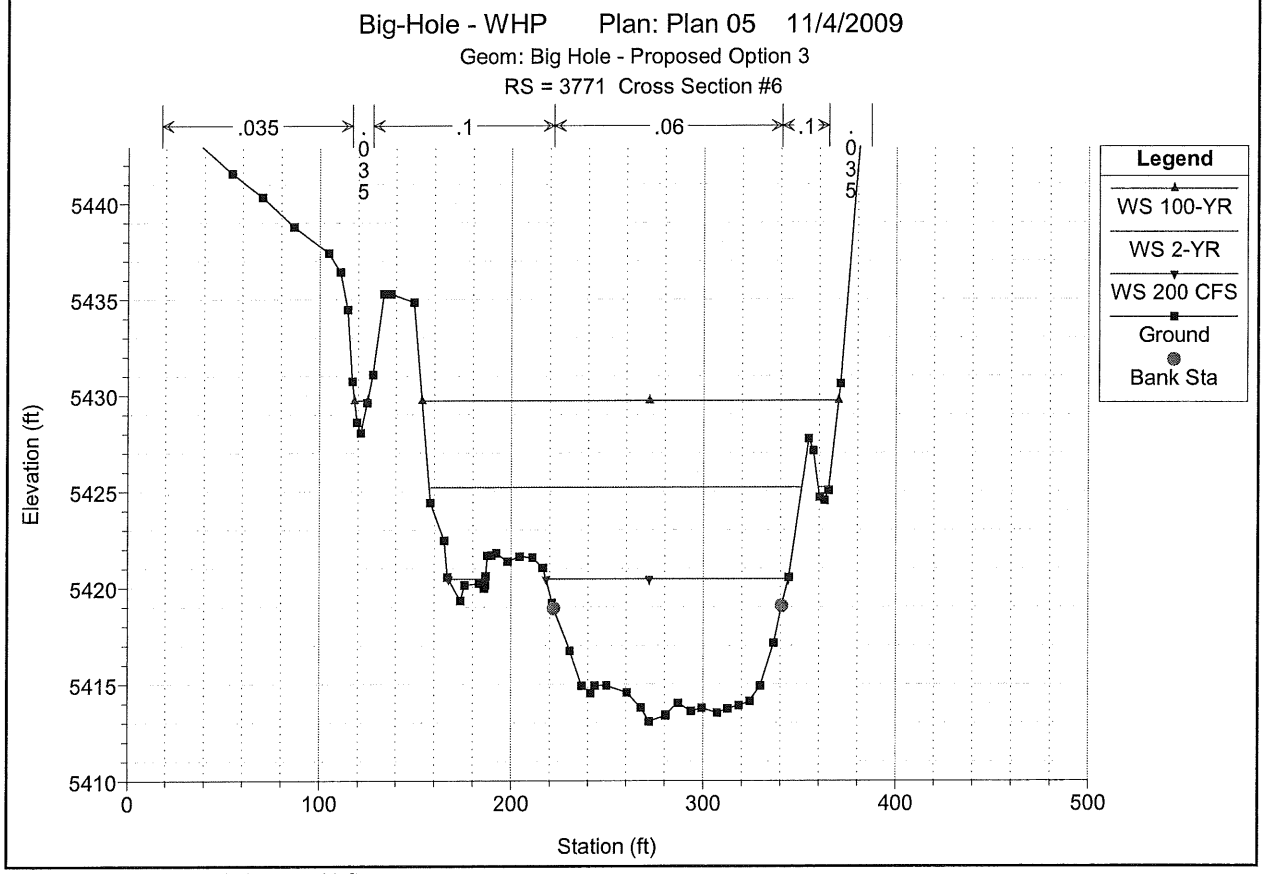
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



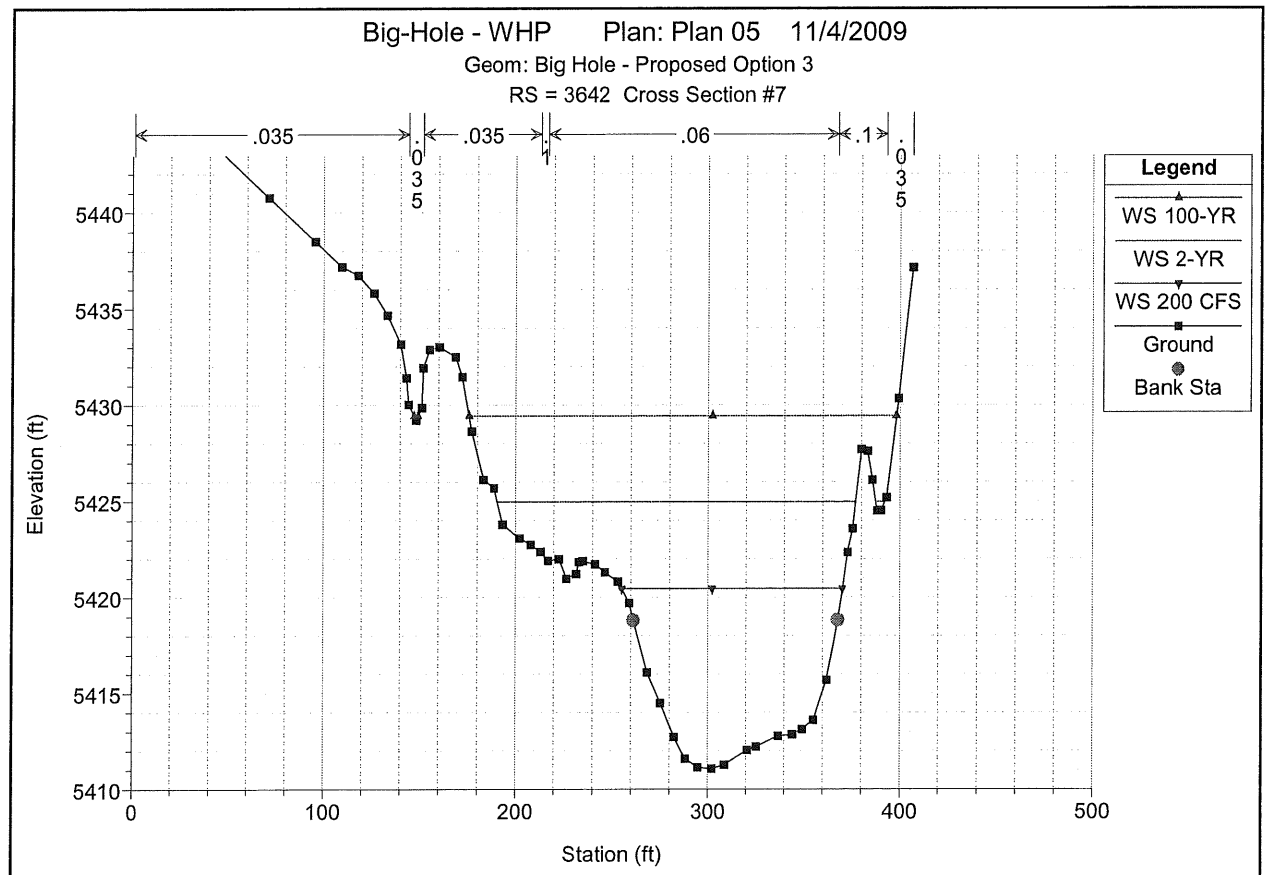


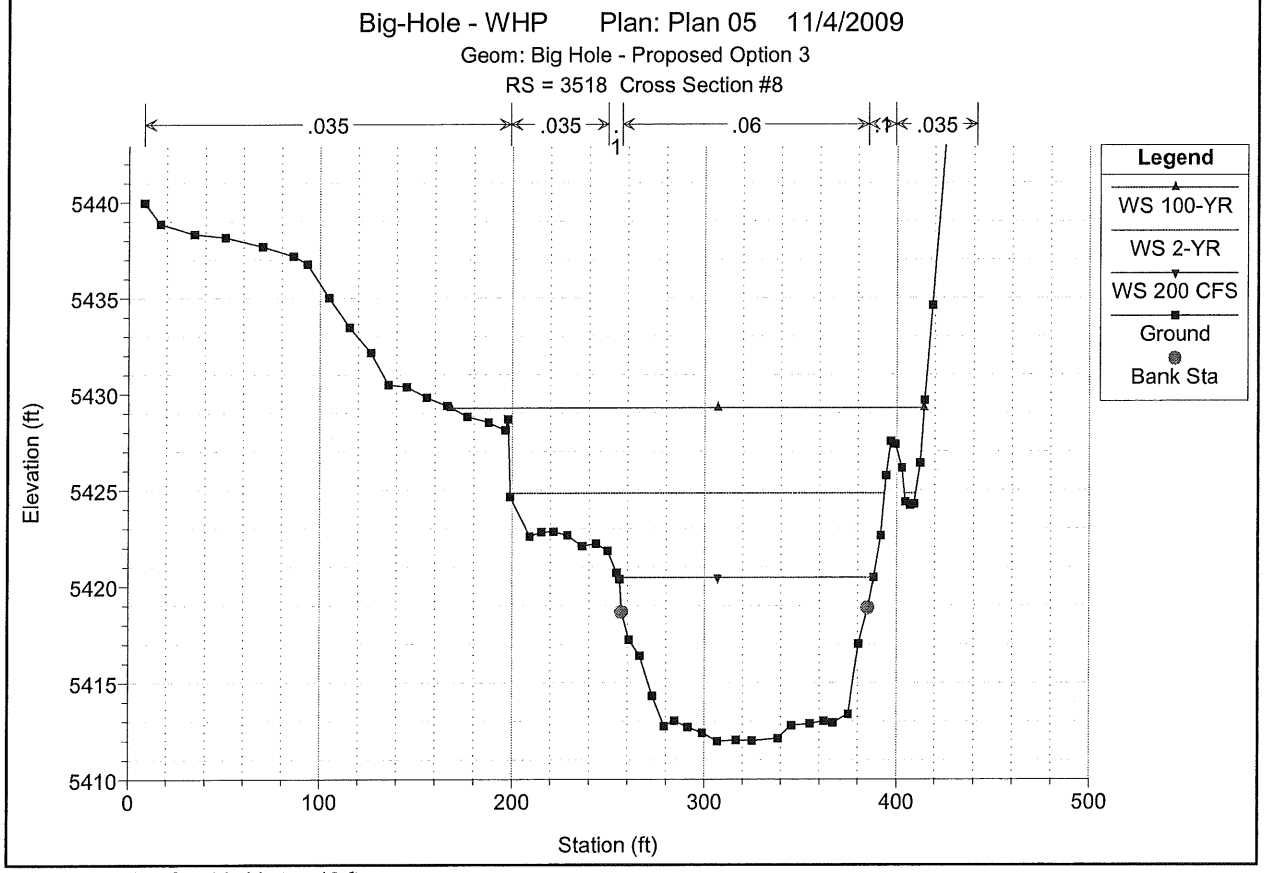
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



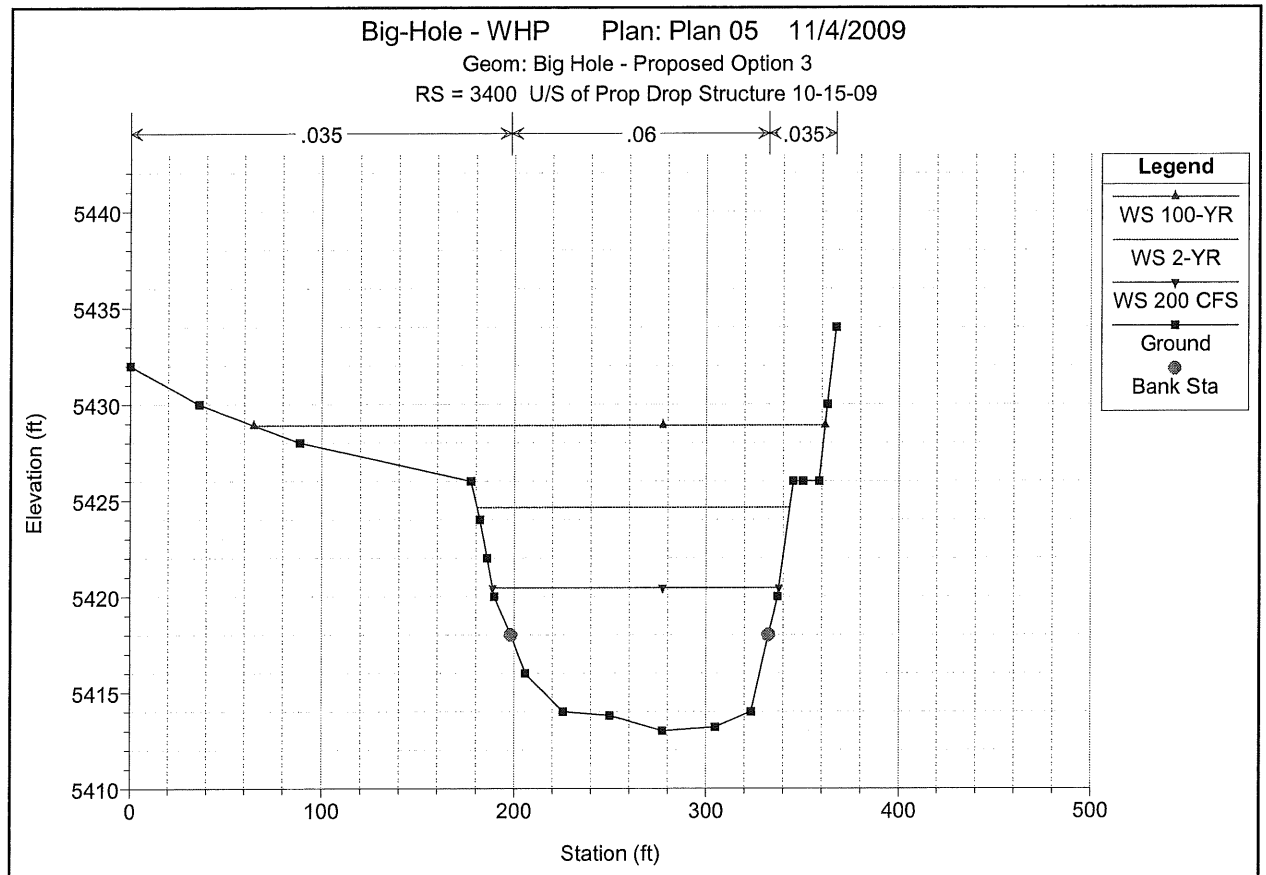


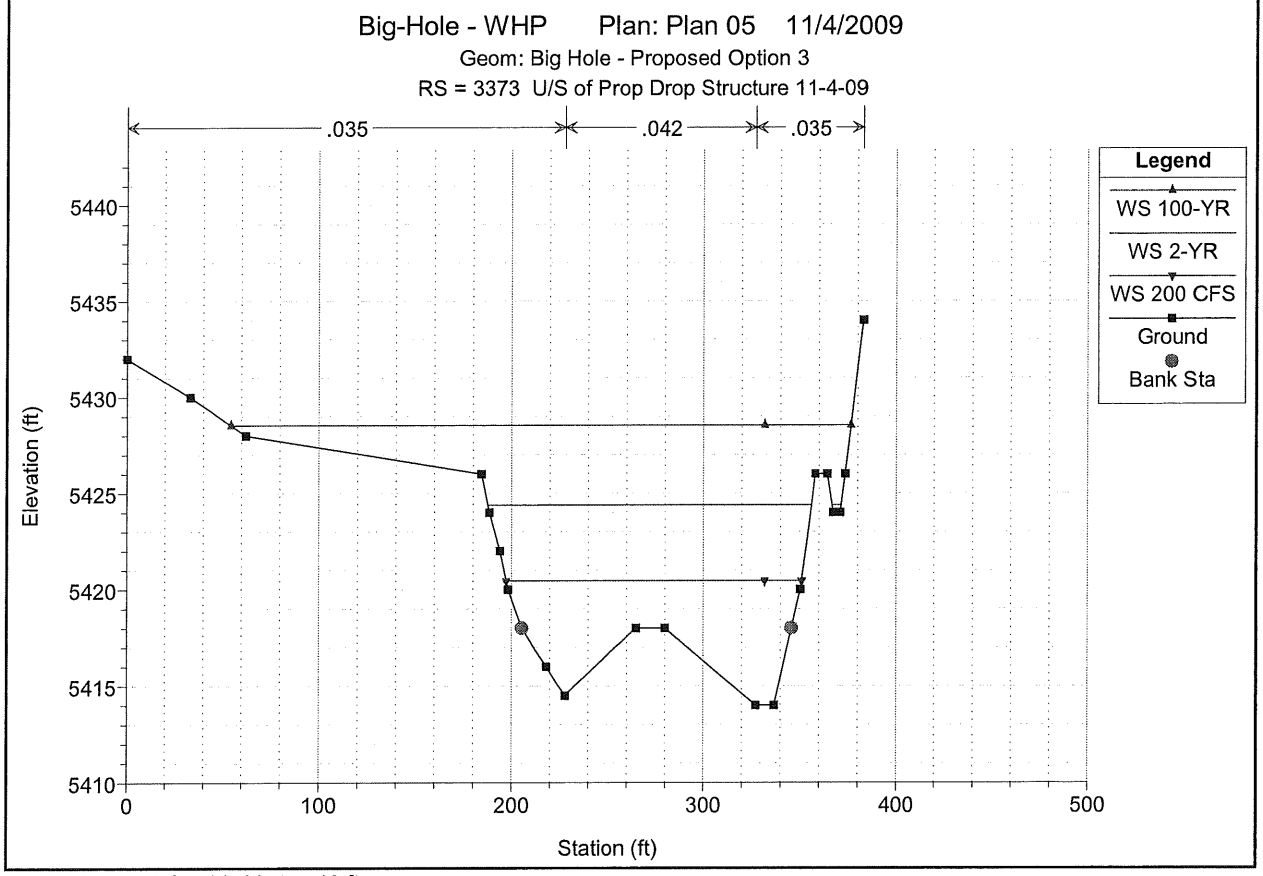
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft





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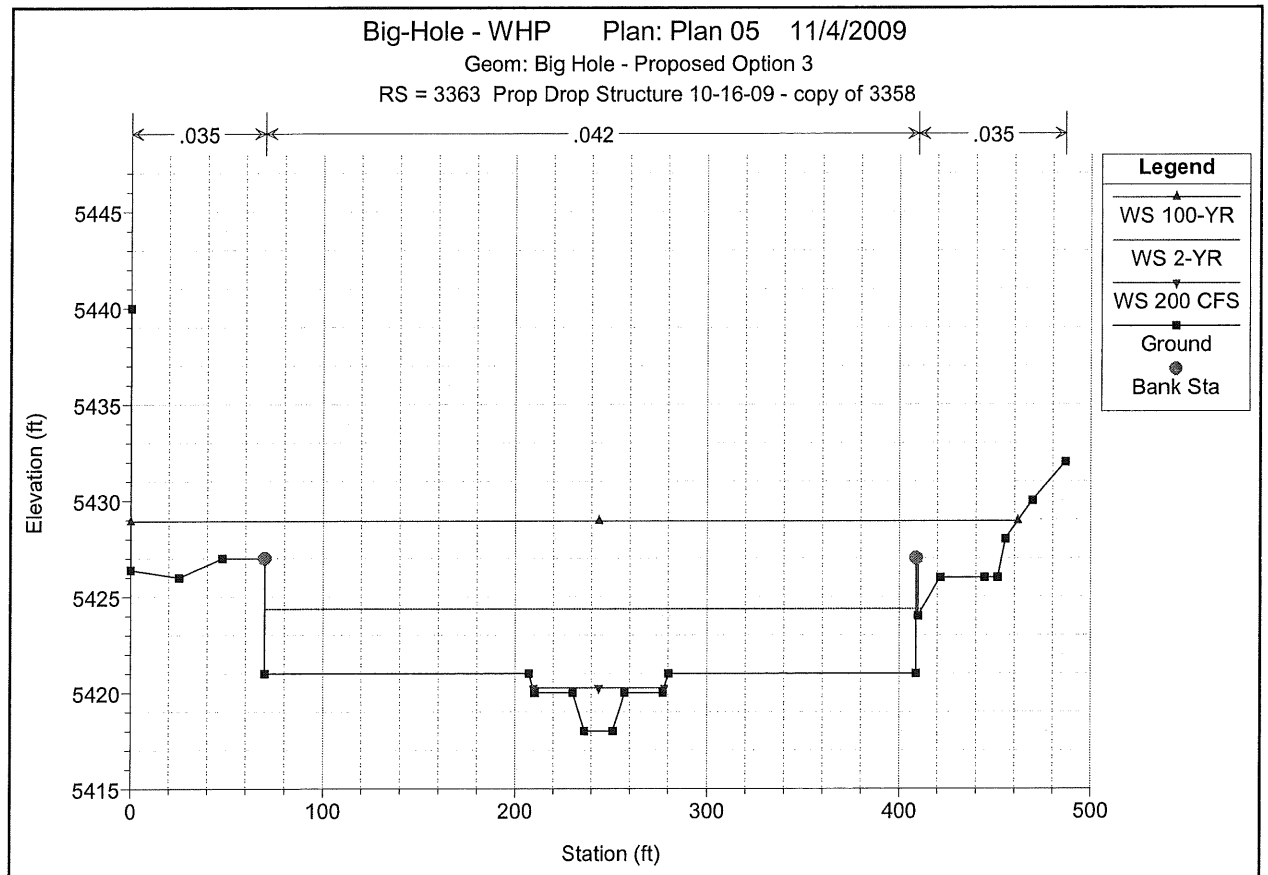

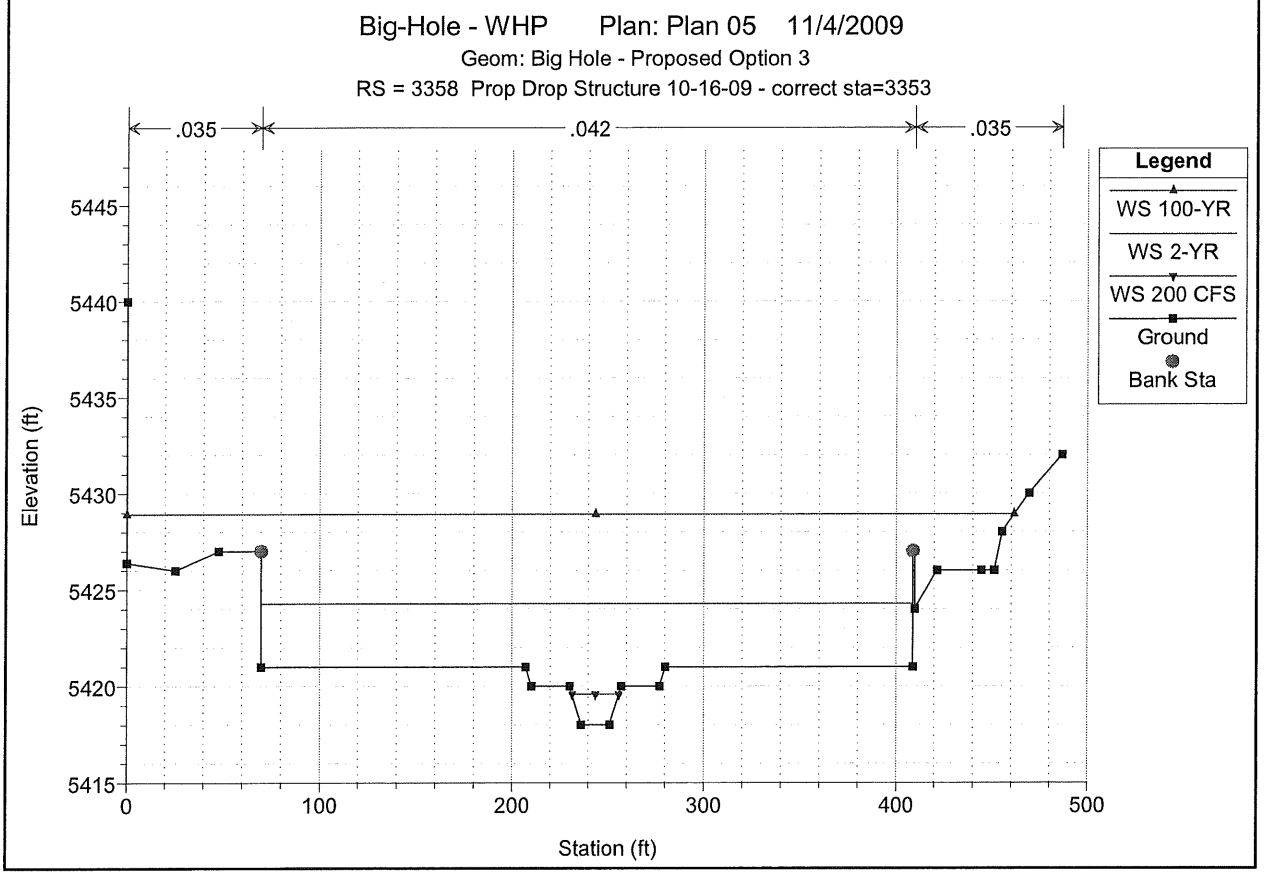

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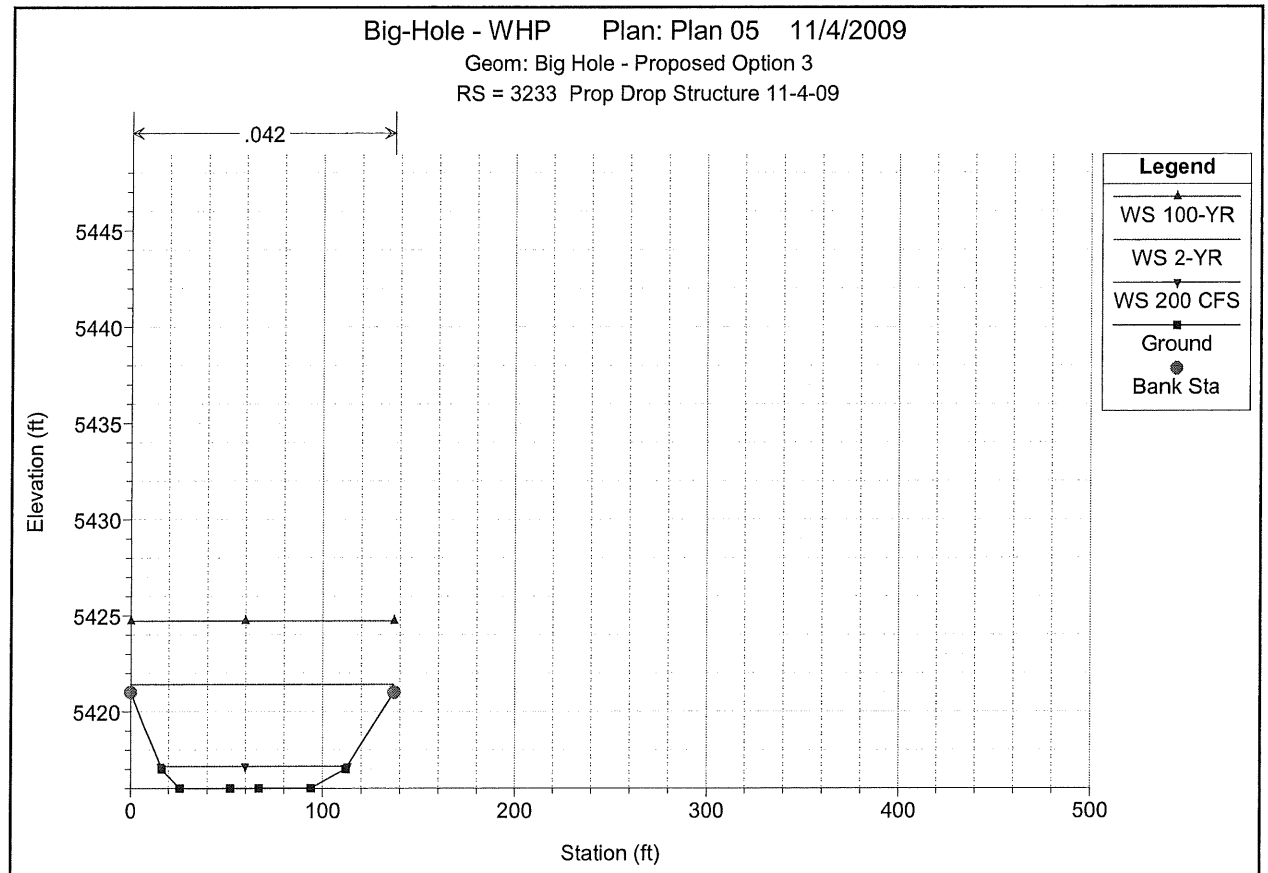

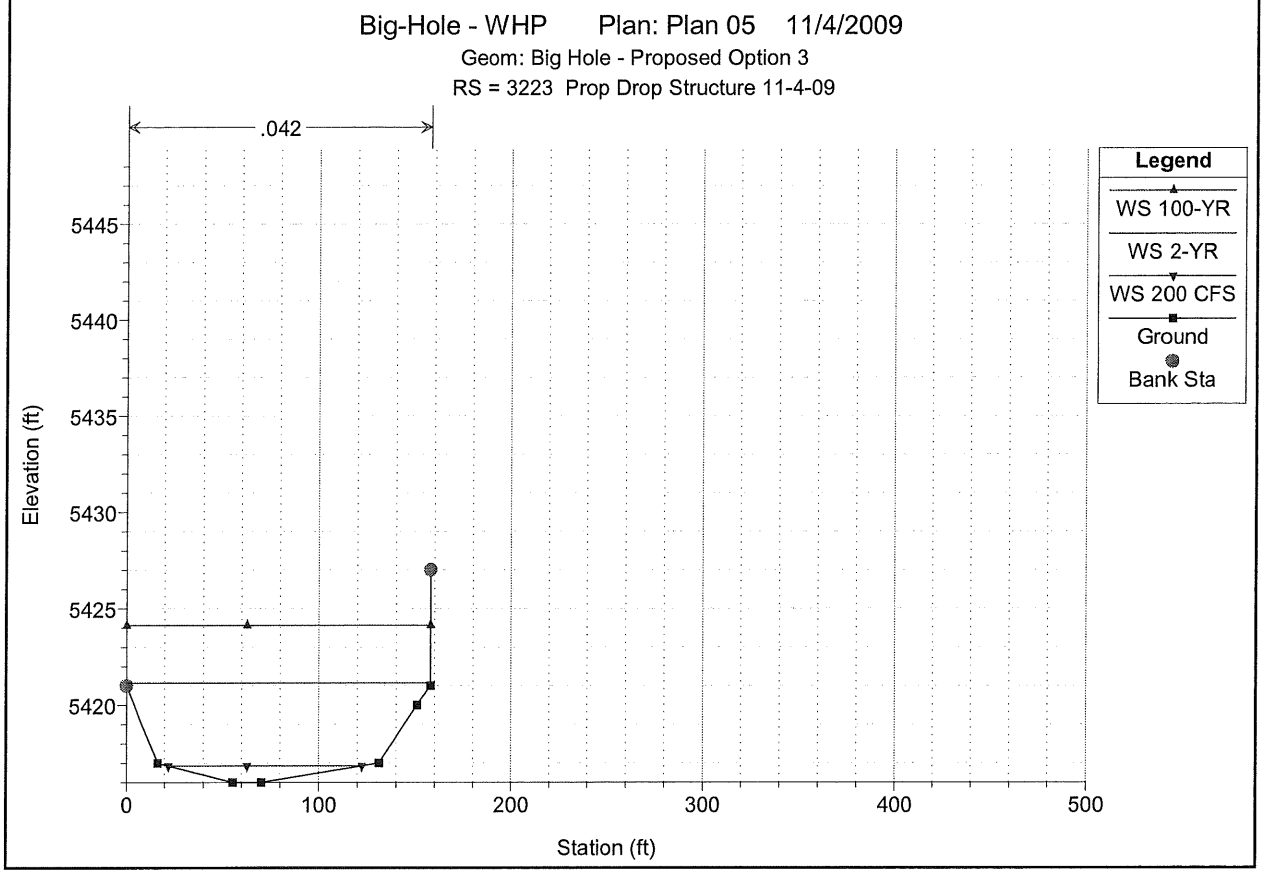

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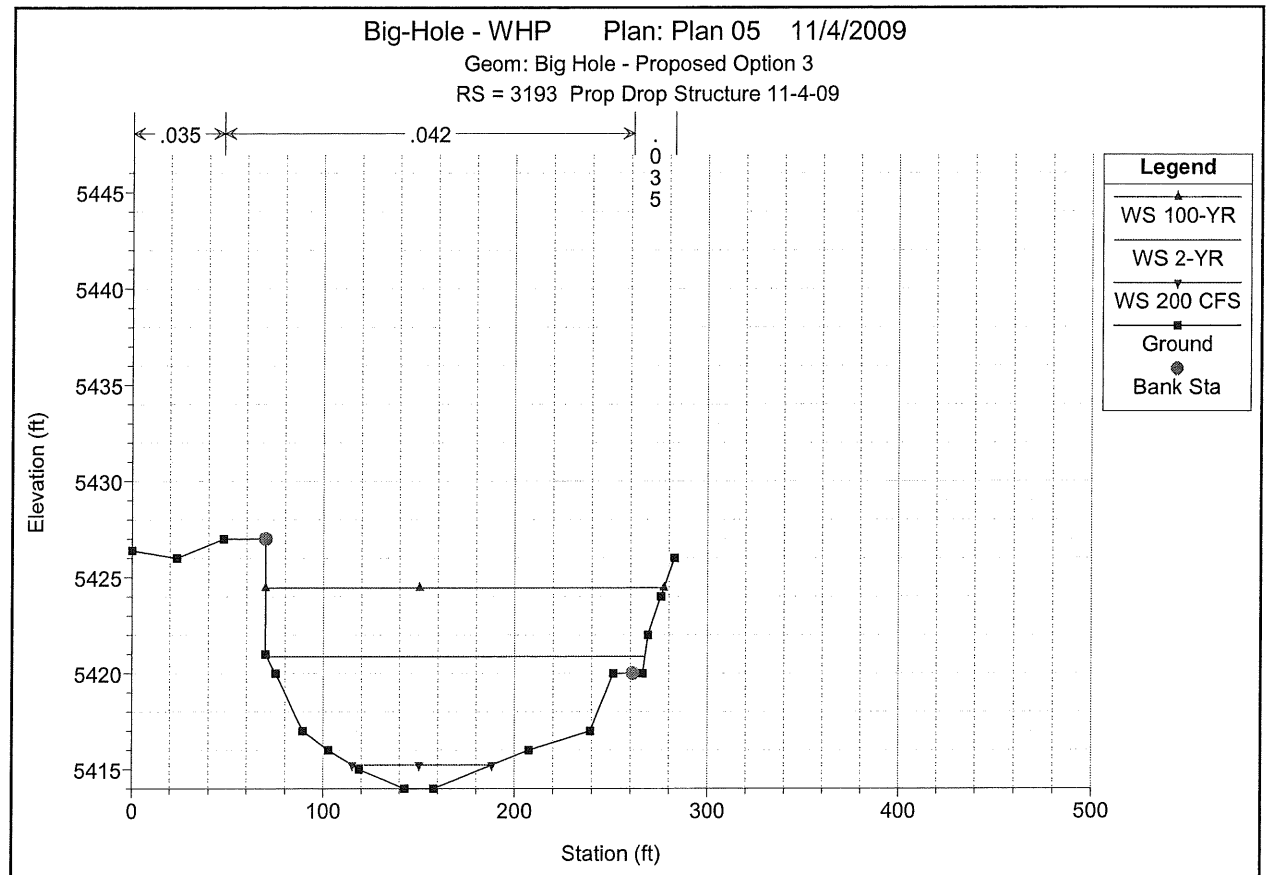

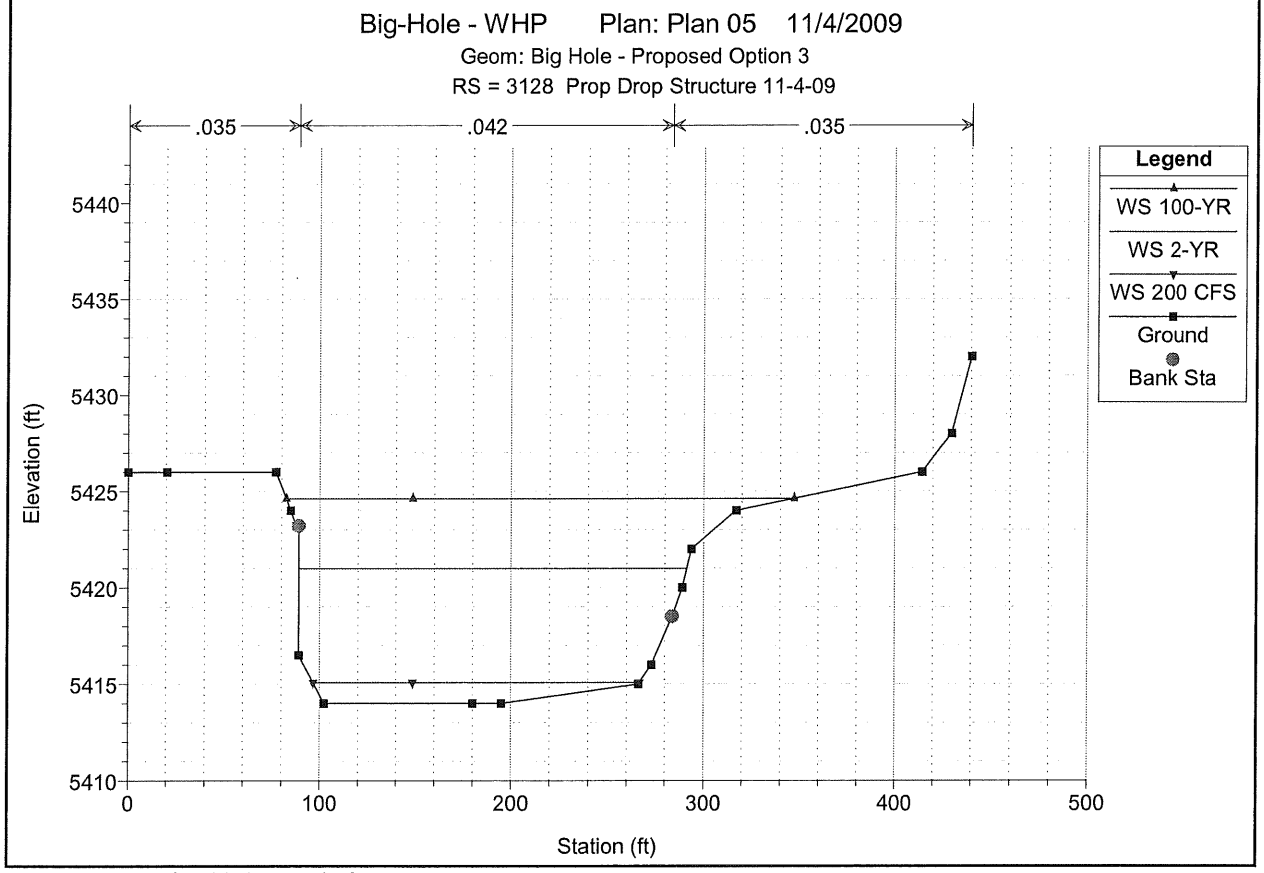

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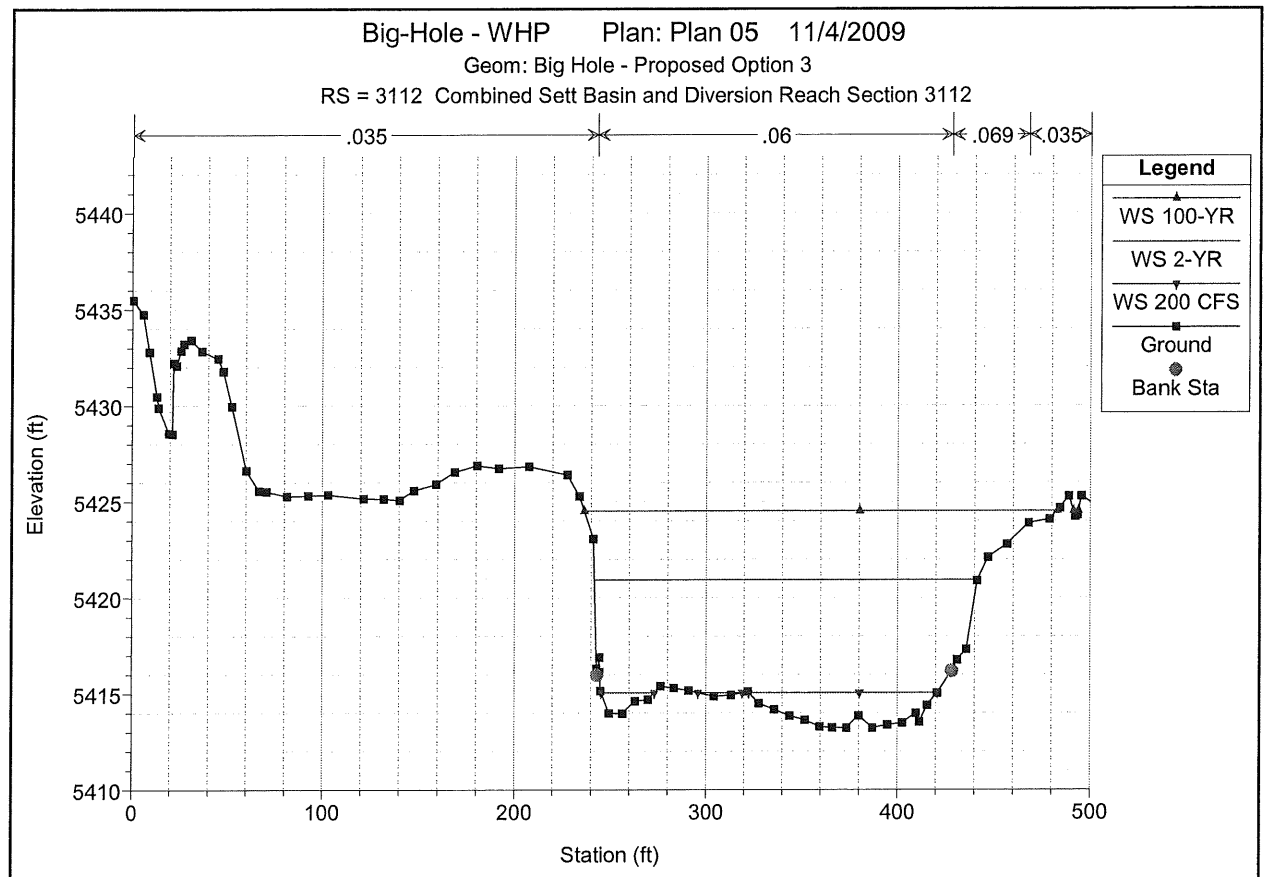
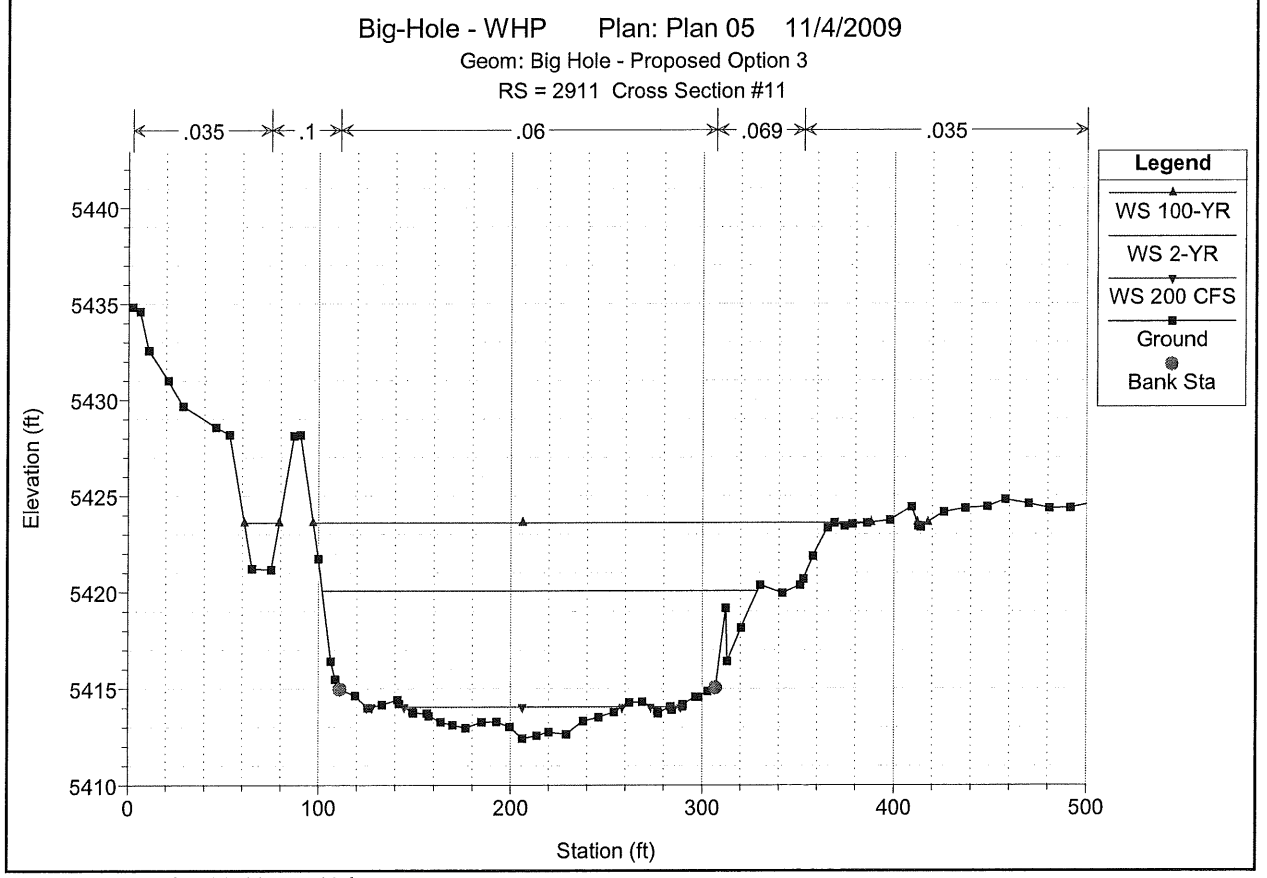
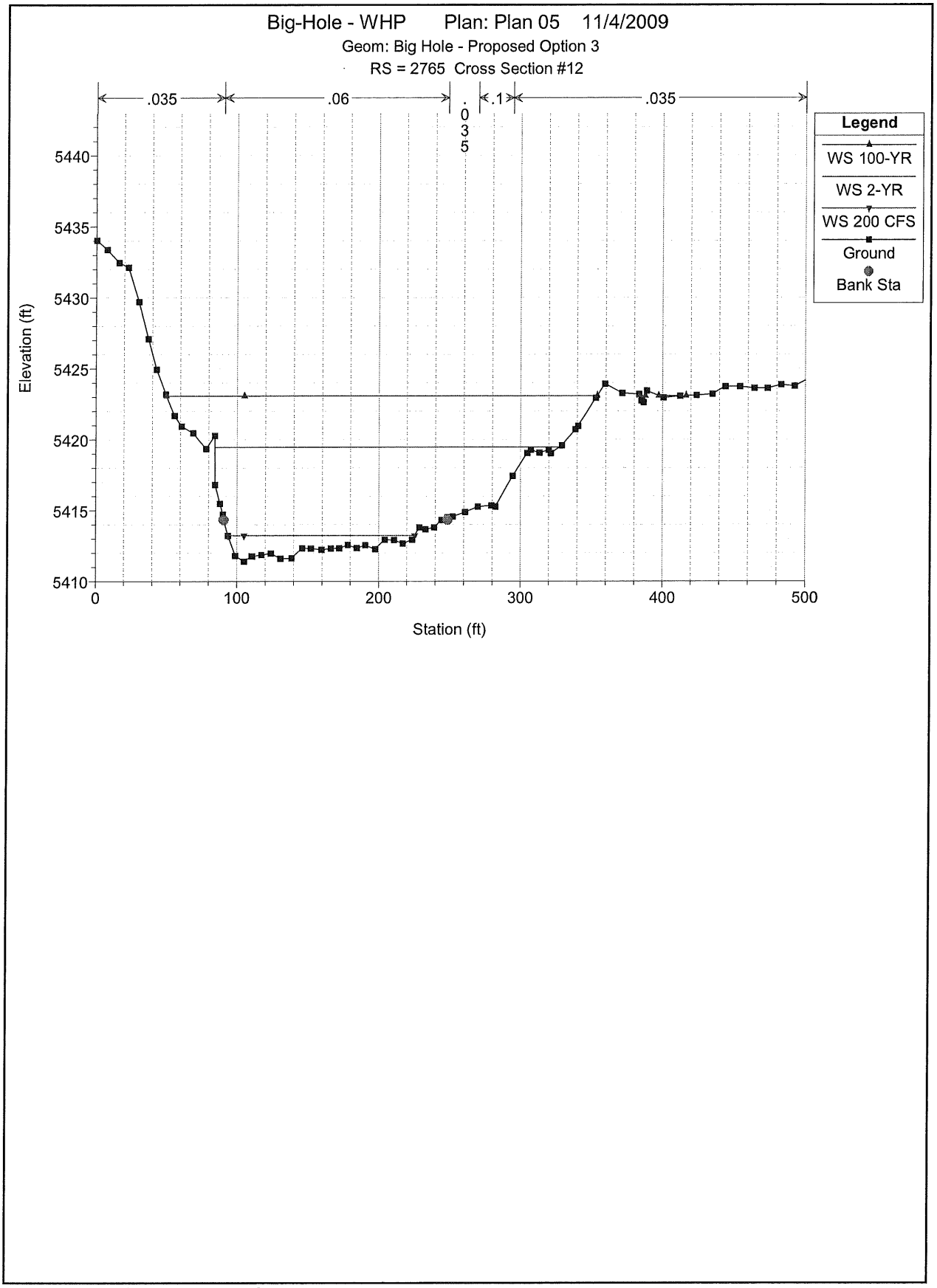




1 in Horiz. = 100 ft 1 in Vert. = 10 ft



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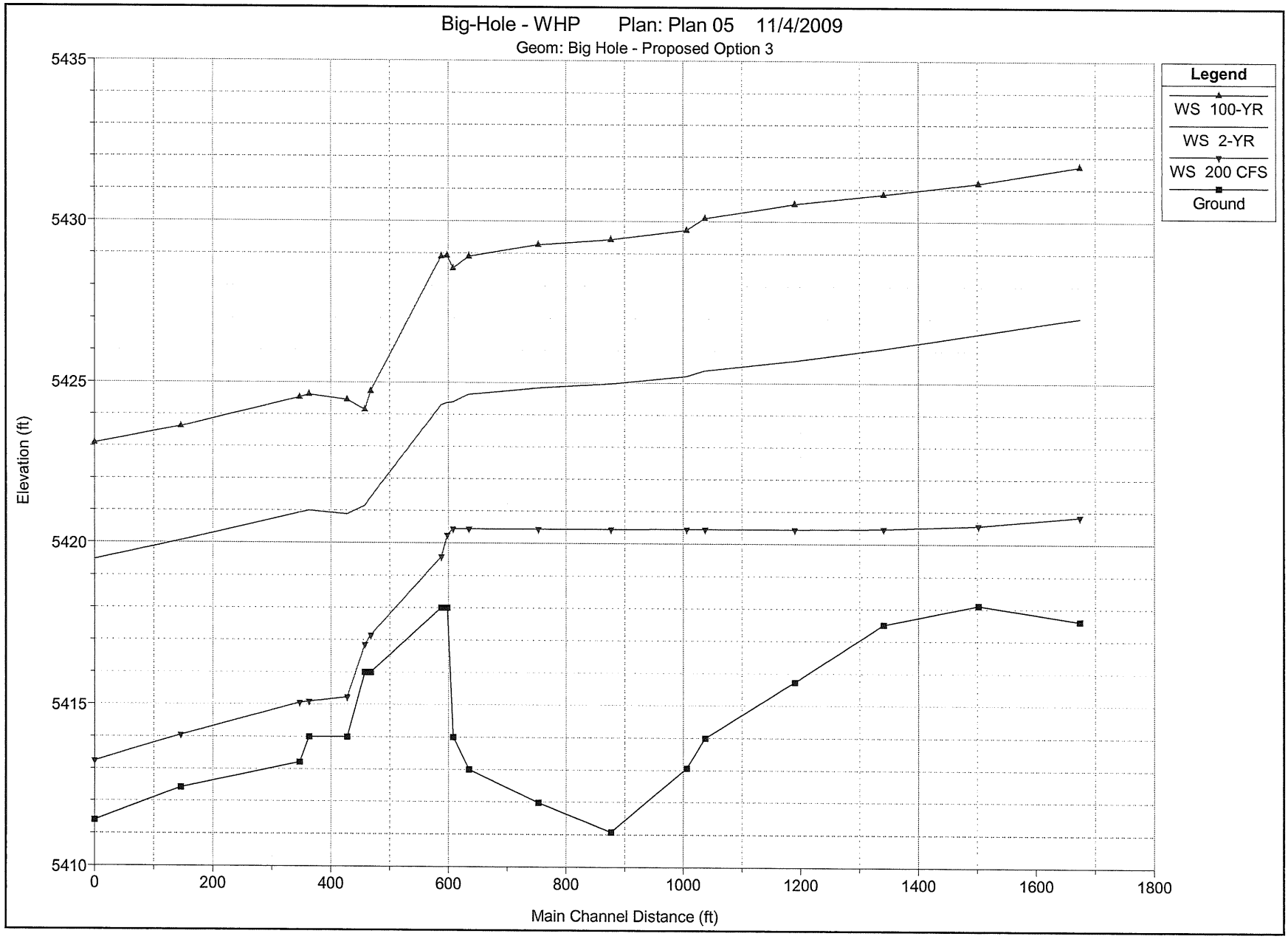

Big-Hole - WHP Plan: Plan 05 11/4/2009
Geom: Big Hole - Proposed Option 3
Legend
WS 100-YR
WS 2-YR
WS 200 CFS
Ground
Elevation (ft)
5435
5430
5425
5420
5415
5410
0
200
400
600
800
1000
1200
1400
1600
1800
Main Channel Distance (ft)

OPTION 3

PROJECT: BIG HOLE - WHP
PLAN: OPTION 3 FULLY OPEN (.p13)
GEOMETRY: OPTION 3 FULLY OPEN (.g13)
FLOW: INTAKE STRUCTURE FLOWS (.f08)

HEC-RAS Plan: Opt 3 Fully River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	200 cfs	200	5417.62	5420.8	5420.2	5420.85	0.005355	1.7	119.6	133.7	0.31
Upstream Chl	4439	500 cfs	500	5417.62	5421.7	5420.7	5421.75	0.003343	1.8	285.7	210.6	0.26
Upstream Chl	4439	750 cfs	750	5417.62	5422.1	5420.9	5422.19	0.003069	2.0	375.4	213.8	0.26
Upstream Chl	4439	1000 cfs	1000	5417.62	5422.5	5421.2	5422.53	0.003071	2.2	446.5	215.4	0.27
Upstream Chl	4439	1250 cfs	1250	5417.62	5422.7	5421.4	5422.84	0.003095	2.5	509.9	216.8	0.28
Upstream Chl	4439	1500 cfs	1500	5417.62	5423.0	5421.5	5423.13	0.003115	2.6	568.4	218.1	0.29
Upstream Chl	4439	1750 cfs	1750	5417.62	5423.3	5421.6	5423.39	0.003137	2.8	622.9	219.3	0.29
Upstream Chl	4439	2000 cfs	2000	5417.62	5423.5	5421.7	5423.64	0.003155	3.0	674.6	221.2	0.30
Upstream Chl	4439	2500 cfs	2500	5417.62	5423.9	5422.0	5424.10	0.003194	3.3	770.5	224.9	0.30
Upstream Chl	4439	3000 cfs	3000	5417.62	5424.3	5422.2	5424.52	0.003211	3.5	862.7	233.7	0.31
Upstream Chl	4439	6000 cfs	6000	5417.62	5426.3	5423.3	5426.59	0.003187	4.6	1327.8	249.3	0.33
Upstream Chl	4267	200 cfs	200	5418.11	5420.5	5419.2	5420.46	0.001198	0.9	216.0	191.8	0.15
Upstream Chl	4267	500 cfs	500	5418.11	5421.5	5419.7	5421.47	0.000902	1.2	423.4	213.0	0.15
Upstream Chl	4267	750 cfs	750	5418.11	5421.8	5420.0	5421.88	0.001118	1.5	507.6	215.7	0.17
Upstream Chl	4267	1000 cfs	1000	5418.11	5422.1	5420.2	5422.19	0.001349	1.8	571.4	217.2	0.19
Upstream Chl	4267	1250 cfs	1250	5418.11	5422.4	5420.4	5422.47	0.001537	2.0	629.6	218.5	0.20
Upstream Chl	4267	1500 cfs	1500	5418.11	5422.7	5420.6	5422.73	0.001690	2.2	684.1	219.9	0.22
Upstream Chl	4267	1750 cfs	1750	5418.11	5422.9	5420.7	5422.98	0.001822	2.4	735.1	221.3	0.23
Upstream Chl	4267	2000 cfs	2000	5418.11	5423.1	5420.8	5423.21	0.001935	2.6	783.8	222.2	0.24
Upstream Chl	4267	2500 cfs	2500	5418.11	5423.5	5421.1	5423.64	0.002121	2.9	874.6	223.6	0.25
Upstream Chl	4267	3000 cfs	3000	5418.11	5423.9	5421.3	5424.05	0.002257	3.2	960.5	224.9	0.27
Upstream Chl	4267	6000 cfs	6000	5418.11	5425.8	5422.4	5426.07	0.002768	4.4	1388.4	233.9	0.31
Upstream Chl	4106	200 cfs	200	5417.51	5420.3	5418.5	5420.32	0.000667	0.9	228.0	141.9	0.12
Upstream Chl	4106	500 cfs	500	5417.51	5421.3	5419.0	5421.32	0.001036	1.2	403.7	208.2	0.16
Upstream Chl	4106	750 cfs	750	5417.51	5421.6	5419.3	5421.67	0.001521	1.6	477.8	230.6	0.19
Upstream Chl	4106	1000 cfs	1000	5417.51	5421.9	5419.6	5421.93	0.001914	1.9	535.1	236.3	0.22
Upstream Chl	4106	1250 cfs	1250	5417.51	5422.1	5419.9	5422.18	0.002172	2.1	589.5	237.1	0.24
Upstream Chl	4106	1500 cfs	1500	5417.51	5422.3	5420.2	5422.41	0.002369	2.4	641.5	237.8	0.25
Upstream Chl	4106	1750 cfs	1750	5417.51	5422.5	5420.4	5422.63	0.002528	2.6	690.8	238.5	0.26
Upstream Chl	4106	2000 cfs	2000	5417.51	5422.7	5420.6	5422.85	0.002654	2.7	738.3	239.2	0.27
Upstream Chl	4106	2500 cfs	2500	5417.51	5423.1	5420.9	5423.25	0.002844	3.0	828.3	240.5	0.29
Upstream Chl	4106	3000 cfs	3000	5417.51	5423.5	5421.2	5423.64	0.002952	3.3	915.6	241.8	0.30
Upstream Chl	4106	6000 cfs	6000	5417.51	5425.3	5422.3	5425.59	0.003266	4.5	1368.2	260.5	0.33
Upstream Chl	3955	200 cfs	200	5415.73	5420.3	5417.0	5420.29	0.000083	0.5	432.2	162.6	0.05
Upstream Chl	3955	500 cfs	500	5415.73	5421.2	5417.7	5421.26	0.000198	0.8	593.7	176.2	0.08
Upstream Chl	3955	750 cfs	750	5415.73	5421.5	5418.1	5421.57	0.000342	1.2	647.8	180.8	0.11
Upstream Chl	3955	1000 cfs	1000	5415.73	5421.8	5418.4	5421.79	0.000512	1.5	685.8	183.8	0.13
Upstream Chl	3955	1250 cfs	1250	5415.73	5422.0	5418.6	5422.00	0.000685	1.8	722.1	187.4	0.15
Upstream Chl	3955	1500 cfs	1500	5415.73	5422.1	5418.8	5422.20	0.000857	2.0	757.5	191.4	0.17
Upstream Chl	3955	1750 cfs	1750	5415.73	5422.3	5419.0	5422.39	0.001023	2.2	791.9	195.5	0.19
Upstream Chl	3955	2000 cfs	2000	5415.73	5422.5	5419.1	5422.58	0.001183	2.5	825.8	200.8	0.21
Upstream Chl	3955	2500 cfs	2500	5415.73	5422.8	5419.4	5422.94	0.001489	2.8	897.1	231.0	0.25
Upstream Chl	3955	3000 cfs	3000	5415.73	5423.1	5419.7	5423.30	0.001699	3.1	975.6	239.9	0.27
Upstream Chl	3955	6000 cfs	6000	5415.73	5424.9	5421.1	5425.17	0.002291	4.4	1411.9	263.7	0.32
Upstream Chl	3802	200 cfs	200	5413.99	5420.3	5415.4	5420.29	0.000021	0.3	638.1	165.3	0.03
Upstream Chl	3802	500 cfs	500	5413.99	5421.2	5415.9	5421.24	0.000071	0.6	803.9	187.6	0.05
Upstream Chl	3802	750 cfs	750	5413.99	5421.5	5416.2	5421.54	0.000133	0.9	860.6	195.9	0.07
Upstream Chl	3802	1000 cfs	1000	5413.99	5421.7	5416.5	5421.74	0.000210	1.1	898.7	196.4	0.09
Upstream Chl	3802	1250 cfs	1250	5413.99	5421.9	5416.7	5421.93	0.000296	1.4	934.3	196.9	0.11
Upstream Chl	3802	1500 cfs	1500	5413.99	5422.1	5416.9	5422.11	0.000387	1.6	968.1	197.3	0.12
Upstream Chl	3802	1750 cfs	1750	5413.99	5422.2	5417.1	5422.28	0.000481	1.8	1000.1	197.6	0.14
Upstream Chl	3802	2000 cfs	2000	5413.99	5422.4	5417.3	5422.45	0.000578	2.0	1030.9	197.8	0.15
Upstream Chl	3802	2500 cfs	2500	5413.99	5422.7	5417.6	5422.77	0.000774	2.4	1089.3	198.2	0.17
Upstream Chl	3802	3000 cfs	3000	5413.99	5423.0	5418.0	5423.10	0.000958	2.7	1149.2	198.6	0.19
Upstream Chl	3802	6000 cfs	6000	5413.99	5424.6	5419.7	5424.85	0.001890	4.3	1466.8	201.5	0.27
Upstream Chl	3771	200 cfs	200	5413.06	5420.3	5414.4	5420.29	0.000015	0.3	676.4	143.3	0.02
Upstream Chl	3771	500 cfs	500	5413.06	5421.2	5415.0	5421.24	0.000055	0.6	815.5	151.6	0.04
Upstream Chl	3771	750 cfs	750	5413.06	5421.5	5415.3	5421.53	0.000106	0.9	860.5	161.2	0.06
Upstream Chl	3771	1000 cfs	1000	5413.06	5421.7	5415.6	5421.73	0.000172	1.2	893.0	176.9	0.08
Upstream Chl	3771	1250 cfs	1250	5413.06	5421.9	5415.8	5421.92	0.000246	1.4	924.7	180.6	0.09
Upstream Chl	3771	1500 cfs	1500	5413.06	5422.1	5416.0	5422.10	0.000327	1.7	954.9	181.0	0.11
Upstream Chl	3771	1750 cfs	1750	5413.06	5422.2	5416.3	5422.27	0.000412	1.9	983.4	181.3	0.12
Upstream Chl	3771	2000 cfs	2000	5413.06	5422.4	5416.5	5422.43	0.000501	2.1	1010.7	181.7	0.14
Upstream Chl	3771	2500 cfs	2500	5413.06	5422.6	5416.8	5422.74	0.000688	2.6	1062.1	182.9	0.16
Upstream Chl	3771	3000 cfs	3000	5413.06	5422.9	5417.2	5423.06	0.000872	3.0	1115.1	184.3	0.18
Upstream Chl	3771	6000 cfs	6000	5413.06	5424.4	5418.9	5424.78	0.001907	4.9	1396.1	191.7	0.28
Upstream Chl	3642	200 cfs	200	5411.07	5420.3	5412.4	5420.29	0.000009	0.3	759.9	113.8	0.02

11/16/09

HEC-RAS Plan: Opt 3 Fully River: Big Hole Reach: Upstream Chl (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3642	500 cfs	500	5411.07	5421.2	5413.2	5421.23	0.000035	0.6	871.4	129.8	0.04
Upstream Chl	3642	750 cfs	750	5411.07	5421.5	5413.6	5421.52	0.000071	0.8	909.3	135.7	0.05
Upstream Chl	3642	1000 cfs	1000	5411.07	5421.7	5413.9	5421.71	0.000116	1.1	934.7	139.4	0.07
Upstream Chl	3642	1250 cfs	1250	5411.07	5421.9	5414.2	5421.89	0.000170	1.3	958.9	147.9	0.08
Upstream Chl	3642	1500 cfs	1500	5411.07	5422.0	5414.4	5422.06	0.000229	1.6	983.1	156.6	0.09
Upstream Chl	3642	1750 cfs	1750	5411.07	5422.2	5414.7	5422.22	0.000294	1.8	1006.5	158.1	0.11
Upstream Chl	3642	2000 cfs	2000	5411.07	5422.3	5414.9	5422.38	0.000363	2.0	1028.9	159.5	0.12
Upstream Chl	3642	2500 cfs	2500	5411.07	5422.6	5415.4	5422.67	0.000511	2.5	1071.1	163.5	0.14
Upstream Chl	3642	3000 cfs	3000	5411.07	5422.8	5415.8	5422.96	0.000663	2.9	1115.5	168.2	0.16
Upstream Chl	3642	6000 cfs	6000	5411.07	5424.2	5417.7	5424.55	0.001590	4.8	1359.4	184.0	0.26
Upstream Chl	3518	200 cfs	200	5411.97	5420.3	5413.0	5420.28	0.000006	0.2	889.2	131.7	0.02
Upstream Chl	3518	500 cfs	500	5411.97	5421.2	5413.4	5421.23	0.000026	0.5	1015.1	137.1	0.03
Upstream Chl	3518	750 cfs	750	5411.97	5421.5	5413.7	5421.51	0.000053	0.7	1054.1	138.8	0.04
Upstream Chl	3518	1000 cfs	1000	5411.97	5421.7	5414.0	5421.70	0.000087	0.9	1079.4	139.8	0.06
Upstream Chl	3518	1250 cfs	1250	5411.97	5421.9	5414.2	5421.87	0.000127	1.1	1102.7	141.1	0.07
Upstream Chl	3518	1500 cfs	1500	5411.97	5422.0	5414.4	5422.03	0.000172	1.4	1124.6	143.8	0.08
Upstream Chl	3518	1750 cfs	1750	5411.97	5422.1	5414.7	5422.19	0.000222	1.5	1145.5	150.7	0.09
Upstream Chl	3518	2000 cfs	2000	5411.97	5422.3	5414.9	5422.33	0.000275	1.7	1166.6	157.7	0.10
Upstream Chl	3518	2500 cfs	2500	5411.97	5422.5	5415.2	5422.60	0.000390	2.1	1206.6	161.5	0.12
Upstream Chl	3518	3000 cfs	3000	5411.97	5422.8	5415.6	5422.88	0.000511	2.5	1249.3	175.5	0.14
Upstream Chl	3518	6000 cfs	6000	5411.97	5424.1	5417.3	5424.36	0.001266	4.2	1492.3	191.6	0.23
Upstream Chl	3400	200 cfs	200	5413.00	5420.3	5414.0	5420.28	0.000008	0.2	851.0	148.4	0.02
Upstream Chl	3400	500 cfs	500	5413.00	5421.2	5414.4	5421.22	0.000031	0.5	991.3	151.5	0.03
Upstream Chl	3400	750 cfs	750	5413.00	5421.5	5414.7	5421.51	0.000061	0.7	1033.7	152.4	0.05
Upstream Chl	3400	1000 cfs	1000	5413.00	5421.7	5414.9	5421.69	0.000100	1.0	1060.8	153.0	0.06
Upstream Chl	3400	1250 cfs	1250	5413.00	5421.8	5415.2	5421.86	0.000146	1.2	1085.3	153.6	0.07
Upstream Chl	3400	1500 cfs	1500	5413.00	5422.0	5415.4	5422.01	0.000196	1.4	1108.2	154.0	0.09
Upstream Chl	3400	1750 cfs	1750	5413.00	5422.1	5415.6	5422.16	0.000252	1.6	1129.3	154.5	0.10
Upstream Chl	3400	2000 cfs	2000	5413.00	5422.2	5415.8	5422.30	0.000311	1.8	1149.3	154.9	0.11
Upstream Chl	3400	2500 cfs	2500	5413.00	5422.5	5416.1	5422.55	0.000439	2.1	1186.0	155.7	0.13
Upstream Chl	3400	3000 cfs	3000	5413.00	5422.7	5416.4	5422.82	0.000572	2.5	1223.6	156.4	0.15
Upstream Chl	3400	6000 cfs	6000	5413.00	5423.9	5418.0	5424.20	0.001450	4.3	1411.4	160.2	0.24
Upstream Chl	3373	200 cfs	200	5414.00	5420.3	5415.5	5420.28	0.000012	0.3	585.2	152.9	0.03
Upstream Chl	3373	500 cfs	500	5414.00	5421.2	5416.3	5421.22	0.000039	0.7	729.1	156.0	0.06
Upstream Chl	3373	750 cfs	750	5414.00	5421.5	5416.7	5421.50	0.000073	1.0	772.1	157.0	0.08
Upstream Chl	3373	1000 cfs	1000	5414.00	5421.7	5417.0	5421.68	0.000116	1.3	799.1	157.5	0.10
Upstream Chl	3373	1250 cfs	1250	5414.00	5421.8	5417.3	5421.85	0.000165	1.6	823.3	158.0	0.12
Upstream Chl	3373	1500 cfs	1500	5414.00	5422.0	5417.5	5422.00	0.000219	1.8	845.6	158.5	0.13
Upstream Chl	3373	1750 cfs	1750	5414.00	5422.1	5417.8	5422.15	0.000277	2.1	866.1	159.0	0.15
Upstream Chl	3373	2000 cfs	2000	5414.00	5422.2	5418.0	5422.28	0.000337	2.3	885.3	159.5	0.17
Upstream Chl	3373	2500 cfs	2500	5414.00	5422.4	5418.4	5422.54	0.000467	2.8	920.0	160.4	0.20
Upstream Chl	3373	3000 cfs	3000	5414.00	5422.6	5418.6	5422.80	0.000597	3.2	955.5	161.3	0.22
Upstream Chl	3373	6000 cfs	6000	5414.00	5423.7	5420.1	5424.14	0.001428	5.5	1126.0	165.5	0.35
Upstream Chl	3363	200 cfs	200	5418.00	5419.6	5419.6	5420.22	0.024420	6.4	31.2	24.5	1.00
Upstream Chl	3363	500 cfs	500	5418.00	5420.6	5420.6	5421.16	0.026024	6.2	80.6	70.4	1.02
Upstream Chl	3363	750 cfs	750	5418.00	5421.2	5421.2	5421.47	0.037072	4.3	172.9	338.9	1.07
Upstream Chl	3363	1000 cfs	1000	5418.00	5421.4	5421.3	5421.66	0.018768	4.0	252.2	338.9	0.81
Upstream Chl	3363	1250 cfs	1250	5418.00	5421.5	5421.4	5421.82	0.017298	4.2	295.5	338.9	0.80
Upstream Chl	3363	1500 cfs	1500	5418.00	5421.7	5421.5	5421.97	0.016269	4.5	335.9	338.9	0.79
Upstream Chl	3363	1750 cfs	1750	5418.00	5421.8	5421.6	5422.11	0.015774	4.7	372.0	338.9	0.79
Upstream Chl	3363	2000 cfs	2000	5418.00	5421.9	5421.7	5422.24	0.015393	4.9	406.1	338.9	0.79
Upstream Chl	3363	2500 cfs	2500	5418.00	5422.0	5421.8	5422.49	0.015278	5.4	465.5	338.9	0.81
Upstream Chl	3363	3000 cfs	3000	5418.00	5422.3	5422.0	5422.75	0.012879	5.5	546.9	338.9	0.76
Upstream Chl	3363	6000 cfs	6000	5418.00	5423.5	5422.8	5424.09	0.008219	6.3	951.1	338.9	0.66
Upstream Chl	3353	200 cfs	200	5414.50	5418.5	5418.5	5419.09	0.005662	6.4	31.1	37.7	0.99
Upstream Chl	3353	500 cfs	500	5414.50	5419.6	5419.6	5420.60	0.009894	8.2	60.8	44.3	1.02
Upstream Chl	3353	750 cfs	750	5414.50	5420.5	5420.5	5421.19	0.009228	6.7	111.2	89.9	0.98
Upstream Chl	3353	1000 cfs	1000	5414.50	5421.2	5421.2	5421.52	0.009354	4.5	222.7	358.9	0.98
Upstream Chl	3353	1250 cfs	1250	5414.50	5421.3	5421.3	5421.68	0.010805	4.8	260.1	358.9	0.98
Upstream Chl	3353	1500 cfs	1500	5414.50	5421.4	5421.4	5421.82	0.012174	5.1	291.8	358.9	0.98
Upstream Chl	3353	1750 cfs	1750	5414.50	5421.5	5421.5	5421.96	0.013086	5.4	323.6	358.9	0.98
Upstream Chl	3353	2000 cfs	2000	5414.50	5421.6	5421.6	5422.08	0.013870	5.7	353.1	358.9	0.99
Upstream Chl	3353	2500 cfs	2500	5414.50	5421.9	5421.8	5422.36	0.010519	5.4	466.6	358.9	0.81
Upstream Chl	3353	3000 cfs	3000	5414.50	5422.2	5421.9	5422.64	0.008880	5.3	564.6	358.9	0.73
Upstream Chl	3353	6000 cfs	6000	5414.50	5423.4	5422.7	5424.01	0.006478	6.0	992.2	358.9	0.63
Upstream Chl	3350		Inl Struct									

HEC-RAS Plan: Opt 3 Fully River: Big Hole Reach: Upstream Chl (Continued)

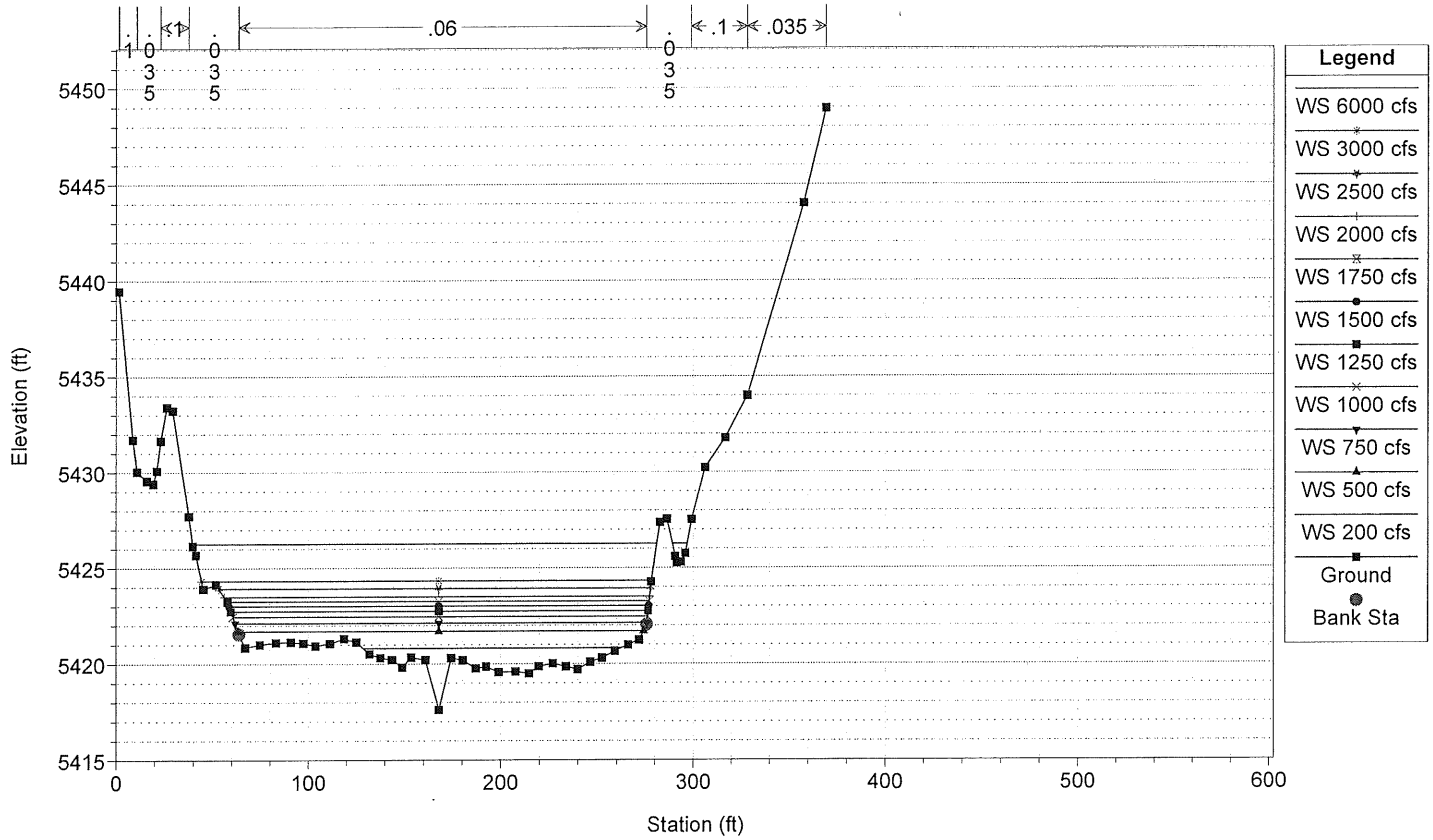
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3128	200 cfs	200	5414.00	5415.1	5414.5	5415.11	0.001817	1.3	148.2	175.0	0.26
Upstream Chl	3128	500 cfs	500	5414.00	5415.8	5414.8	5415.82	0.001611	1.9	270.3	181.5	0.27
Upstream Chl	3128	750 cfs	750	5414.00	5416.2	5415.1	5416.23	0.001715	2.2	341.1	185.1	0.29
Upstream Chl	3128	1000 cfs	1000	5414.00	5416.5	5415.2	5416.57	0.001821	2.5	400.7	188.1	0.30
Upstream Chl	3128	1250 cfs	1250	5414.00	5416.8	5415.4	5416.88	0.001872	2.7	455.9	189.4	0.31
Upstream Chl	3128	1500 cfs	1500	5414.00	5417.0	5415.6	5417.17	0.001910	3.0	507.0	190.5	0.32
Upstream Chl	3128	1750 cfs	1750	5414.00	5417.3	5415.7	5417.44	0.001942	3.2	554.9	191.6	0.33
Upstream Chl	3128	2000 cfs	2000	5414.00	5417.5	5415.8	5417.70	0.001970	3.3	600.2	192.5	0.33
Upstream Chl	3128	2500 cfs	2500	5414.00	5418.0	5416.1	5418.17	0.002017	3.7	684.5	194.3	0.34
Upstream Chl	3128	3000 cfs	3000	5414.00	5418.4	5416.3	5418.60	0.002035	3.9	762.6	195.4	0.35
Upstream Chl	3128	6000 cfs	6000	5414.00	5420.3	5417.5	5420.75	0.002123	5.2	1151.0	200.5	0.38
Upstream Chl	3118	200 cfs	200	5414.00	5415.1	5414.5	5415.09	0.001969	1.4	144.6	174.8	0.27
Upstream Chl	3118	500 cfs	500	5414.00	5415.8	5414.8	5415.81	0.001676	1.9	267.0	181.3	0.27
Upstream Chl	3118	750 cfs	750	5414.00	5416.1	5415.1	5416.21	0.001774	2.2	337.4	184.9	0.29
Upstream Chl	3118	1000 cfs	1000	5414.00	5416.5	5415.2	5416.55	0.001880	2.5	396.7	187.9	0.31
Upstream Chl	3118	1250 cfs	1250	5414.00	5416.7	5415.4	5416.86	0.001929	2.8	451.7	189.4	0.32
Upstream Chl	3118	1500 cfs	1500	5414.00	5417.0	5415.6	5417.15	0.001963	3.0	502.7	190.5	0.32
Upstream Chl	3118	1750 cfs	1750	5414.00	5417.3	5415.7	5417.42	0.001993	3.2	550.5	191.5	0.33
Upstream Chl	3118	2000 cfs	2000	5414.00	5417.5	5415.8	5417.67	0.002018	3.4	595.6	192.4	0.34
Upstream Chl	3118	2500 cfs	2500	5414.00	5417.9	5416.1	5418.15	0.002061	3.7	679.9	194.2	0.35
Upstream Chl	3118	3000 cfs	3000	5414.00	5418.3	5416.3	5418.58	0.002077	4.0	757.9	195.4	0.35
Upstream Chl	3118	6000 cfs	6000	5414.00	5420.3	5417.5	5420.72	0.002155	5.3	1145.7	200.4	0.38
Upstream Chl	3112	200 cfs	200	5413.21	5415.1	5414.1	5415.08	0.002991	1.3	148.5	149.3	0.24
Upstream Chl	3112	500 cfs	500	5413.21	5415.7	5414.6	5415.79	0.003448	1.9	266.2	180.5	0.27
Upstream Chl	3112	750 cfs	750	5413.21	5416.1	5414.9	5416.20	0.003657	2.2	336.0	183.5	0.29
Upstream Chl	3112	1000 cfs	1000	5413.21	5416.4	5415.2	5416.54	0.003851	2.5	394.4	186.0	0.31
Upstream Chl	3112	1250 cfs	1250	5413.21	5416.7	5415.4	5416.85	0.003955	2.8	448.7	187.9	0.32
Upstream Chl	3112	1500 cfs	1500	5413.21	5417.0	5415.5	5417.14	0.004025	3.0	499.3	190.3	0.32
Upstream Chl	3112	1750 cfs	1750	5413.21	5417.2	5415.7	5417.40	0.004071	3.2	546.9	192.5	0.33
Upstream Chl	3112	2000 cfs	2000	5413.21	5417.5	5415.8	5417.66	0.004108	3.4	592.2	193.4	0.34
Upstream Chl	3112	2500 cfs	2500	5413.21	5417.9	5416.1	5418.13	0.004166	3.7	676.3	194.2	0.35
Upstream Chl	3112	3000 cfs	3000	5413.21	5418.3	5416.3	5418.56	0.004211	4.0	753.9	194.9	0.35
Upstream Chl	3112	6000 cfs	6000	5413.21	5420.3	5417.5	5420.70	0.004410	5.4	1137.7	198.4	0.39
Upstream Chl	2911	200 cfs	200	5412.42	5414.1	5413.6	5414.11	0.008912	2.0	101.6	131.3	0.39
Upstream Chl	2911	500 cfs	500	5412.42	5414.7	5414.0	5414.83	0.007006	2.3	216.9	184.7	0.37
Upstream Chl	2911	750 cfs	750	5412.42	5415.2	5414.3	5415.27	0.005922	2.5	298.0	197.0	0.36
Upstream Chl	2911	1000 cfs	1000	5412.42	5415.5	5414.5	5415.63	0.005343	2.7	365.9	198.8	0.35
Upstream Chl	2911	1250 cfs	1250	5412.42	5415.8	5414.7	5415.95	0.005018	2.9	427.0	200.0	0.35
Upstream Chl	2911	1500 cfs	1500	5412.42	5416.1	5414.8	5416.25	0.004823	3.1	482.9	201.0	0.35
Upstream Chl	2911	1750 cfs	1750	5412.42	5416.4	5415.0	5416.52	0.004711	3.3	534.4	202.0	0.35
Upstream Chl	2911	2000 cfs	2000	5412.42	5416.6	5415.1	5416.78	0.004634	3.5	582.8	203.5	0.36
Upstream Chl	2911	2500 cfs	2500	5412.42	5417.0	5415.4	5417.25	0.004539	3.8	672.9	206.5	0.36
Upstream Chl	2911	3000 cfs	3000	5412.42	5417.4	5415.6	5417.69	0.004476	4.0	756.7	209.3	0.36
Upstream Chl	2911	6000 cfs	6000	5412.42	5419.4	5416.7	5419.81	0.004381	5.2	1179.3	223.0	0.39
Upstream Chl	2765	200 cfs	200	5411.40	5413.2	5412.6	5413.28	0.003899	1.5	130.4	131.7	0.27
Upstream Chl	2765	500 cfs	500	5411.40	5414.0	5413.0	5414.08	0.003899	2.1	237.9	149.6	0.29
Upstream Chl	2765	750 cfs	750	5411.40	5414.5	5413.2	5414.57	0.003904	2.4	309.6	159.6	0.30
Upstream Chl	2765	1000 cfs	1000	5411.40	5414.9	5413.5	5414.97	0.003904	2.7	370.4	169.8	0.31
Upstream Chl	2765	1250 cfs	1250	5411.40	5415.2	5413.7	5415.31	0.003904	3.0	426.9	178.7	0.32
Upstream Chl	2765	1500 cfs	1500	5411.40	5415.5	5413.9	5415.62	0.003902	3.2	481.2	195.0	0.33
Upstream Chl	2765	1750 cfs	1750	5411.40	5415.7	5414.0	5415.90	0.003904	3.4	532.6	197.2	0.33
Upstream Chl	2765	2000 cfs	2000	5411.40	5416.0	5414.2	5416.16	0.003902	3.5	581.2	199.2	0.33
Upstream Chl	2765	2500 cfs	2500	5411.40	5416.4	5414.5	5416.64	0.003908	3.8	671.0	202.9	0.34
Upstream Chl	2765	3000 cfs	3000	5411.40	5416.8	5414.8	5417.08	0.003901	4.1	754.8	206.2	0.35
Upstream Chl	2765	6000 cfs	6000	5411.40	5418.8	5416.1	5419.21	0.003907	5.3	1172.8	218.5	0.37

HEC-RAS Plan: Opt 3 Fully River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Q Total	Q Weir	Q Gates
			(ft)	(ft)	(cfs)	(cfs)	(cfs)
Upstream Chl	3350	200 cfs	5419.09	5418.45	200.00	45.58	154.42
Upstream Chl	3350	500 cfs	5420.60	5419.55	500.00	251.86	248.14
Upstream Chl	3350	750 cfs	5421.19	5420.49	750.00	458.32	291.68
Upstream Chl	3350	1000 cfs	5421.52	5421.21	1000.00	702.36	297.64
Upstream Chl	3350	1250 cfs	5421.68	5421.32	1250.00	920.50	329.50
Upstream Chl	3350	1500 cfs	5421.82	5421.41	1500.00	1145.32	354.68
Upstream Chl	3350	1750 cfs	5421.96	5421.50	1750.00	1375.19	374.81
Upstream Chl	3350	2000 cfs	5422.08	5421.59	2000.00	1609.69	390.31
Upstream Chl	3350	2500 cfs	5422.36	5421.92	2500.00	2094.89	405.11
Upstream Chl	3350	3000 cfs	5422.64	5422.20	3000.00	2588.14	411.86
Upstream Chl	3350	6000 cfs	5424.01	5423.44	6000.00	5554.36	445.64

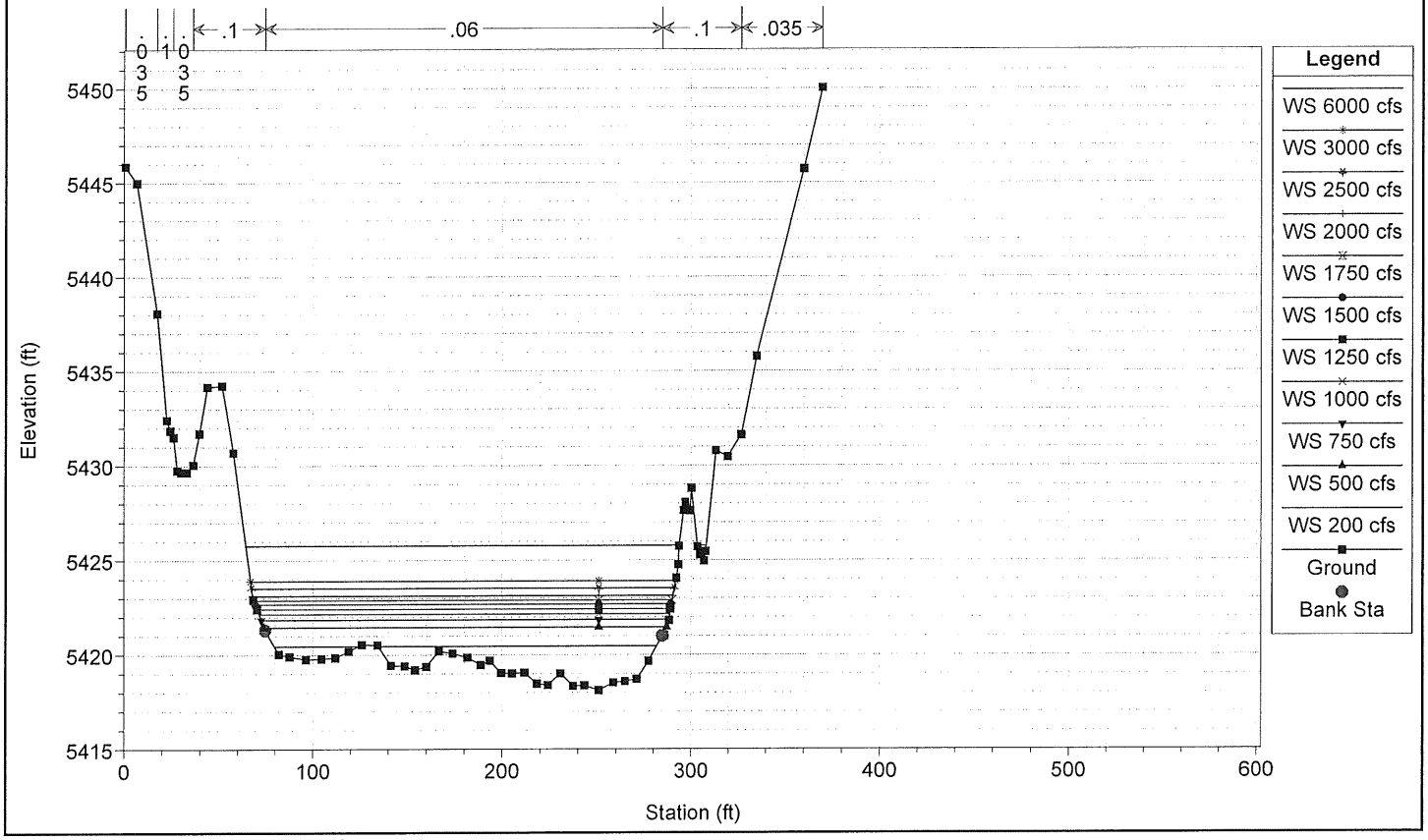
Big-Hole - WHP Plan: Option 3 Fully Open 11/16/2009

RS = 4439 Cross Section #1

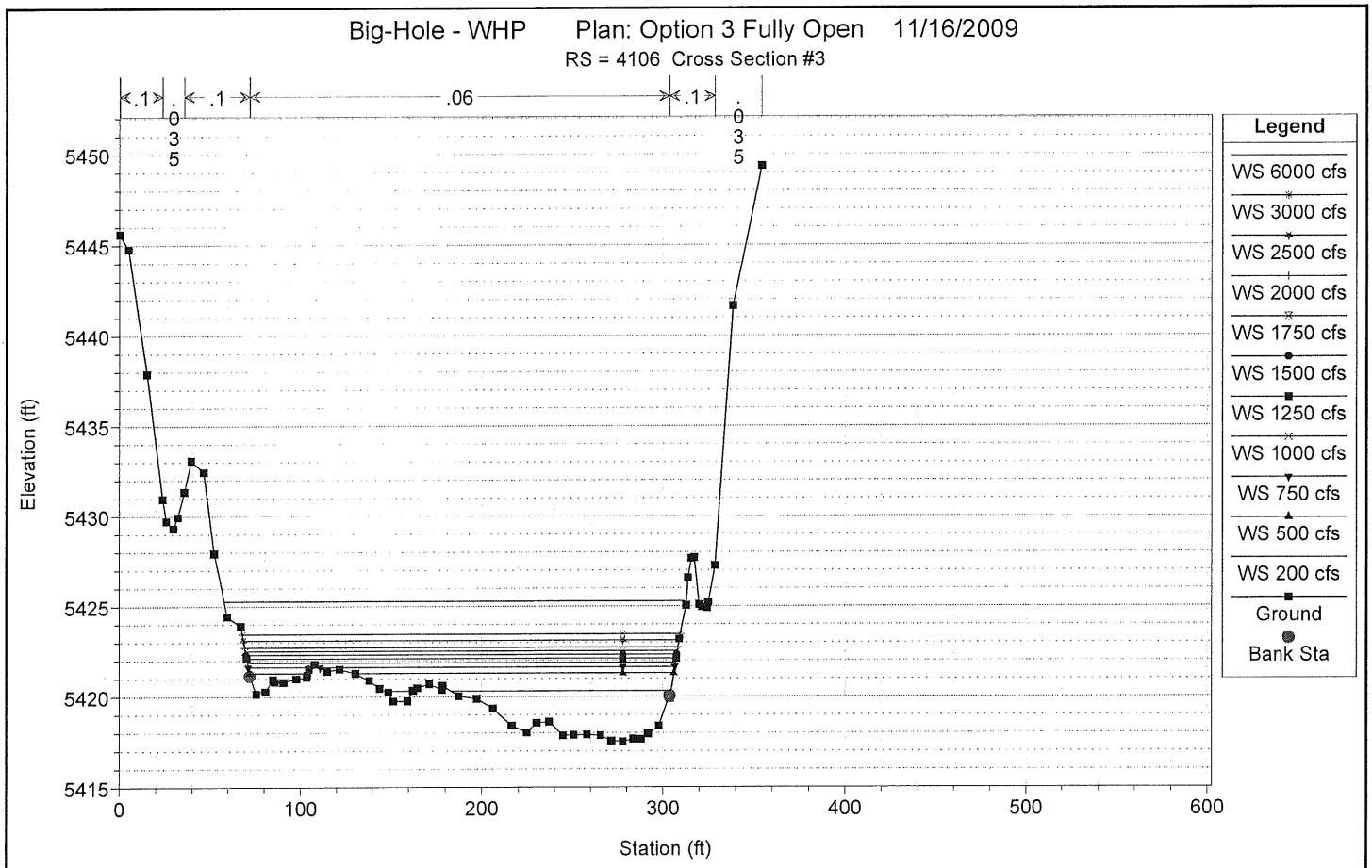


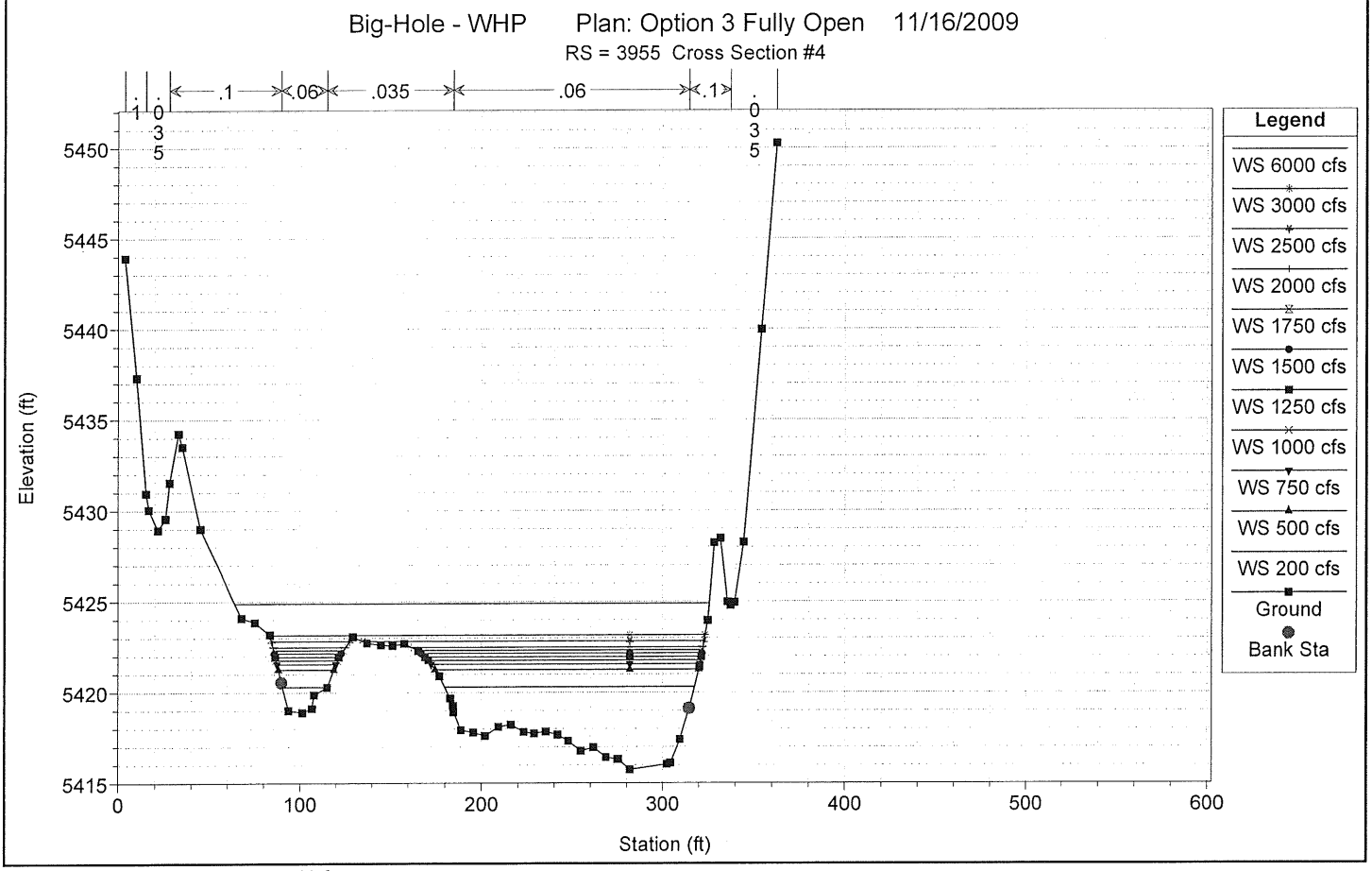
Big-Hole - WHP Plan: Option 3 Fully Open 11/16/2009

RS = 4267 Cross Section #2

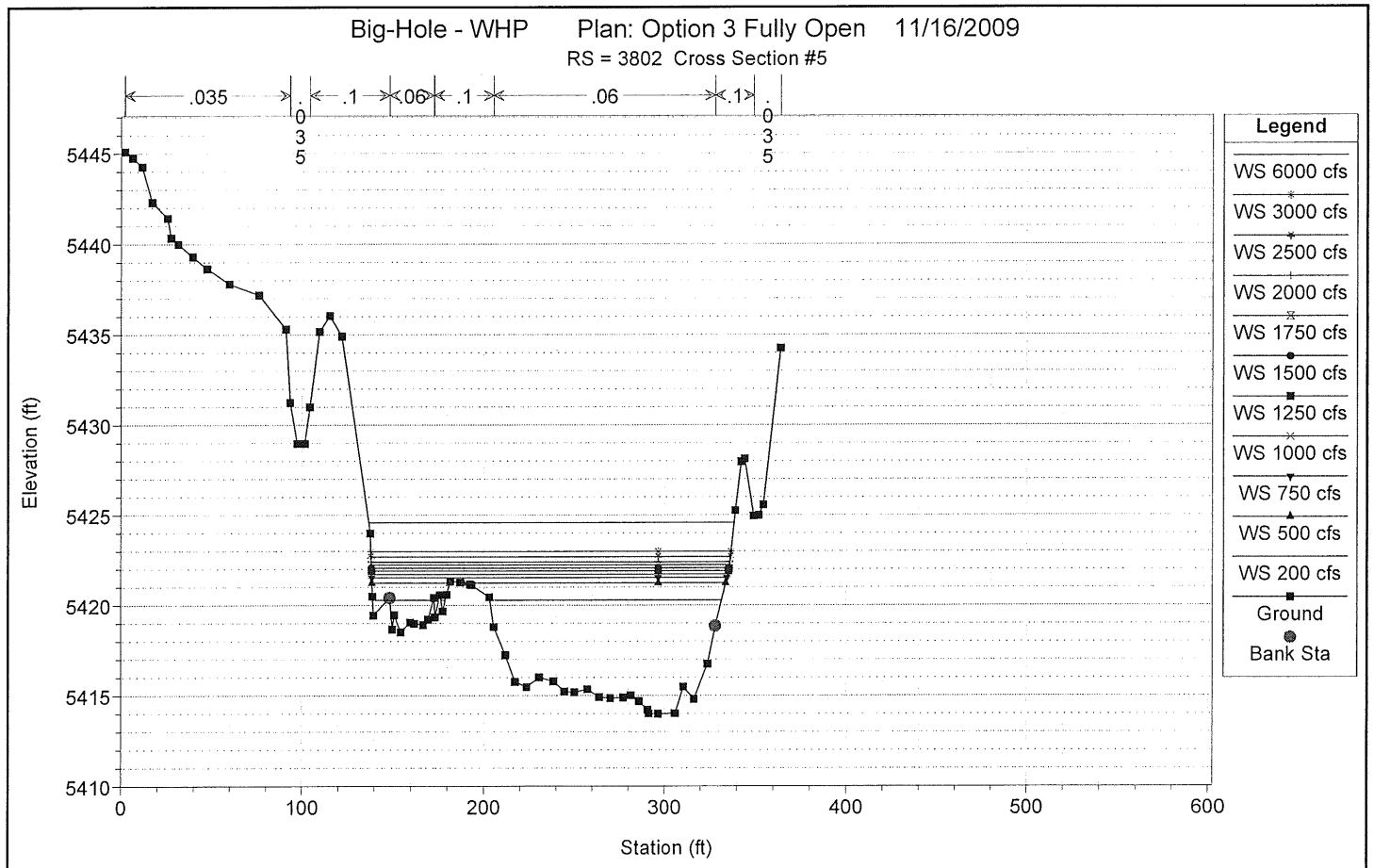


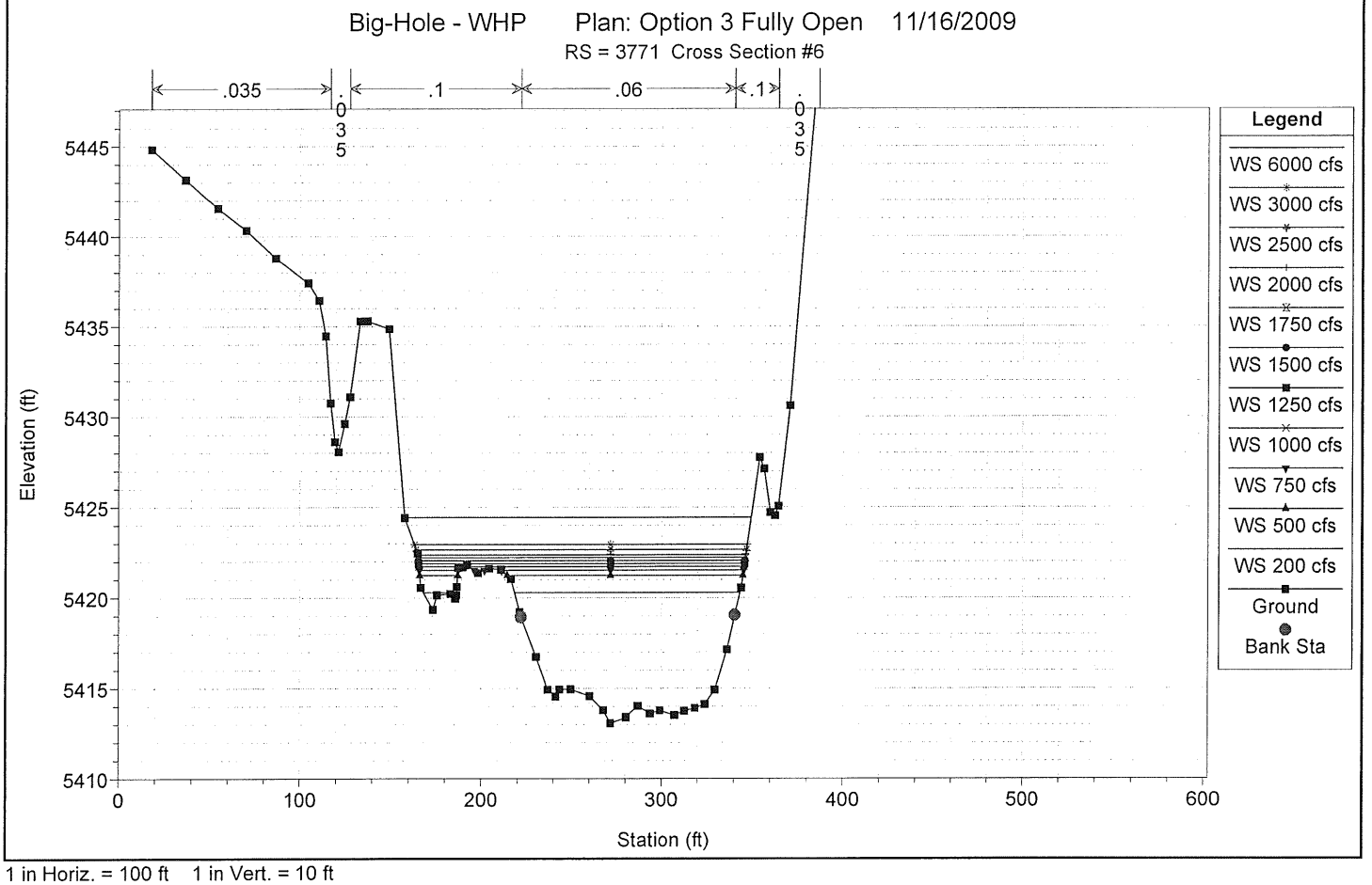
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft

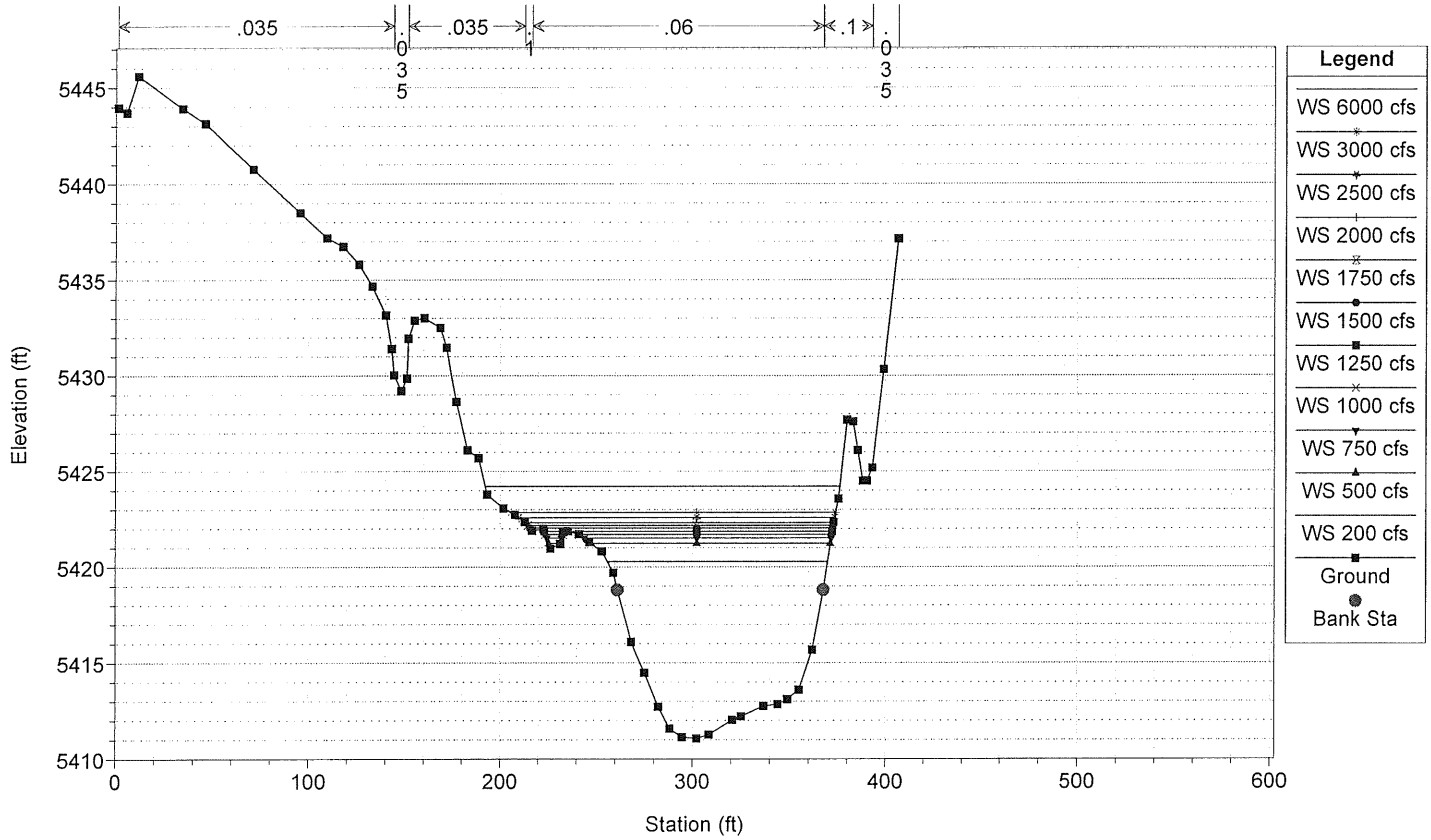




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

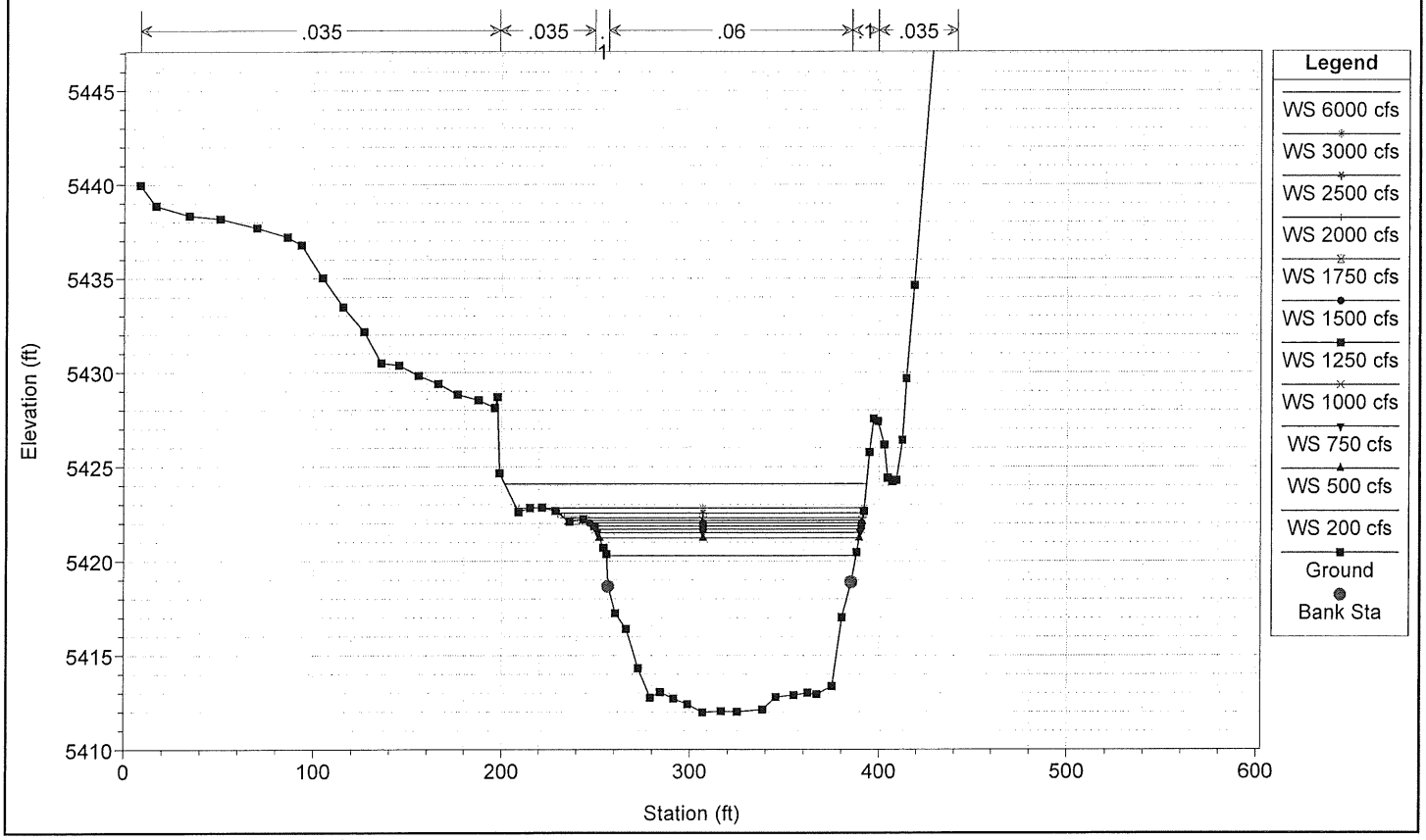
Big-Hole - WHP Plan: Option 3 Fully Open 11/16/2009

RS = 3642 Cross Section #7

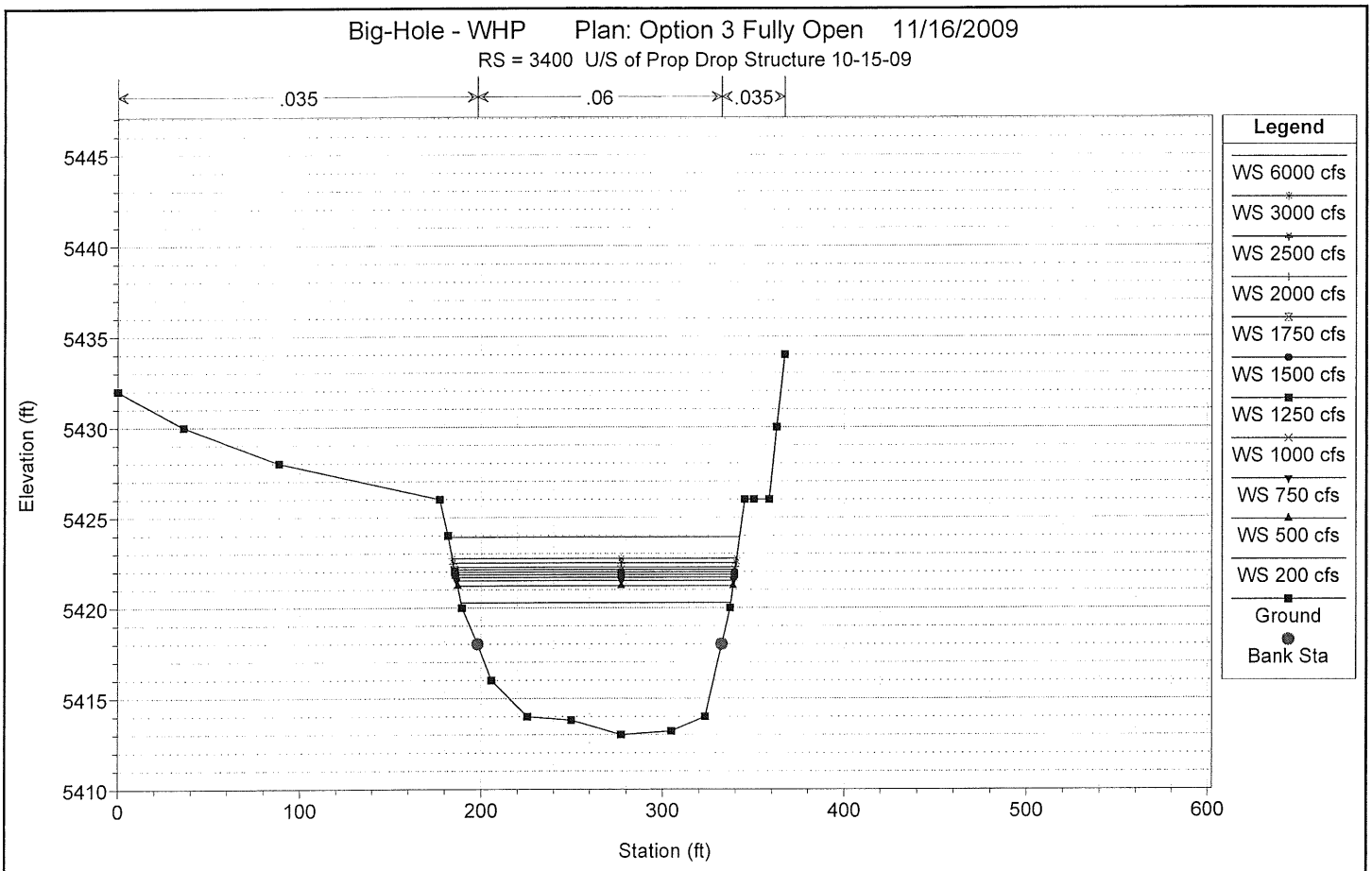


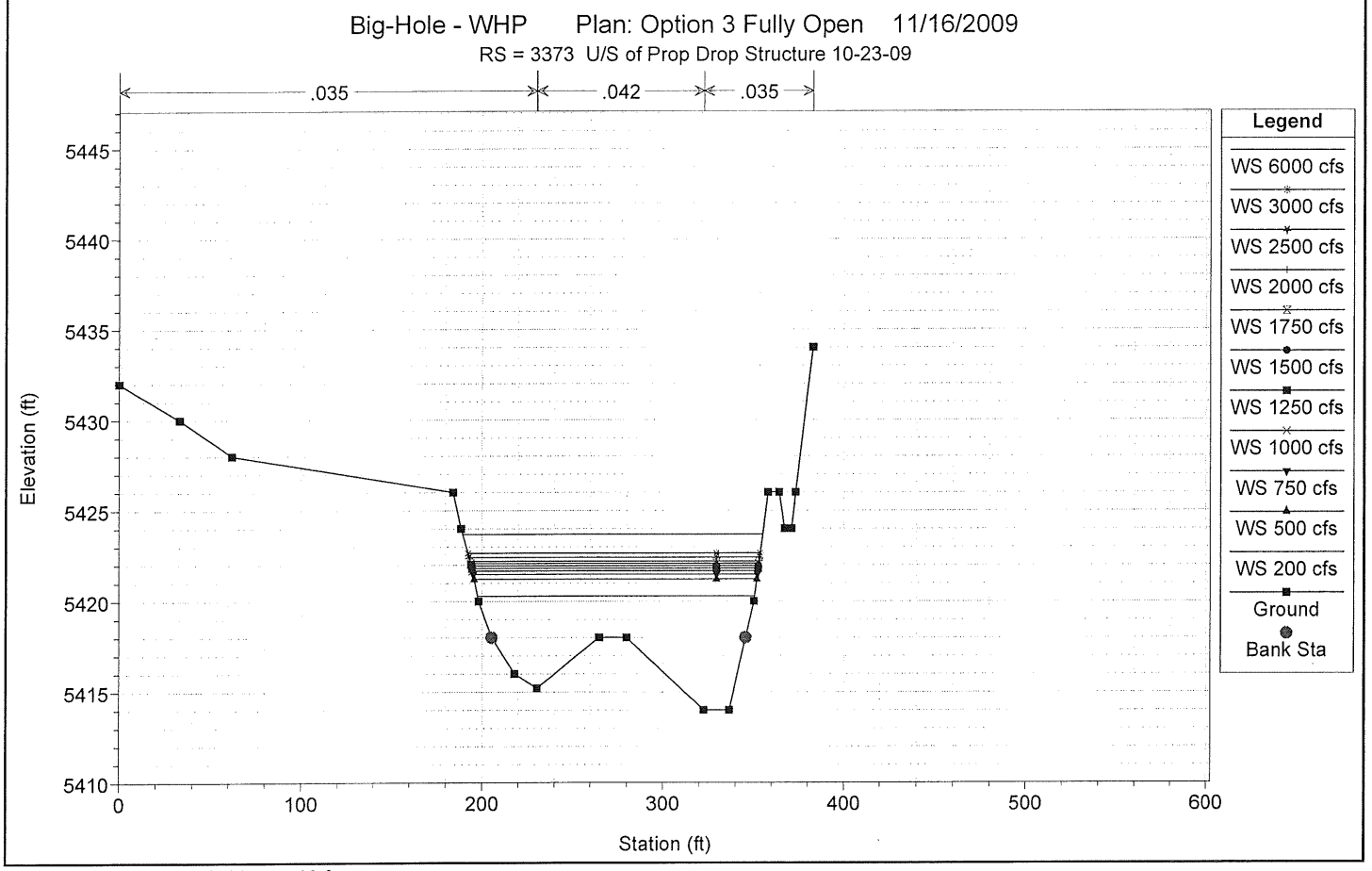
Big-Hole - WHP Plan: Option 3 Fully Open 11/16/2009

RS = 3518 Cross Section #8

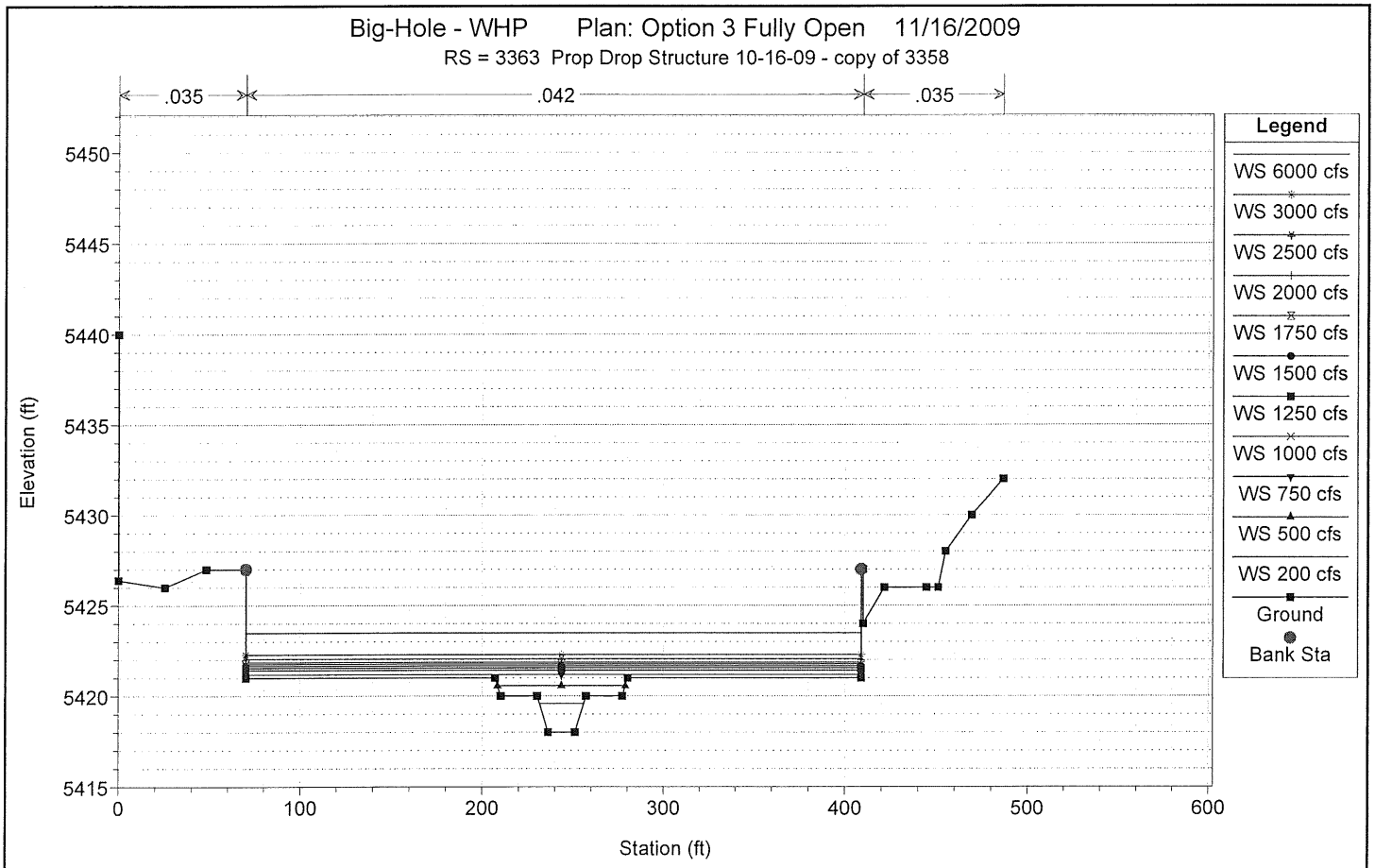


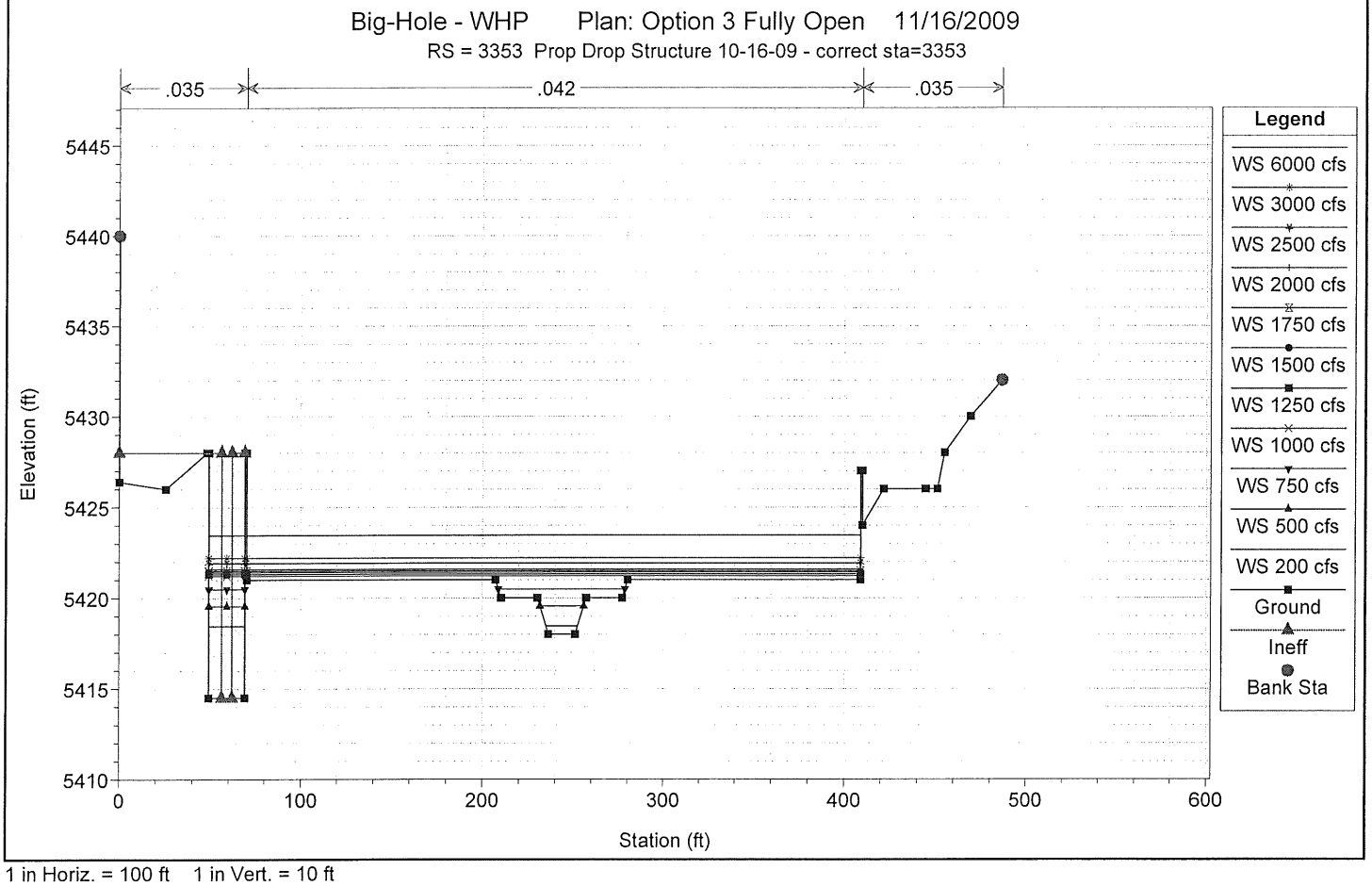
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



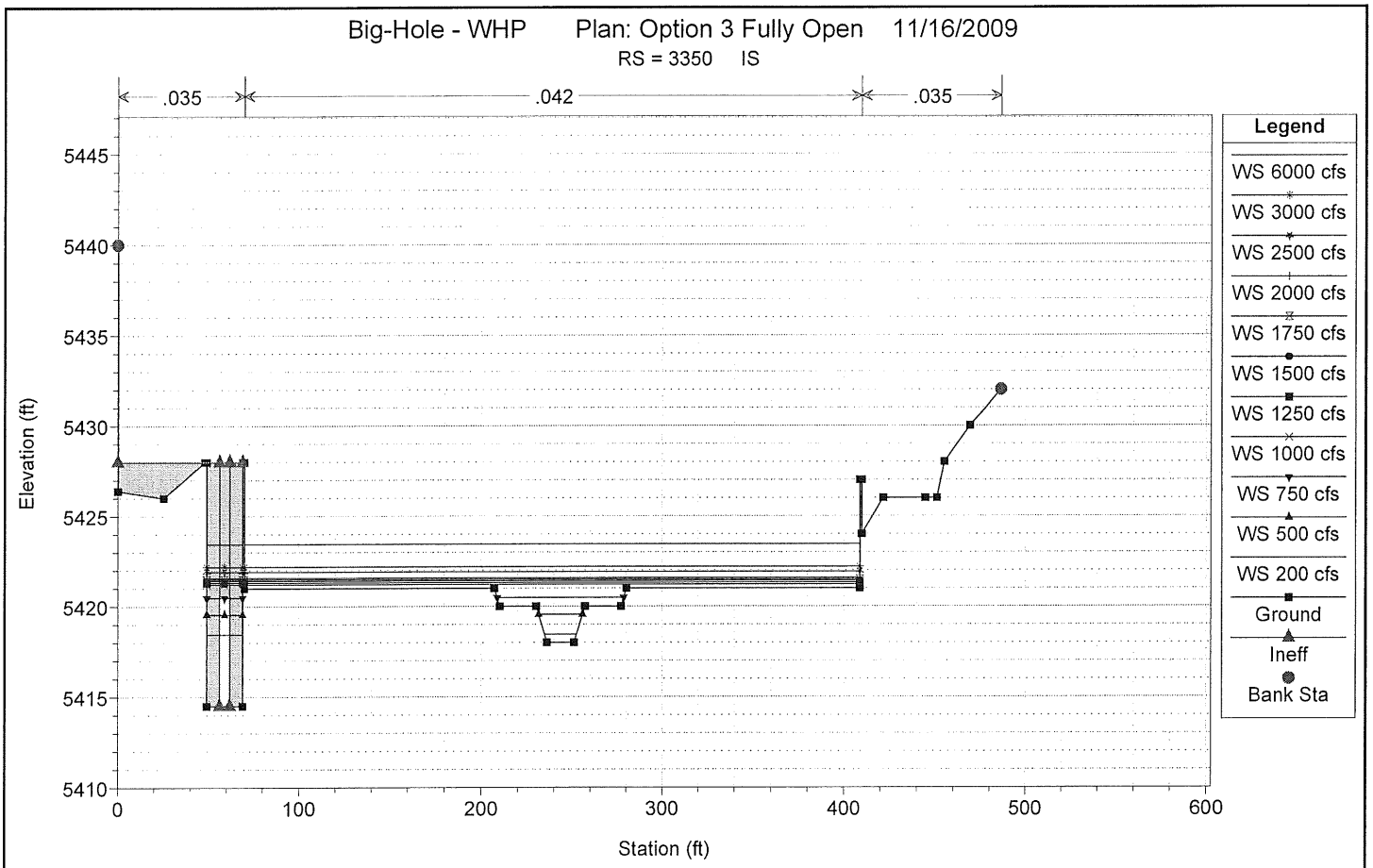


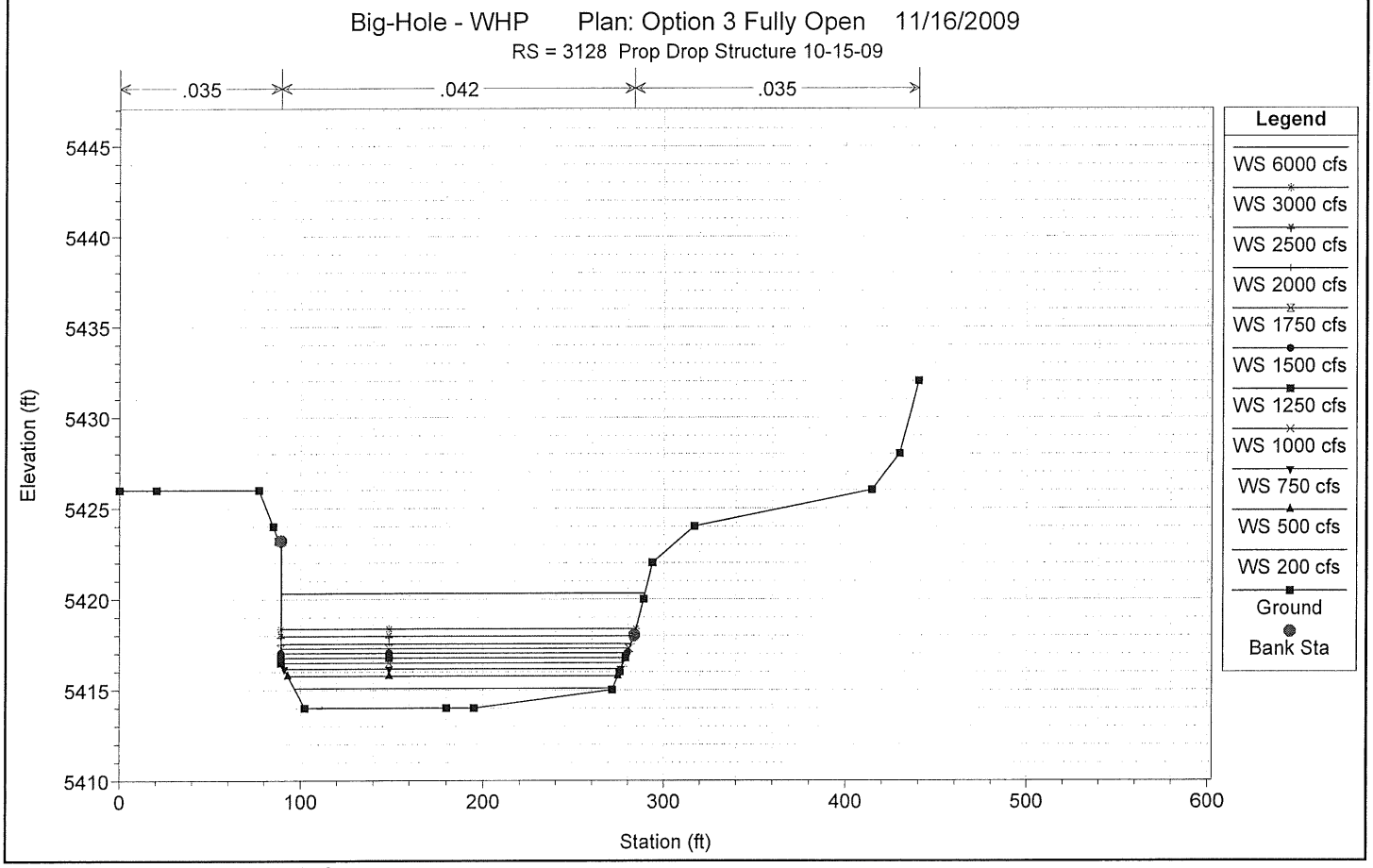
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



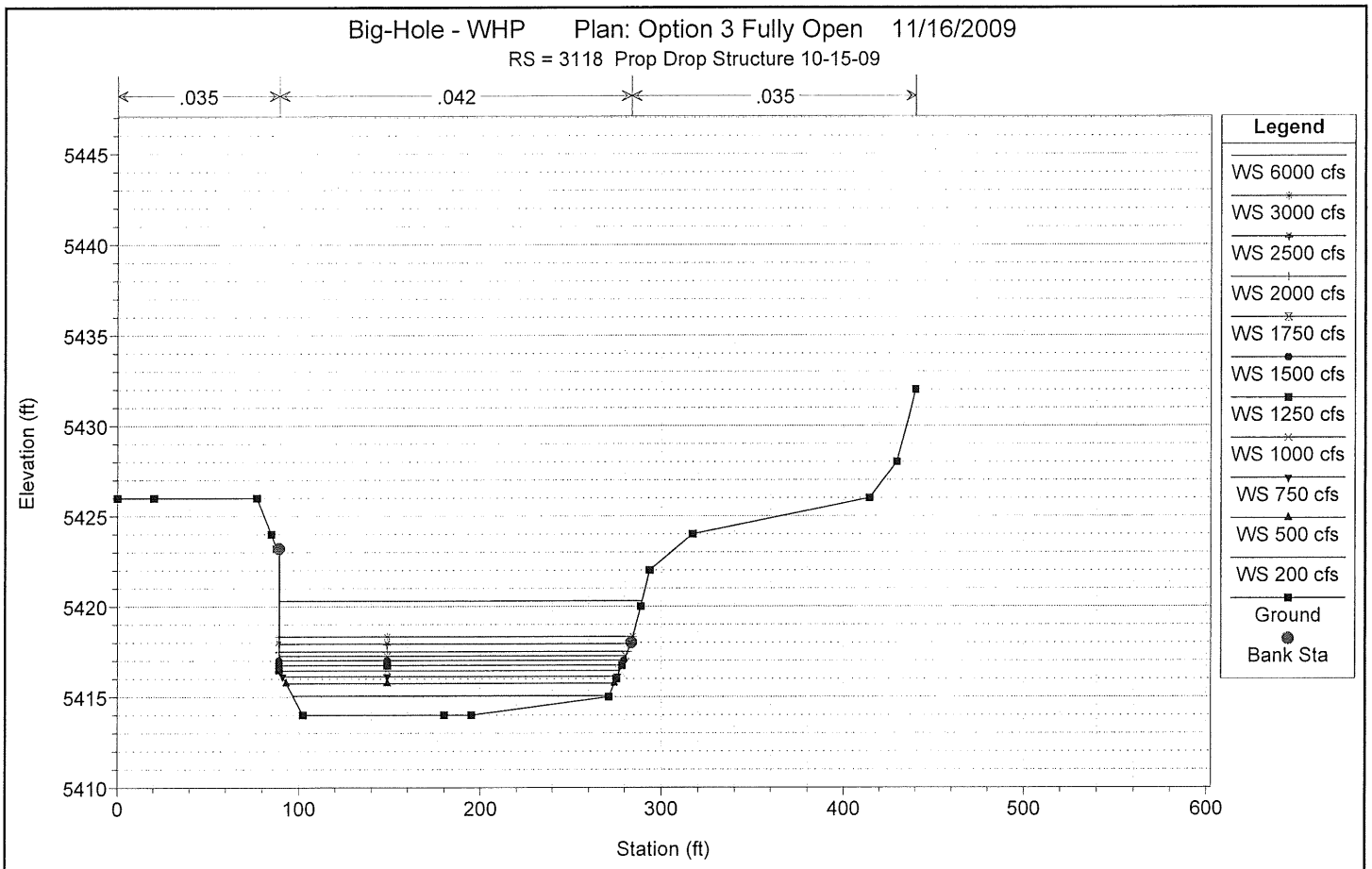


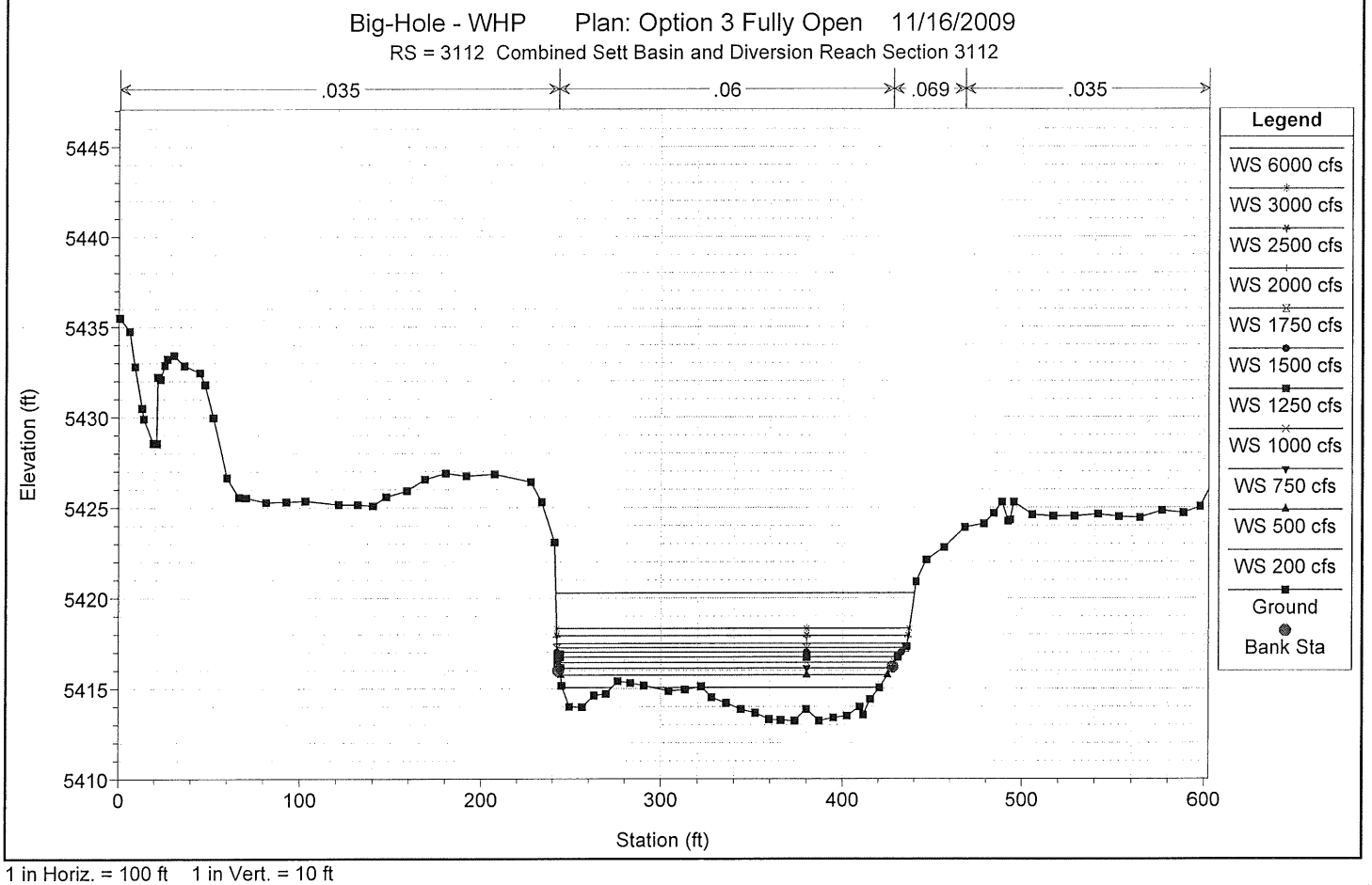
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



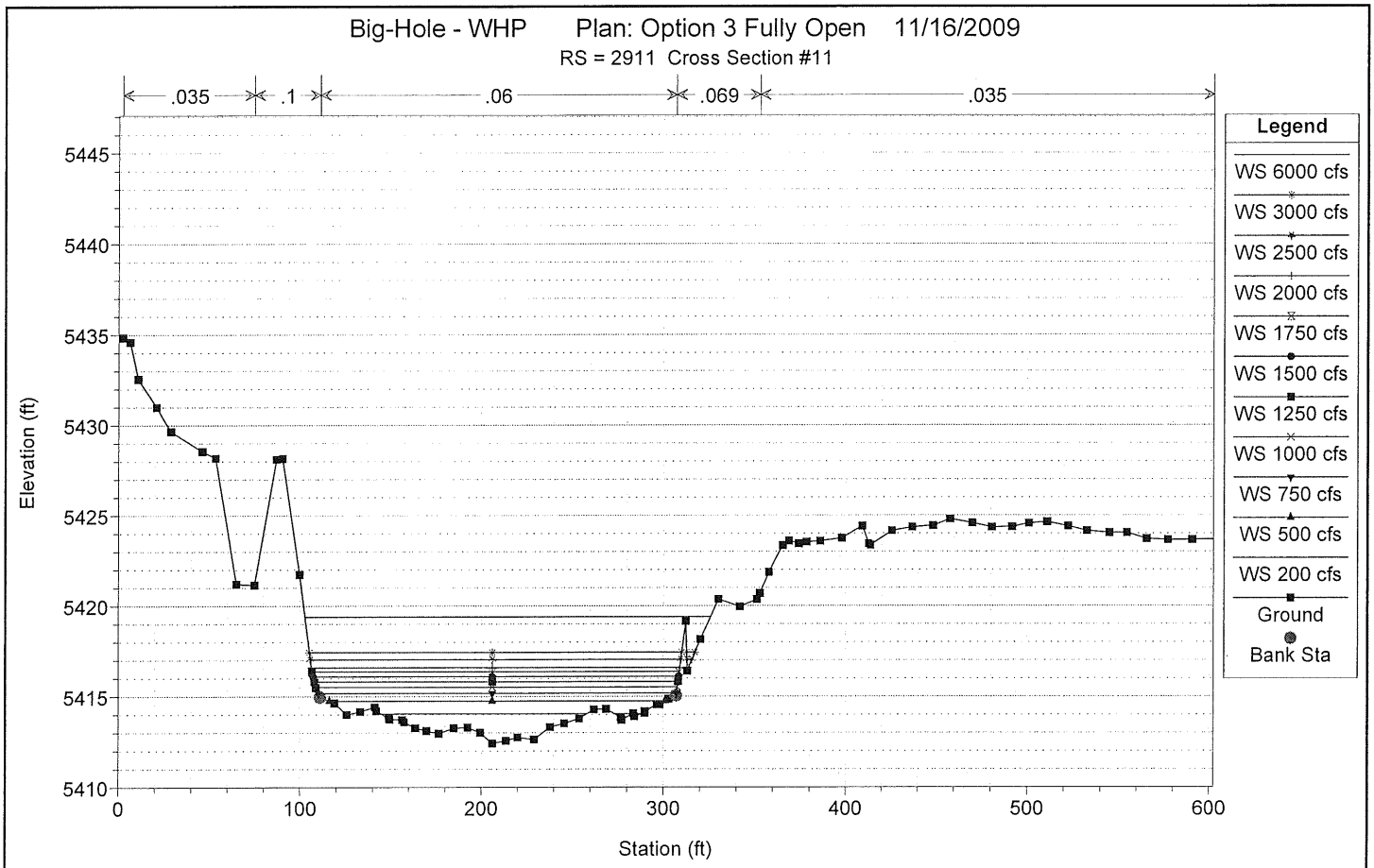


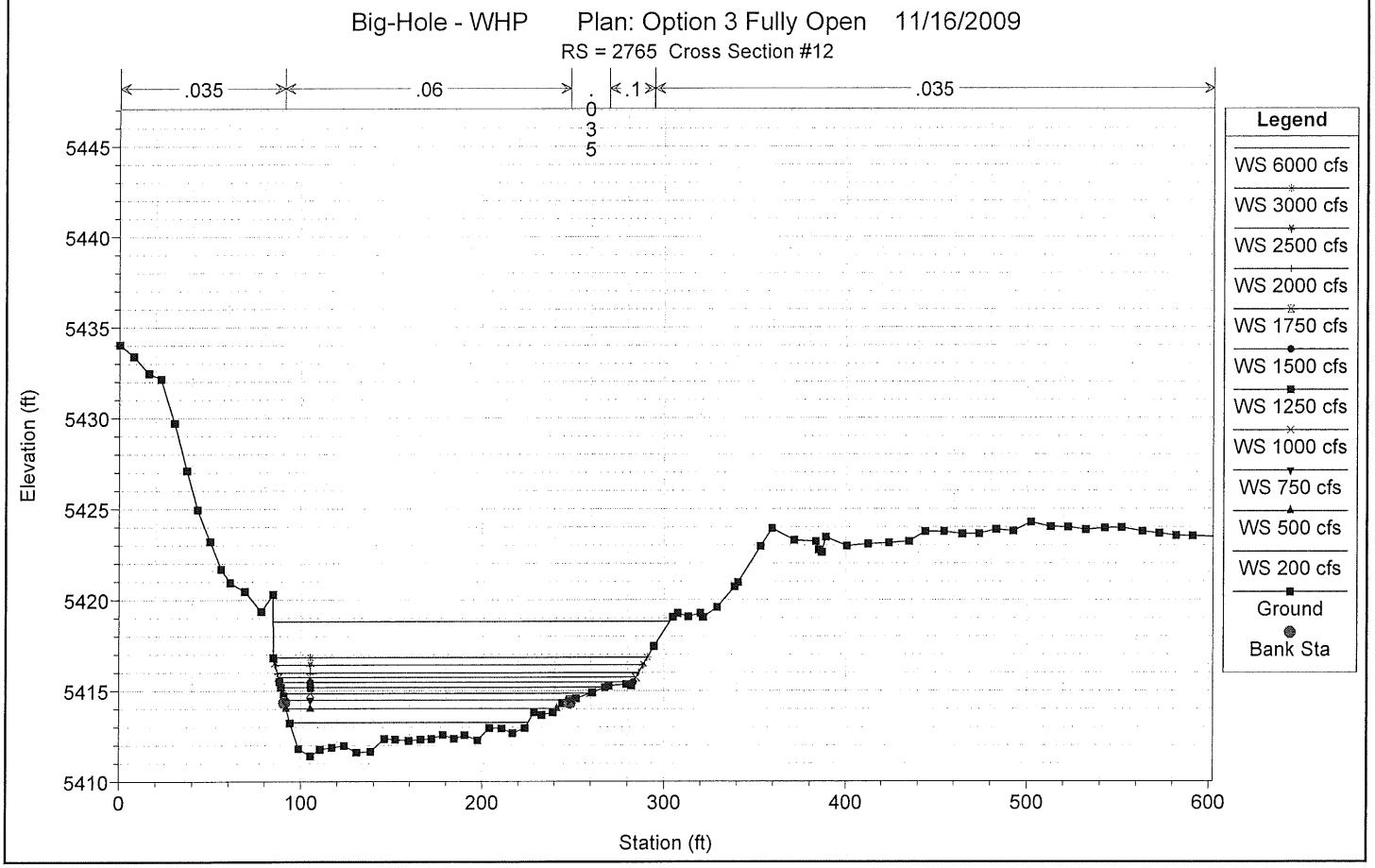
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



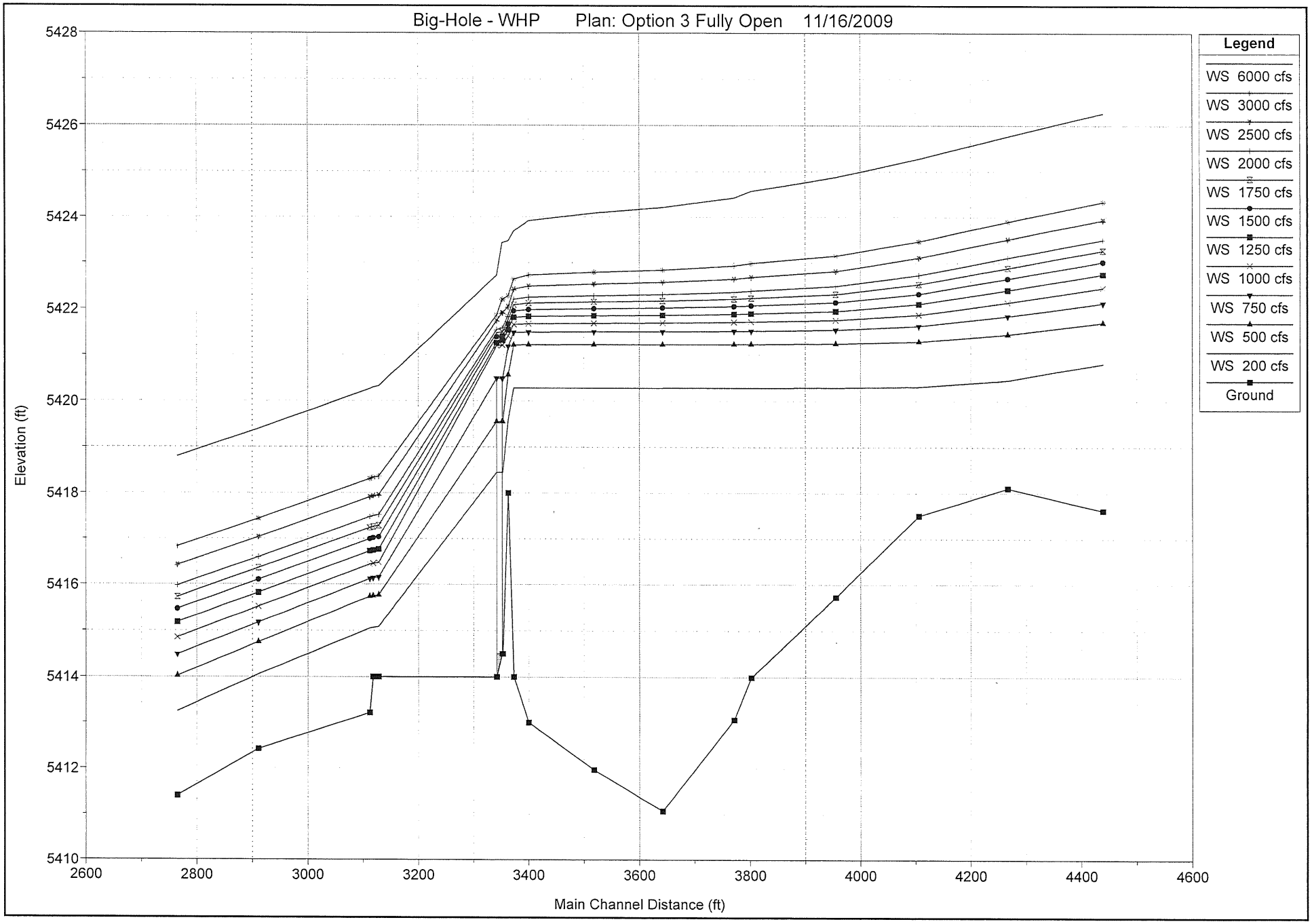


1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft


Big-Hole - WHP Plan: Option 3 Fully Open 11/16/2009
Elevation (ft)
5428
5426
5424
5422
5420
5418
5416
5414
5412
5410
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
Main Channel Distance (ft)
Legend
WS 6000 cfs
WS 3000 cfs
WS 2500 cfs
WS 2000 cfs
WS 1750 cfs
WS 1500 cfs
WS 1250 cfs
WS 1000 cfs
WS 750 cfs
WS 500 cfs
WS 200 cfs
Ground

14/14

OPTION 3

PROJECT: BIG HOLE - WHP
PLAN: OPTION 3 HALF OPEN (.p16)

GEOMETRY: OPTION 3 HALF OPEN (.g16)
FLOW: INTAKE STRUCTURE FLOWS (.f08)

HEC-RAS Plan: Op 3 Half River: Big Hole Reach: Upstream Chl

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	4439	200 cfs	200	5417.62	5420.8	5420.2	5420.85	0.005355	1.7	119.6	133.7	0.31
Upstream Chl	4439	500 cfs	500	5417.62	5421.7	5420.7	5421.75	0.003343	1.8	285.7	210.6	0.26
Upstream Chl	4439	750 cfs	750	5417.62	5422.1	5420.9	5422.19	0.003069	2.0	375.4	213.8	0.26
Upstream Chl	4439	1000 cfs	1000	5417.62	5422.5	5421.2	5422.53	0.003071	2.2	446.5	215.4	0.27
Upstream Chl	4439	1250 cfs	1250	5417.62	5422.7	5421.4	5422.84	0.003099	2.5	509.7	216.8	0.28
Upstream Chl	4439	1500 cfs	1500	5417.62	5423.0	5421.5	5423.13	0.003111	2.6	568.7	218.1	0.29
Upstream Chl	4439	1750 cfs	1750	5417.62	5423.3	5421.6	5423.40	0.003116	2.8	624.2	219.4	0.29
Upstream Chl	4439	2000 cfs	2000	5417.62	5423.5	5421.7	5423.65	0.003122	3.0	676.8	221.2	0.29
Upstream Chl	4439	2500 cfs	2500	5417.62	5424.0	5422.0	5424.12	0.003129	3.2	775.3	225.6	0.30
Upstream Chl	4439	3000 cfs	3000	5417.62	5424.4	5422.2	5424.54	0.003147	3.5	868.0	233.8	0.31
Upstream Chl	4439	6000 cfs	6000	5417.62	5426.3	5423.3	5426.61	0.003146	4.5	1333.3	249.5	0.33
Upstream Chl	4267	200 cfs	200	5418.11	5420.5	5419.2	5420.46	0.001198	0.9	216.0	191.8	0.15
Upstream Chl	4267	500 cfs	500	5418.11	5421.5	5419.7	5421.47	0.000902	1.2	423.4	213.0	0.15
Upstream Chl	4267	750 cfs	750	5418.11	5421.8	5420.0	5421.88	0.001118	1.5	507.6	215.7	0.17
Upstream Chl	4267	1000 cfs	1000	5418.11	5422.1	5420.2	5422.19	0.001349	1.8	571.4	217.2	0.19
Upstream Chl	4267	1250 cfs	1250	5418.11	5422.4	5420.4	5422.47	0.001540	2.0	629.3	218.5	0.20
Upstream Chl	4267	1500 cfs	1500	5418.11	5422.7	5420.6	5422.73	0.001689	2.2	684.3	219.9	0.22
Upstream Chl	4267	1750 cfs	1750	5418.11	5422.9	5420.7	5422.98	0.001807	2.4	737.1	221.3	0.23
Upstream Chl	4267	2000 cfs	2000	5418.11	5423.1	5420.8	5423.23	0.001906	2.6	787.5	222.2	0.24
Upstream Chl	4267	2500 cfs	2500	5418.11	5423.5	5421.1	5423.67	0.002068	2.9	881.5	223.7	0.25
Upstream Chl	4267	3000 cfs	3000	5418.11	5423.9	5421.3	5424.08	0.002203	3.2	967.8	225.0	0.26
Upstream Chl	4267	6000 cfs	6000	5418.11	5425.8	5422.4	5426.10	0.002725	4.4	1395.3	234.0	0.31
Upstream Chl	4106	200 cfs	200	5417.51	5420.3	5418.5	5420.32	0.000667	0.9	228.0	141.9	0.12
Upstream Chl	4106	500 cfs	500	5417.51	5421.3	5419.0	5421.32	0.001036	1.2	403.7	208.2	0.16
Upstream Chl	4106	750 cfs	750	5417.51	5421.6	5419.3	5421.67	0.001521	1.6	477.8	230.6	0.19
Upstream Chl	4106	1000 cfs	1000	5417.51	5421.9	5419.6	5421.93	0.001914	1.9	535.1	236.3	0.22
Upstream Chl	4106	1250 cfs	1250	5417.51	5422.1	5419.9	5422.17	0.002180	2.1	589.0	237.1	0.24
Upstream Chl	4106	1500 cfs	1500	5417.51	5422.3	5420.2	5422.41	0.002365	2.4	641.8	237.9	0.25
Upstream Chl	4106	1750 cfs	1750	5417.51	5422.5	5420.4	5422.64	0.002490	2.5	693.9	238.6	0.26
Upstream Chl	4106	2000 cfs	2000	5417.51	5422.8	5420.6	5422.87	0.002587	2.7	744.1	239.3	0.27
Upstream Chl	4106	2500 cfs	2500	5417.51	5423.2	5420.9	5423.29	0.002725	3.0	839.3	240.6	0.28
Upstream Chl	4106	3000 cfs	3000	5417.51	5423.5	5421.2	5423.68	0.002834	3.3	927.2	242.0	0.29
Upstream Chl	4106	6000 cfs	6000	5417.51	5425.3	5422.3	5425.63	0.003187	4.5	1378.9	260.7	0.33
Upstream Chl	3955	200 cfs	200	5415.73	5420.3	5417.0	5420.29	0.000083	0.5	432.2	162.6	0.05
Upstream Chl	3955	500 cfs	500	5415.73	5421.2	5417.7	5421.26	0.000198	0.8	593.7	176.2	0.08
Upstream Chl	3955	750 cfs	750	5415.73	5421.5	5418.1	5421.57	0.000342	1.2	647.8	180.8	0.11
Upstream Chl	3955	1000 cfs	1000	5415.73	5421.8	5418.4	5421.79	0.000512	1.5	685.8	183.8	0.13
Upstream Chl	3955	1250 cfs	1250	5415.73	5421.9	5418.6	5422.00	0.000687	1.8	721.5	187.3	0.15
Upstream Chl	3955	1500 cfs	1500	5415.73	5422.1	5418.8	5422.20	0.000856	2.0	757.8	191.5	0.17
Upstream Chl	3955	1750 cfs	1750	5415.73	5422.3	5419.0	5422.41	0.001012	2.2	794.9	196.0	0.19
Upstream Chl	3955	2000 cfs	2000	5415.73	5422.5	5419.1	5422.61	0.001159	2.4	831.8	201.7	0.21
Upstream Chl	3955	2500 cfs	2500	5415.73	5422.9	5419.4	5422.99	0.001430	2.8	910.5	233.0	0.25
Upstream Chl	3955	3000 cfs	3000	5415.73	5423.2	5419.7	5423.36	0.001626	3.1	990.5	240.4	0.26
Upstream Chl	3955	6000 cfs	6000	5415.73	5424.9	5421.1	5425.22	0.002224	4.4	1425.8	265.2	0.32
Upstream Chl	3802	200 cfs	200	5413.99	5420.3	5415.4	5420.29	0.000021	0.3	638.1	165.3	0.03
Upstream Chl	3802	500 cfs	500	5413.99	5421.2	5415.9	5421.24	0.000071	0.6	803.9	187.6	0.05
Upstream Chl	3802	750 cfs	750	5413.99	5421.5	5416.2	5421.54	0.000133	0.9	860.6	195.9	0.07
Upstream Chl	3802	1000 cfs	1000	5413.99	5421.7	5416.5	5421.74	0.000210	1.1	898.7	196.4	0.09
Upstream Chl	3802	1250 cfs	1250	5413.99	5421.9	5416.7	5421.92	0.000296	1.4	933.6	196.9	0.11
Upstream Chl	3802	1500 cfs	1500	5413.99	5422.1	5416.9	5422.11	0.000386	1.6	968.4	197.4	0.12
Upstream Chl	3802	1750 cfs	1750	5413.99	5422.2	5417.1	5422.30	0.000477	1.8	1003.4	197.6	0.14
Upstream Chl	3802	2000 cfs	2000	5413.99	5422.4	5417.3	5422.48	0.000568	2.0	1037.1	197.8	0.15
Upstream Chl	3802	2500 cfs	2500	5413.99	5422.7	5417.6	5422.83	0.000750	2.3	1101.5	198.3	0.17
Upstream Chl	3802	3000 cfs	3000	5413.99	5423.1	5418.0	5423.16	0.000927	2.7	1162.6	198.7	0.19
Upstream Chl	3802	6000 cfs	6000	5413.99	5424.6	5419.7	5424.91	0.001845	4.2	1479.0	201.7	0.27
Upstream Chl	3771	200 cfs	200	5413.06	5420.3	5414.4	5420.29	0.000015	0.3	676.4	143.3	0.02
Upstream Chl	3771	500 cfs	500	5413.06	5421.2	5415.0	5421.24	0.000055	0.6	815.5	151.6	0.04
Upstream Chl	3771	750 cfs	750	5413.06	5421.5	5415.3	5421.53	0.000106	0.9	860.5	161.2	0.06
Upstream Chl	3771	1000 cfs	1000	5413.06	5421.7	5415.6	5421.73	0.000172	1.2	893.0	176.9	0.08
Upstream Chl	3771	1250 cfs	1250	5413.06	5421.9	5415.8	5421.92	0.000246	1.4	924.1	180.6	0.09
Upstream Chl	3771	1500 cfs	1500	5413.06	5422.1	5416.0	5422.10	0.000326	1.7	955.2	181.0	0.11
Upstream Chl	3771	1750 cfs	1750	5413.06	5422.2	5416.3	5422.28	0.000409	1.9	986.4	181.4	0.12
Upstream Chl	3771	2000 cfs	2000	5413.06	5422.4	5416.5	5422.46	0.000494	2.1	1016.4	181.8	0.14
Upstream Chl	3771	2500 cfs	2500	5413.06	5422.7	5416.8	5422.81	0.000669	2.6	1073.6	183.2	0.16
Upstream Chl	3771	3000 cfs	3000	5413.06	5423.0	5417.2	5423.13	0.000846	2.9	1127.8	184.6	0.18
Upstream Chl	3771	6000 cfs	6000	5413.06	5424.5	5418.9	5424.84	0.001862	4.9	1408.3	191.9	0.27
Upstream Chl	3642	200 cfs	200	5411.07	5420.3	5412.4	5420.29	0.000009	0.3	759.9	113.8	0.02

11/16/09

HEC-RAS Plan: Op 3 Half River: Big Hole Reach: Upstream Chl (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3642	500 cfs	500	5411.07	5421.2	5413.2	5421.23	0.000035	0.6	871.4	129.8	0.04
Upstream Chl	3642	750 cfs	750	5411.07	5421.5	5413.6	5421.52	0.000071	0.8	909.3	135.7	0.05
Upstream Chl	3642	1000 cfs	1000	5411.07	5421.7	5413.9	5421.71	0.000116	1.1	934.7	139.4	0.07
Upstream Chl	3642	1250 cfs	1250	5411.07	5421.9	5414.2	5421.89	0.000170	1.3	958.4	147.6	0.08
Upstream Chl	3642	1500 cfs	1500	5411.07	5422.0	5414.4	5422.06	0.000229	1.6	983.4	156.7	0.09
Upstream Chl	3642	1750 cfs	1750	5411.07	5422.2	5414.7	5422.24	0.000292	1.8	1009.2	158.3	0.11
Upstream Chl	3642	2000 cfs	2000	5411.07	5422.3	5414.9	5422.41	0.000358	2.0	1034.0	159.8	0.12
Upstream Chl	3642	2500 cfs	2500	5411.07	5422.6	5415.4	5422.73	0.000498	2.4	1081.6	164.5	0.14
Upstream Chl	3642	3000 cfs	3000	5411.07	5422.9	5415.8	5423.03	0.000645	2.8	1127.5	169.6	0.16
Upstream Chl	3642	6000 cfs	6000	5411.07	5424.3	5417.7	5424.62	0.001551	4.8	1372.1	184.3	0.25
Upstream Chl	3518	200 cfs	200	5411.97	5420.3	5413.0	5420.28	0.000006	0.2	889.2	131.7	0.02
Upstream Chl	3518	500 cfs	500	5411.97	5421.2	5413.4	5421.23	0.000026	0.5	1015.1	137.1	0.03
Upstream Chl	3518	750 cfs	750	5411.97	5421.5	5413.7	5421.51	0.000053	0.7	1054.1	138.8	0.04
Upstream Chl	3518	1000 cfs	1000	5411.97	5421.7	5414.0	5421.70	0.000087	0.9	1079.4	139.8	0.06
Upstream Chl	3518	1250 cfs	1250	5411.97	5421.8	5414.2	5421.87	0.000127	1.1	1102.2	141.0	0.07
Upstream Chl	3518	1500 cfs	1500	5411.97	5422.0	5414.4	5422.03	0.000172	1.4	1124.8	143.8	0.08
Upstream Chl	3518	1750 cfs	1750	5411.97	5422.2	5414.7	5422.20	0.000220	1.5	1148.2	152.2	0.09
Upstream Chl	3518	2000 cfs	2000	5411.97	5422.3	5414.9	5422.36	0.000272	1.7	1171.7	158.2	0.10
Upstream Chl	3518	2500 cfs	2500	5411.97	5422.6	5415.2	5422.67	0.000381	2.1	1217.1	162.8	0.12
Upstream Chl	3518	3000 cfs	3000	5411.97	5422.9	5415.6	5422.96	0.000498	2.4	1262.4	184.4	0.14
Upstream Chl	3518	6000 cfs	6000	5411.97	5424.2	5417.3	5424.42	0.001233	4.2	1506.2	192.0	0.23
Upstream Chl	3400	200 cfs	200	5413.00	5420.3	5414.0	5420.28	0.000008	0.2	851.0	148.4	0.02
Upstream Chl	3400	500 cfs	500	5413.00	5421.2	5414.4	5421.22	0.000031	0.5	991.3	151.5	0.03
Upstream Chl	3400	750 cfs	750	5413.00	5421.5	5414.7	5421.51	0.000061	0.7	1033.7	152.4	0.05
Upstream Chl	3400	1000 cfs	1000	5413.00	5421.7	5414.9	5421.69	0.000100	1.0	1060.8	153.0	0.06
Upstream Chl	3400	1250 cfs	1250	5413.00	5421.8	5415.2	5421.85	0.000146	1.2	1084.8	153.5	0.07
Upstream Chl	3400	1500 cfs	1500	5413.00	5422.0	5415.4	5422.01	0.000196	1.4	1108.4	154.0	0.09
Upstream Chl	3400	1750 cfs	1750	5413.00	5422.1	5415.6	5422.18	0.000250	1.6	1132.1	154.5	0.10
Upstream Chl	3400	2000 cfs	2000	5413.00	5422.3	5415.8	5422.33	0.000306	1.8	1154.4	155.0	0.11
Upstream Chl	3400	2500 cfs	2500	5413.00	5422.6	5416.1	5422.62	0.000427	2.1	1196.3	155.9	0.13
Upstream Chl	3400	3000 cfs	3000	5413.00	5422.8	5416.4	5422.89	0.000555	2.5	1235.2	156.7	0.15
Upstream Chl	3400	6000 cfs	6000	5413.00	5424.0	5418.0	5424.27	0.001411	4.3	1423.8	160.5	0.24
Upstream Chl	3373	200 cfs	200	5414.00	5420.3	5415.5	5420.28	0.000012	0.3	585.2	152.9	0.03
Upstream Chl	3373	500 cfs	500	5414.00	5421.2	5416.3	5421.22	0.000039	0.7	729.1	156.0	0.06
Upstream Chl	3373	750 cfs	750	5414.00	5421.5	5416.7	5421.50	0.000073	1.0	772.1	157.0	0.08
Upstream Chl	3373	1000 cfs	1000	5414.00	5421.7	5417.0	5421.68	0.000116	1.3	799.1	157.5	0.10
Upstream Chl	3373	1250 cfs	1250	5414.00	5421.8	5417.3	5421.85	0.000166	1.6	822.8	158.0	0.12
Upstream Chl	3373	1500 cfs	1500	5414.00	5422.0	5417.5	5422.01	0.000219	1.8	845.9	158.5	0.13
Upstream Chl	3373	1750 cfs	1750	5414.00	5422.1	5417.8	5422.17	0.000274	2.1	869.1	159.1	0.15
Upstream Chl	3373	2000 cfs	2000	5414.00	5422.2	5418.0	5422.32	0.000331	2.3	890.7	159.6	0.17
Upstream Chl	3373	2500 cfs	2500	5414.00	5422.5	5418.4	5422.60	0.000450	2.8	931.0	160.7	0.19
Upstream Chl	3373	3000 cfs	3000	5414.00	5422.7	5418.6	5422.87	0.000573	3.2	968.0	161.6	0.22
Upstream Chl	3373	6000 cfs	6000	5414.00	5423.8	5420.1	5424.21	0.001374	5.4	1140.2	165.9	0.35
Upstream Chl	3363	200 cfs	200	5418.00	5419.6	5419.6	5420.22	0.024420	6.4	31.2	24.5	1.00
Upstream Chl	3363	500 cfs	500	5418.00	5420.6	5420.6	5421.16	0.026024	6.2	80.6	70.4	1.02
Upstream Chl	3363	750 cfs	750	5418.00	5421.2	5421.2	5421.47	0.037072	4.3	172.9	338.9	1.07
Upstream Chl	3363	1000 cfs	1000	5418.00	5421.4	5421.3	5421.66	0.018768	4.0	252.2	338.9	0.81
Upstream Chl	3363	1250 cfs	1250	5418.00	5421.5	5421.4	5421.82	0.018060	4.3	291.7	338.9	0.81
Upstream Chl	3363	1500 cfs	1500	5418.00	5421.7	5421.5	5421.97	0.015927	4.4	338.0	338.9	0.78
Upstream Chl	3363	1750 cfs	1750	5418.00	5421.8	5421.6	5422.13	0.013514	4.5	389.7	338.9	0.74
Upstream Chl	3363	2000 cfs	2000	5418.00	5422.0	5421.7	5422.28	0.012166	4.6	435.8	338.9	0.71
Upstream Chl	3363	2500 cfs	2500	5418.00	5422.2	5421.8	5422.57	0.010403	4.8	522.6	338.9	0.68
Upstream Chl	3363	3000 cfs	3000	5418.00	5422.5	5422.0	5422.83	0.009288	5.0	603.5	338.9	0.66
Upstream Chl	3363	6000 cfs	6000	5418.00	5423.6	5422.8	5424.18	0.007017	6.0	997.6	338.9	0.62
Upstream Chl	3353	200 cfs	200	5414.50	5419.4	5418.5	5419.59	0.001890	3.6	55.9	43.3	0.46
Upstream Chl	3353	500 cfs	500	5414.50	5420.5	5419.6	5420.82	0.003884	4.4	114.2	90.2	0.63
Upstream Chl	3353	750 cfs	750	5414.50	5420.7	5420.5	5421.24	0.006776	5.8	128.4	91.3	0.80
Upstream Chl	3353	1000 cfs	1000	5414.50	5421.2	5421.2	5421.52	0.009354	4.5	222.7	358.9	0.98
Upstream Chl	3353	1250 cfs	1250	5414.50	5421.4	5421.3	5421.68	0.009798	4.6	272.6	358.9	0.91
Upstream Chl	3353	1500 cfs	1500	5414.50	5421.6	5421.4	5421.86	0.008177	4.3	346.4	358.9	0.76
Upstream Chl	3353	1750 cfs	1750	5414.50	5421.7	5421.5	5422.03	0.007467	4.3	406.0	358.9	0.70
Upstream Chl	3353	2000 cfs	2000	5414.50	5421.9	5421.6	5422.18	0.007166	4.4	456.0	358.9	0.67
Upstream Chl	3353	2500 cfs	2500	5414.50	5422.2	5421.8	5422.48	0.006701	4.6	548.4	358.9	0.64
Upstream Chl	3353	3000 cfs	3000	5414.50	5422.4	5421.9	5422.75	0.006349	4.7	633.7	358.9	0.62
Upstream Chl	3353	6000 cfs	6000	5414.50	5423.6	5422.7	5424.10	0.005552	5.8	1042.2	358.9	0.58
Upstream Chl	3350		Inl Struct									

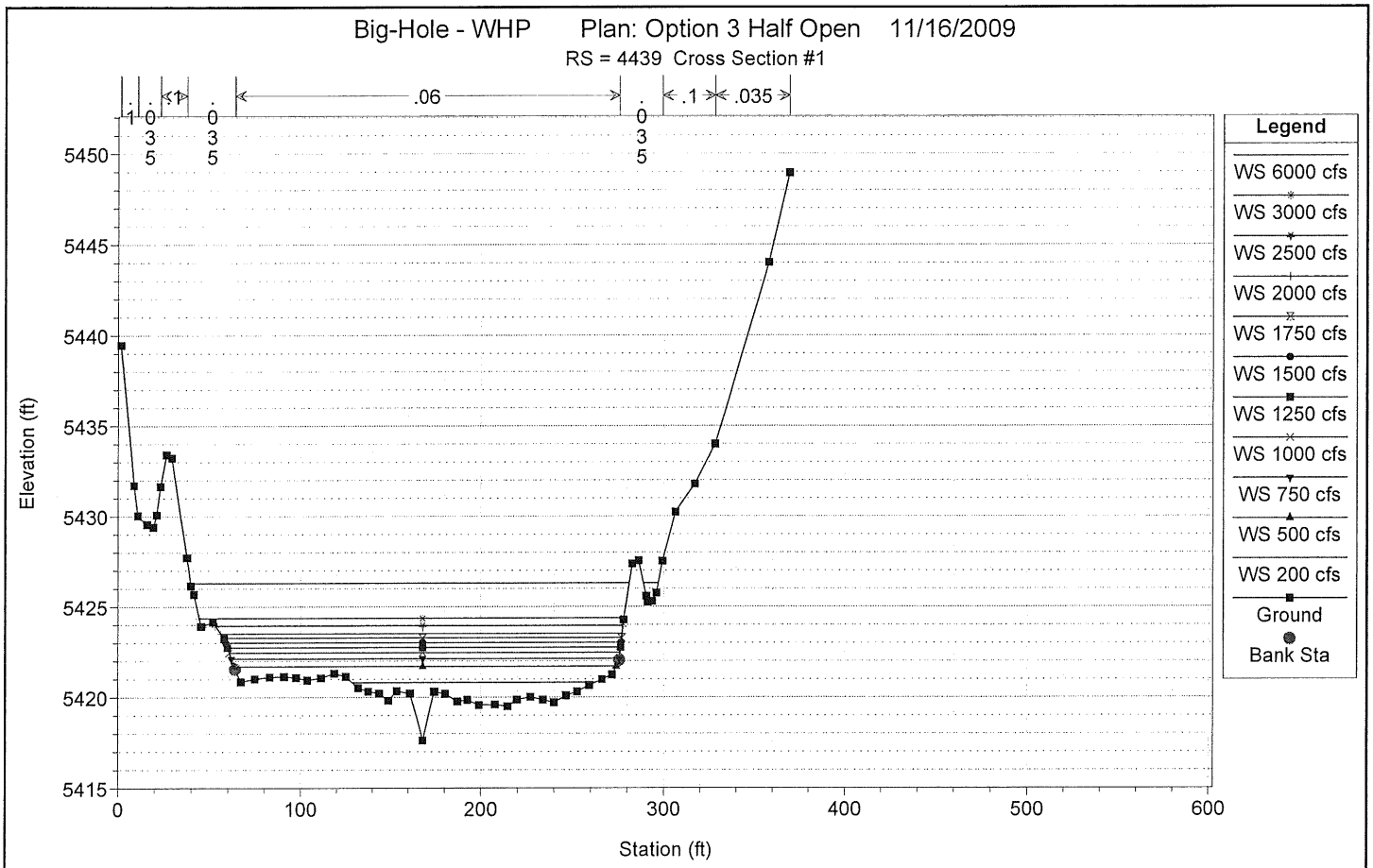
11/16/09

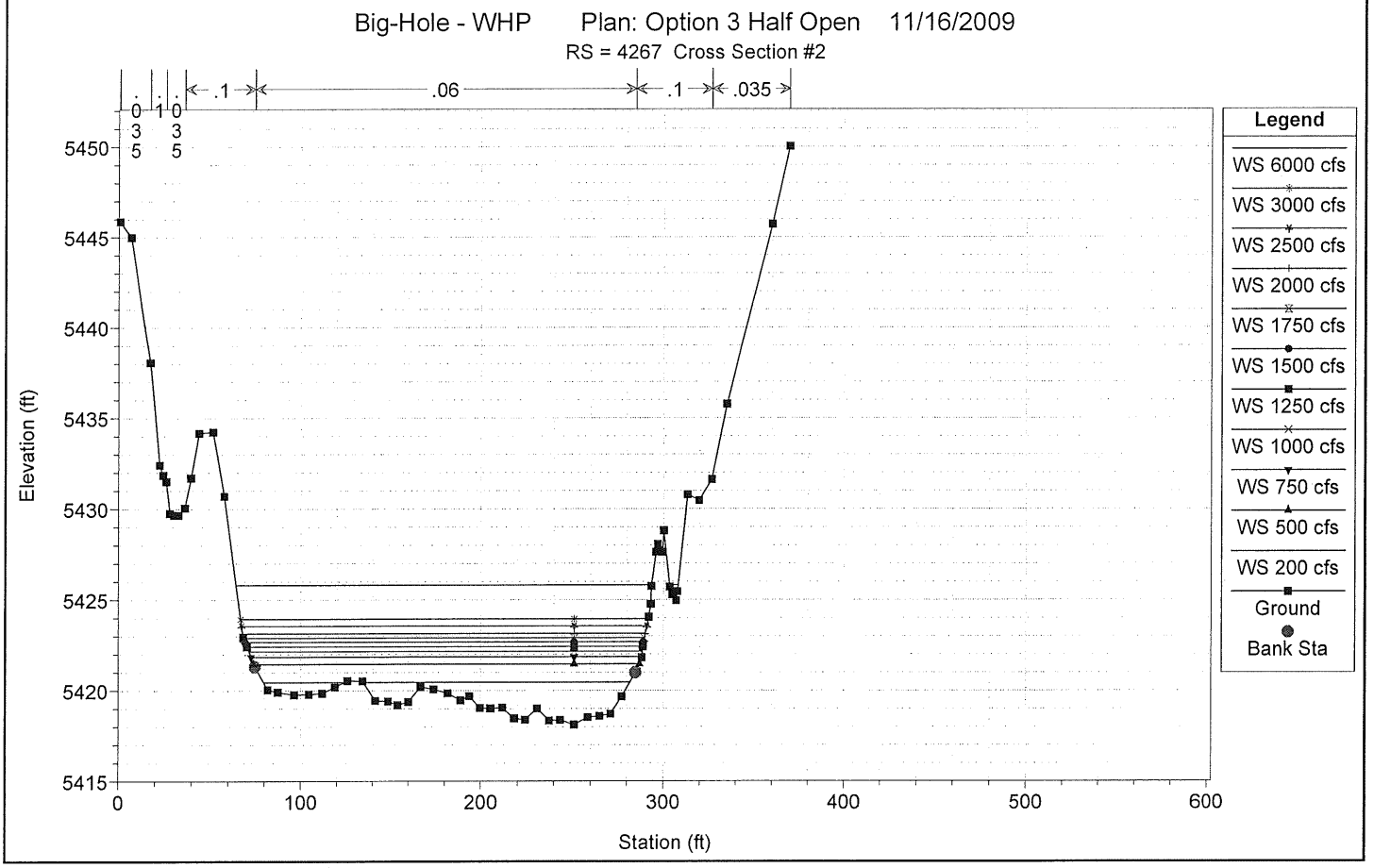
HEC-RAS Plan: Op 3 Half River: Big Hole Reach: Upstream Chl (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upstream Chl	3128	200 cfs	200	5414.00	5415.1	5414.5	5415.11	0.001817	1.3	148.2	175.0	0.26
Upstream Chl	3128	500 cfs	500	5414.00	5415.8	5414.8	5415.82	0.001611	1.9	270.3	181.5	0.27
Upstream Chl	3128	750 cfs	750	5414.00	5416.2	5415.1	5416.23	0.001715	2.2	341.1	185.1	0.29
Upstream Chl	3128	1000 cfs	1000	5414.00	5416.5	5415.2	5416.57	0.001821	2.5	400.7	188.1	0.30
Upstream Chl	3128	1250 cfs	1250	5414.00	5416.8	5415.4	5416.88	0.001872	2.7	455.9	189.4	0.31
Upstream Chl	3128	1500 cfs	1500	5414.00	5417.0	5415.6	5417.17	0.001910	3.0	507.0	190.5	0.32
Upstream Chl	3128	1750 cfs	1750	5414.00	5417.3	5415.7	5417.44	0.001942	3.2	554.9	191.6	0.33
Upstream Chl	3128	2000 cfs	2000	5414.00	5417.5	5415.8	5417.70	0.001970	3.3	600.2	192.5	0.33
Upstream Chl	3128	2500 cfs	2500	5414.00	5418.0	5416.1	5418.17	0.002017	3.7	684.5	194.3	0.34
Upstream Chl	3128	3000 cfs	3000	5414.00	5418.4	5416.3	5418.60	0.002035	3.9	762.6	195.4	0.35
Upstream Chl	3128	6000 cfs	6000	5414.00	5420.3	5417.5	5420.75	0.002123	5.2	1151.0	200.5	0.38
Upstream Chl	3118	200 cfs	200	5414.00	5415.1	5414.5	5415.09	0.001969	1.4	144.6	174.8	0.27
Upstream Chl	3118	500 cfs	500	5414.00	5415.8	5414.8	5415.81	0.001676	1.9	267.0	181.3	0.27
Upstream Chl	3118	750 cfs	750	5414.00	5416.1	5415.1	5416.21	0.001774	2.2	337.4	184.9	0.29
Upstream Chl	3118	1000 cfs	1000	5414.00	5416.5	5415.2	5416.55	0.001880	2.5	396.7	187.9	0.31
Upstream Chl	3118	1250 cfs	1250	5414.00	5416.7	5415.4	5416.86	0.001929	2.8	451.7	189.4	0.32
Upstream Chl	3118	1500 cfs	1500	5414.00	5417.0	5415.6	5417.15	0.001963	3.0	502.7	190.5	0.32
Upstream Chl	3118	1750 cfs	1750	5414.00	5417.3	5415.7	5417.42	0.001993	3.2	550.5	191.5	0.33
Upstream Chl	3118	2000 cfs	2000	5414.00	5417.5	5415.8	5417.67	0.002018	3.4	595.6	192.4	0.34
Upstream Chl	3118	2500 cfs	2500	5414.00	5417.9	5416.1	5418.15	0.002061	3.7	679.9	194.2	0.35
Upstream Chl	3118	3000 cfs	3000	5414.00	5418.3	5416.3	5418.58	0.002077	4.0	757.9	195.4	0.35
Upstream Chl	3118	6000 cfs	6000	5414.00	5420.3	5417.5	5420.72	0.002155	5.3	1145.7	200.4	0.38
Upstream Chl	3112	200 cfs	200	5413.21	5415.1	5414.1	5415.08	0.002991	1.3	148.5	149.3	0.24
Upstream Chl	3112	500 cfs	500	5413.21	5415.7	5414.6	5415.79	0.003448	1.9	266.2	180.5	0.27
Upstream Chl	3112	750 cfs	750	5413.21	5416.1	5414.9	5416.20	0.003657	2.2	336.0	183.5	0.29
Upstream Chl	3112	1000 cfs	1000	5413.21	5416.4	5415.2	5416.54	0.003851	2.5	394.4	186.0	0.31
Upstream Chl	3112	1250 cfs	1250	5413.21	5416.7	5415.4	5416.85	0.003955	2.8	448.7	187.9	0.32
Upstream Chl	3112	1500 cfs	1500	5413.21	5417.0	5415.5	5417.14	0.004025	3.0	499.3	190.3	0.32
Upstream Chl	3112	1750 cfs	1750	5413.21	5417.2	5415.7	5417.40	0.004071	3.2	546.9	192.5	0.33
Upstream Chl	3112	2000 cfs	2000	5413.21	5417.5	5415.8	5417.66	0.004108	3.4	592.2	193.4	0.34
Upstream Chl	3112	2500 cfs	2500	5413.21	5417.9	5416.1	5418.13	0.004166	3.7	676.3	194.2	0.35
Upstream Chl	3112	3000 cfs	3000	5413.21	5418.3	5416.3	5418.56	0.004211	4.0	753.9	194.9	0.35
Upstream Chl	3112	6000 cfs	6000	5413.21	5420.3	5417.5	5420.70	0.004410	5.4	1137.7	198.4	0.39
Upstream Chl	2911	200 cfs	200	5412.42	5414.1	5413.6	5414.11	0.008912	2.0	101.6	131.3	0.39
Upstream Chl	2911	500 cfs	500	5412.42	5414.7	5414.0	5414.83	0.007006	2.3	216.9	184.7	0.37
Upstream Chl	2911	750 cfs	750	5412.42	5415.2	5414.3	5415.27	0.005922	2.5	298.0	197.0	0.36
Upstream Chl	2911	1000 cfs	1000	5412.42	5415.5	5414.5	5415.63	0.005343	2.7	365.9	198.8	0.35
Upstream Chl	2911	1250 cfs	1250	5412.42	5415.8	5414.7	5415.95	0.005018	2.9	427.0	200.0	0.35
Upstream Chl	2911	1500 cfs	1500	5412.42	5416.1	5414.8	5416.25	0.004823	3.1	482.9	201.0	0.35
Upstream Chl	2911	1750 cfs	1750	5412.42	5416.4	5415.0	5416.52	0.004711	3.3	534.4	202.0	0.35
Upstream Chl	2911	2000 cfs	2000	5412.42	5416.6	5415.1	5416.78	0.004634	3.5	582.8	203.5	0.36
Upstream Chl	2911	2500 cfs	2500	5412.42	5417.0	5415.4	5417.25	0.004539	3.8	672.9	206.5	0.36
Upstream Chl	2911	3000 cfs	3000	5412.42	5417.4	5415.6	5417.69	0.004476	4.0	756.7	209.3	0.36
Upstream Chl	2911	6000 cfs	6000	5412.42	5419.4	5416.7	5419.81	0.004381	5.2	1179.3	223.0	0.39
Upstream Chl	2765	200 cfs	200	5411.40	5413.2	5412.6	5413.28	0.003899	1.5	130.4	131.7	0.27
Upstream Chl	2765	500 cfs	500	5411.40	5414.0	5413.0	5414.08	0.003899	2.1	237.9	149.6	0.29
Upstream Chl	2765	750 cfs	750	5411.40	5414.5	5413.2	5414.57	0.003904	2.4	309.6	159.6	0.30
Upstream Chl	2765	1000 cfs	1000	5411.40	5414.9	5413.5	5414.97	0.003904	2.7	370.4	169.8	0.31
Upstream Chl	2765	1250 cfs	1250	5411.40	5415.2	5413.7	5415.31	0.003904	3.0	426.9	178.7	0.32
Upstream Chl	2765	1500 cfs	1500	5411.40	5415.5	5413.9	5415.62	0.003902	3.2	481.2	195.0	0.33
Upstream Chl	2765	1750 cfs	1750	5411.40	5415.7	5414.0	5415.90	0.003904	3.4	532.6	197.2	0.33
Upstream Chl	2765	2000 cfs	2000	5411.40	5416.0	5414.2	5416.16	0.003902	3.5	581.2	199.2	0.33
Upstream Chl	2765	2500 cfs	2500	5411.40	5416.4	5414.5	5416.64	0.003908	3.8	671.0	202.9	0.34
Upstream Chl	2765	3000 cfs	3000	5411.40	5416.8	5414.8	5417.08	0.003901	4.1	754.8	206.2	0.35
Upstream Chl	2765	6000 cfs	6000	5411.40	5418.8	5416.1	5419.21	0.003907	5.3	1172.8	218.5	0.37

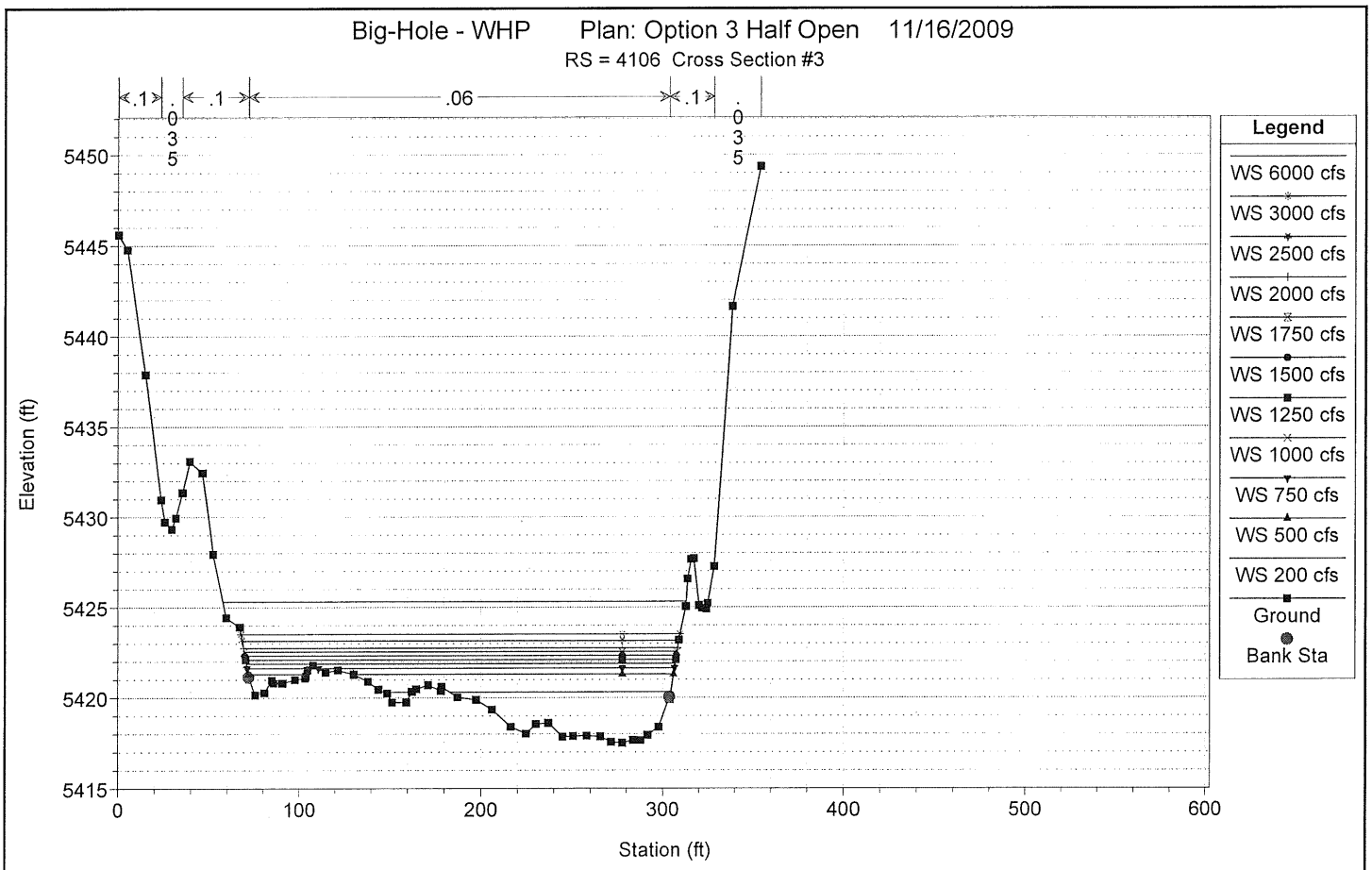
HEC-RAS Plan: Op 3 Half River: Big Hole Reach: Upstream Chl

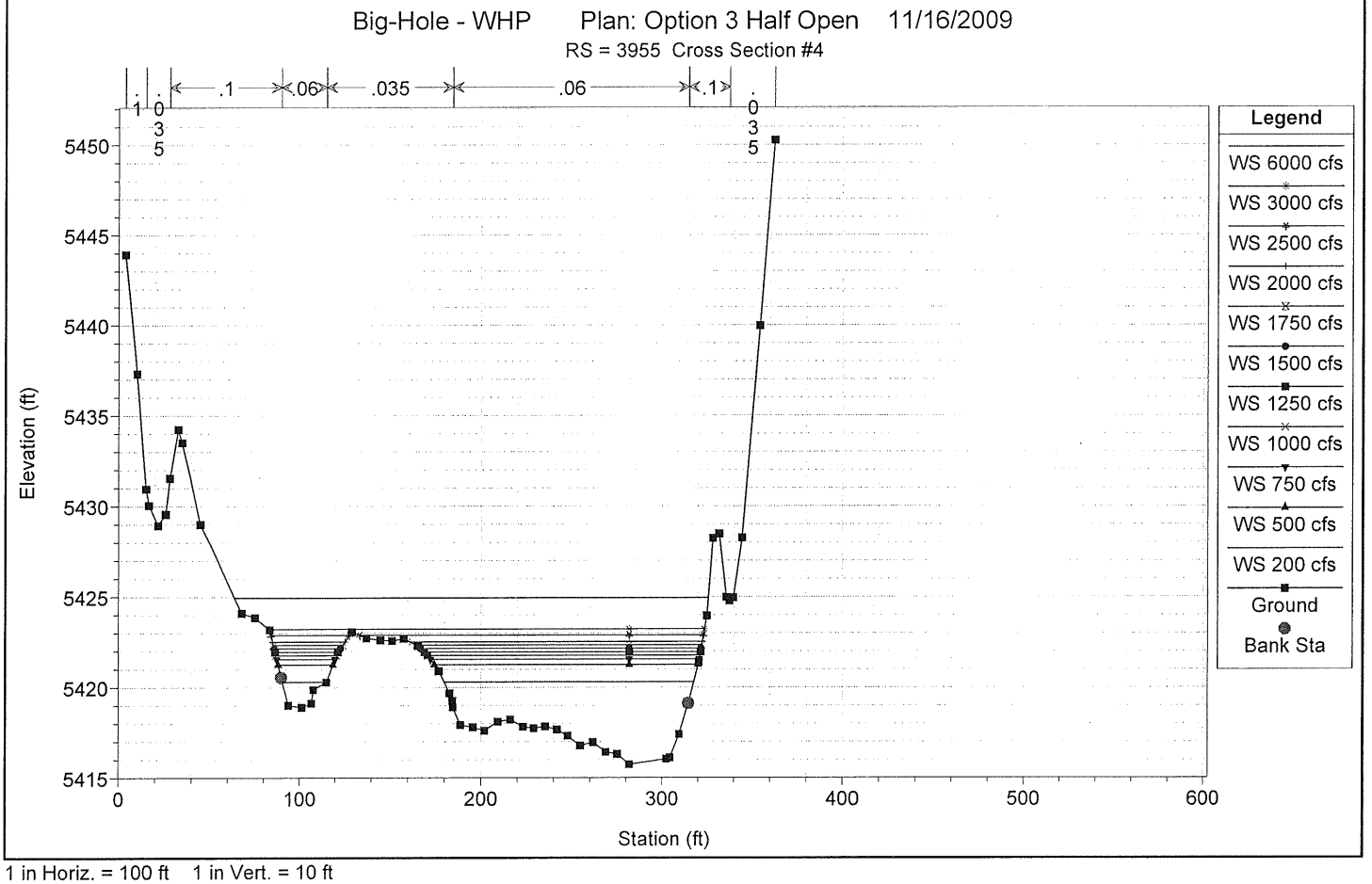
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Q Total	Q Weir	Q Gates
			(ft)	(ft)	(cfs)	(cfs)	(cfs)
Upstream Chl	3350	200 cfs	5419.59	5419.39	200.00	96.84	103.16
Upstream Chl	3350	500 cfs	5420.82	5420.53	500.00	348.48	151.52
Upstream Chl	3350	750 cfs	5421.24	5420.71	750.00	577.29	172.71
Upstream Chl	3350	1000 cfs	5421.52	5421.21	1000.00	825.16	174.84
Upstream Chl	3350	1250 cfs	5421.68	5421.35	1250.00	1060.98	189.02
Upstream Chl	3350	1500 cfs	5421.86	5421.57	1500.00	1305.33	194.67
Upstream Chl	3350	1750 cfs	5422.03	5421.74	1750.00	1552.08	197.92
Upstream Chl	3350	2000 cfs	5422.18	5421.88	2000.00	1799.62	200.38
Upstream Chl	3350	2500 cfs	5422.48	5422.15	2500.00	2295.86	204.14
Upstream Chl	3350	3000 cfs	5422.75	5422.40	3000.00	2792.86	207.14
Upstream Chl	3350	6000 cfs	5424.10	5423.58	6000.00	5776.26	223.74



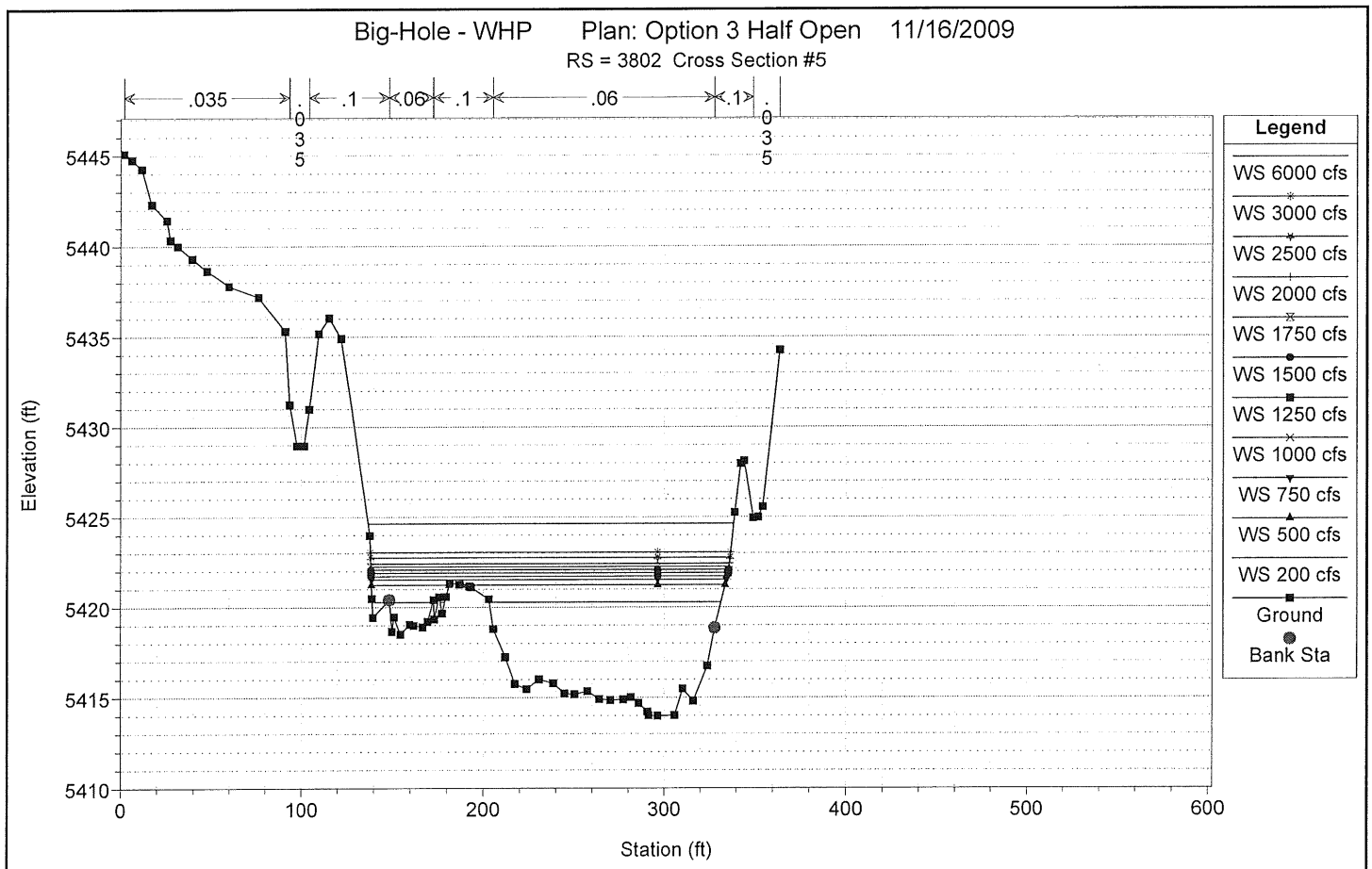


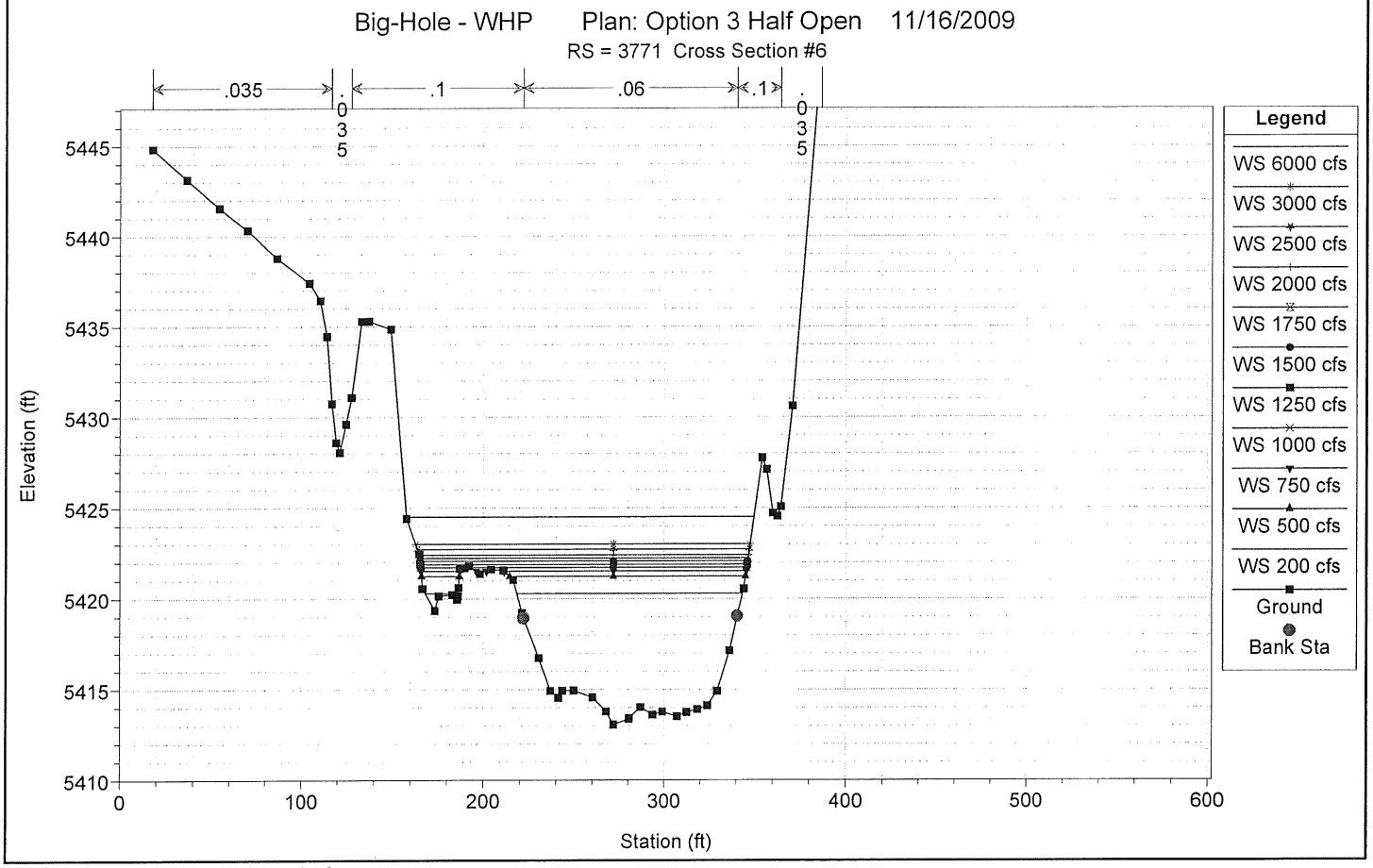
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft

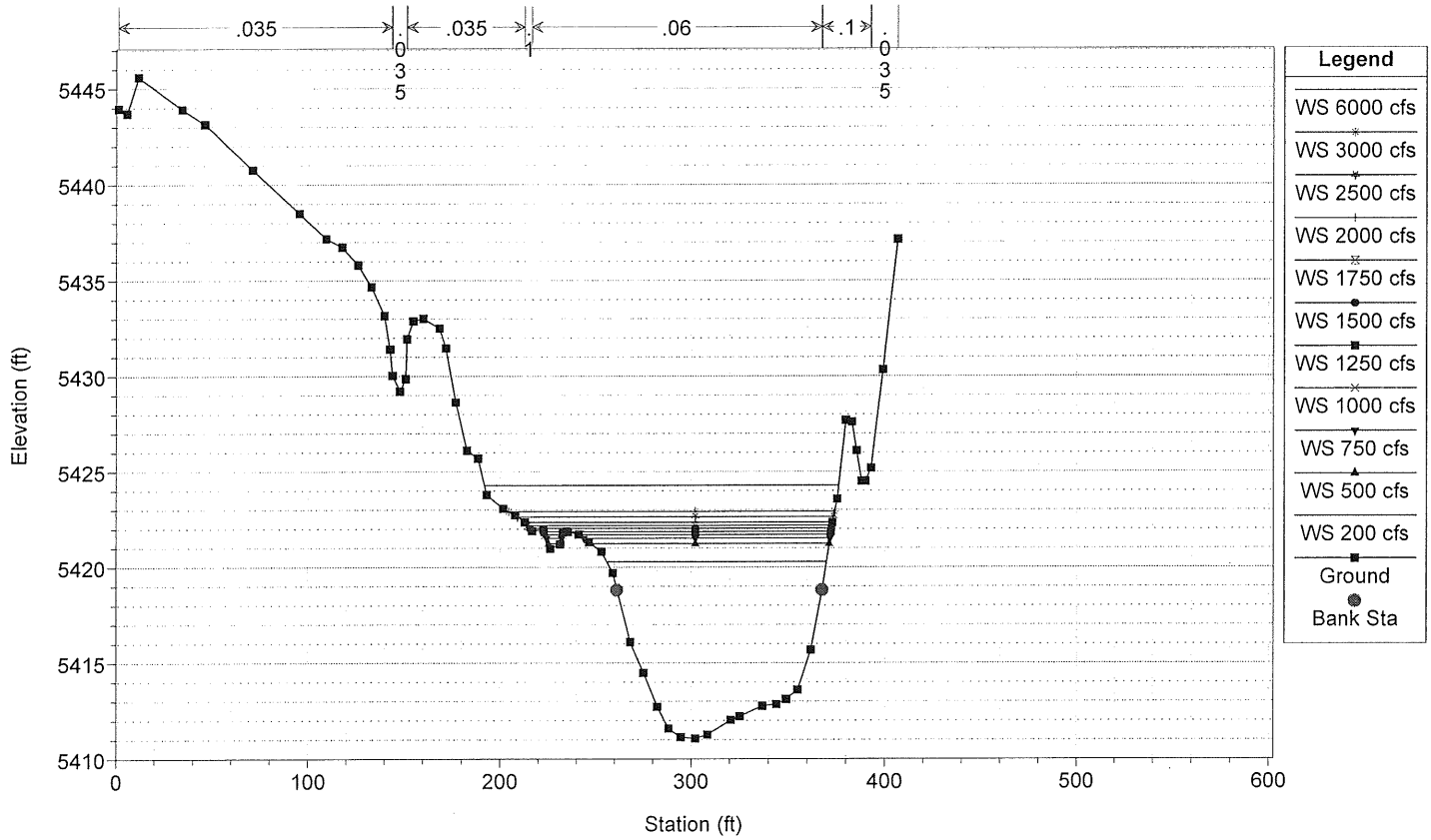




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

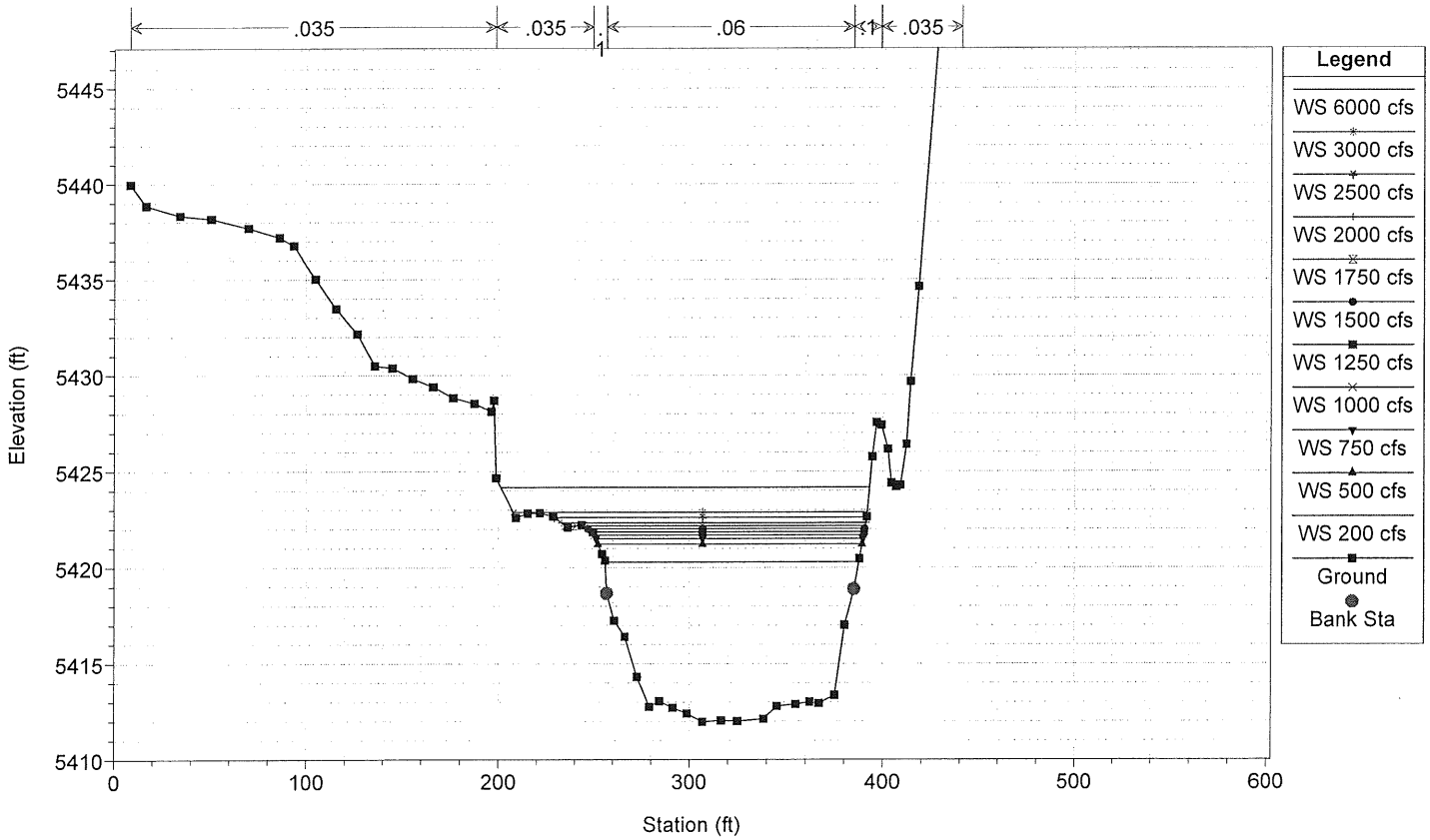
Big-Hole - WHP Plan: Option 3 Half Open 11/16/2009

RS = 3642 Cross Section #7

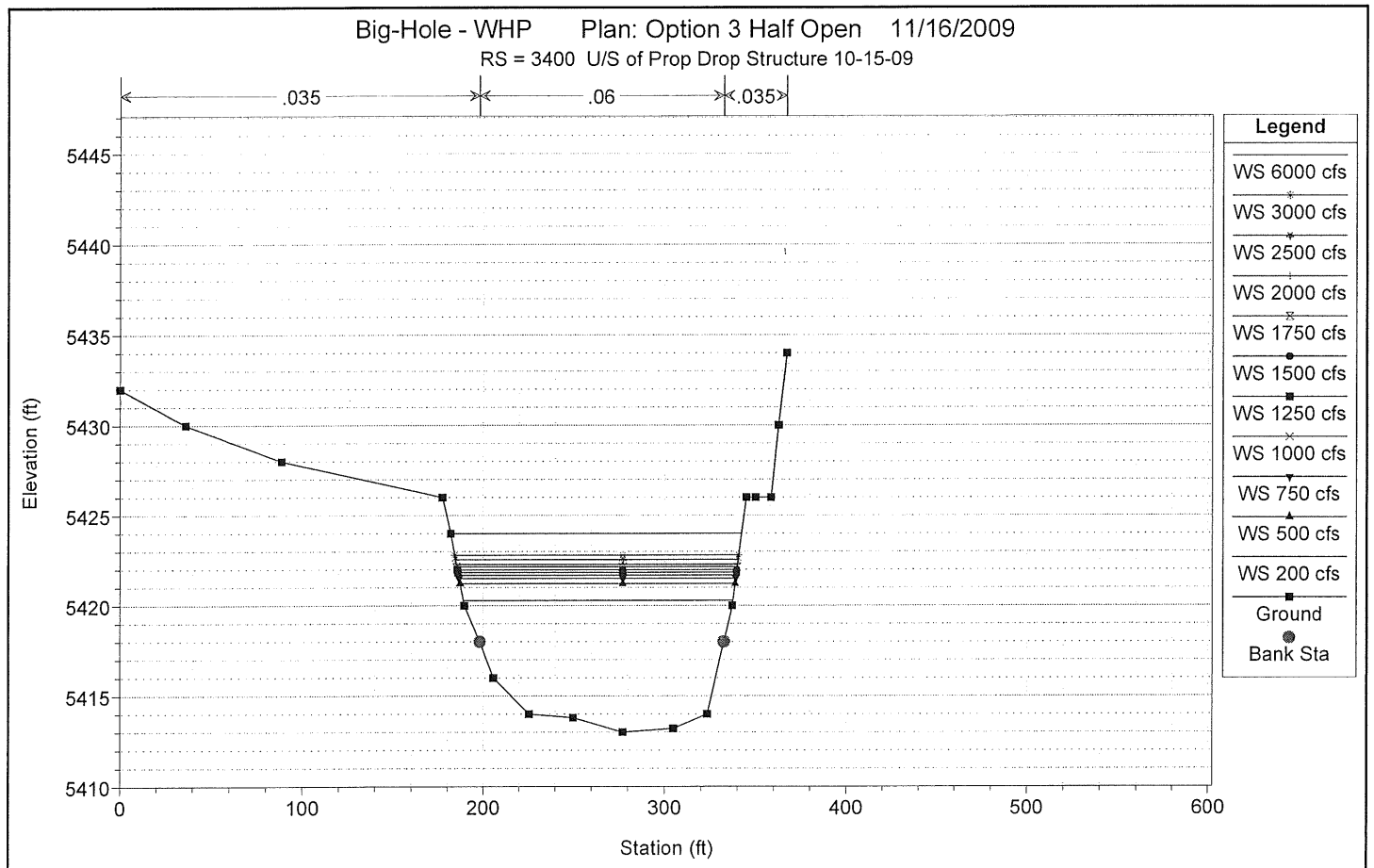


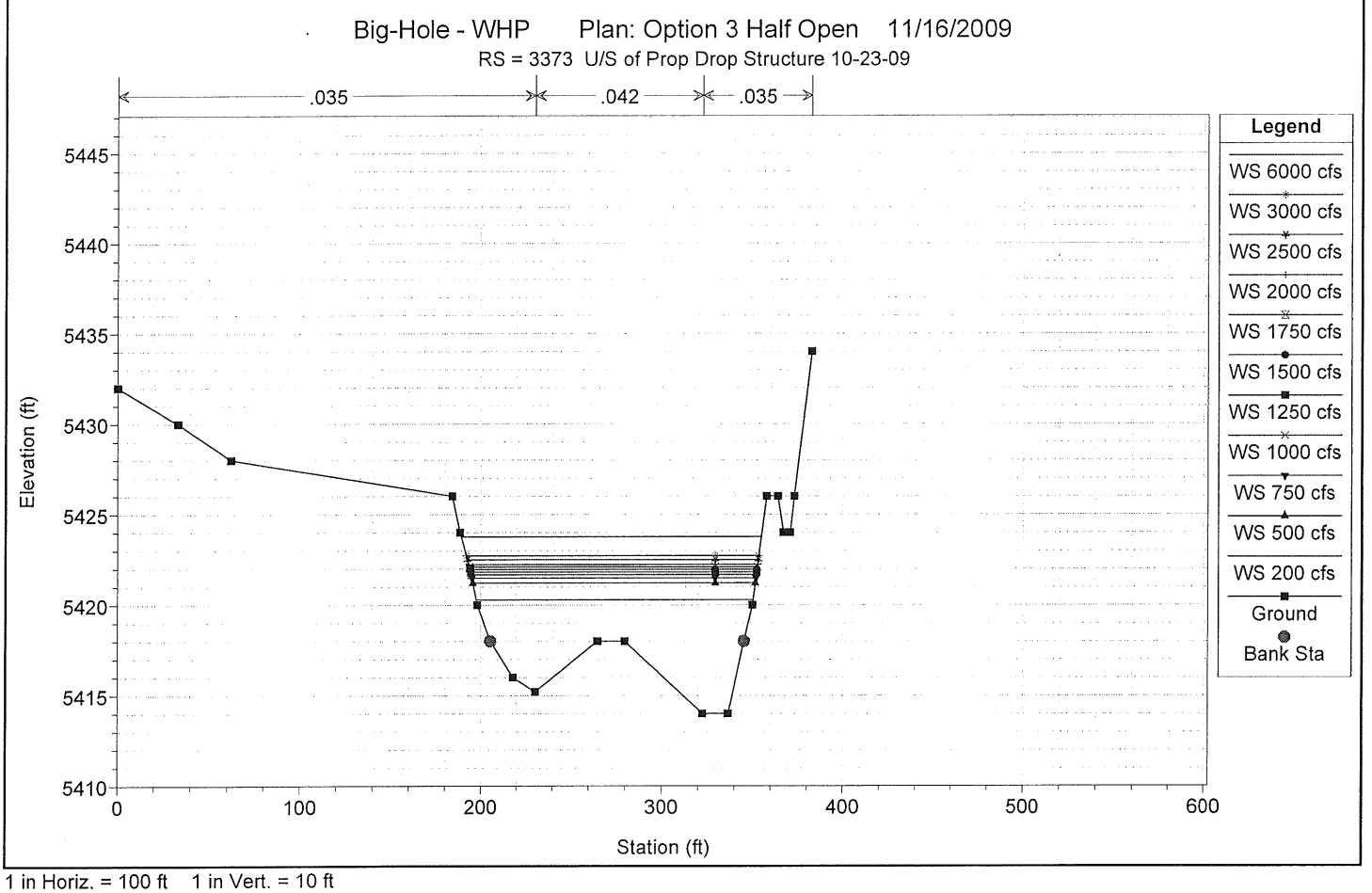
Big-Hole - WHP Plan: Option 3 Half Open 11/16/2009

RS = 3518 Cross Section #8

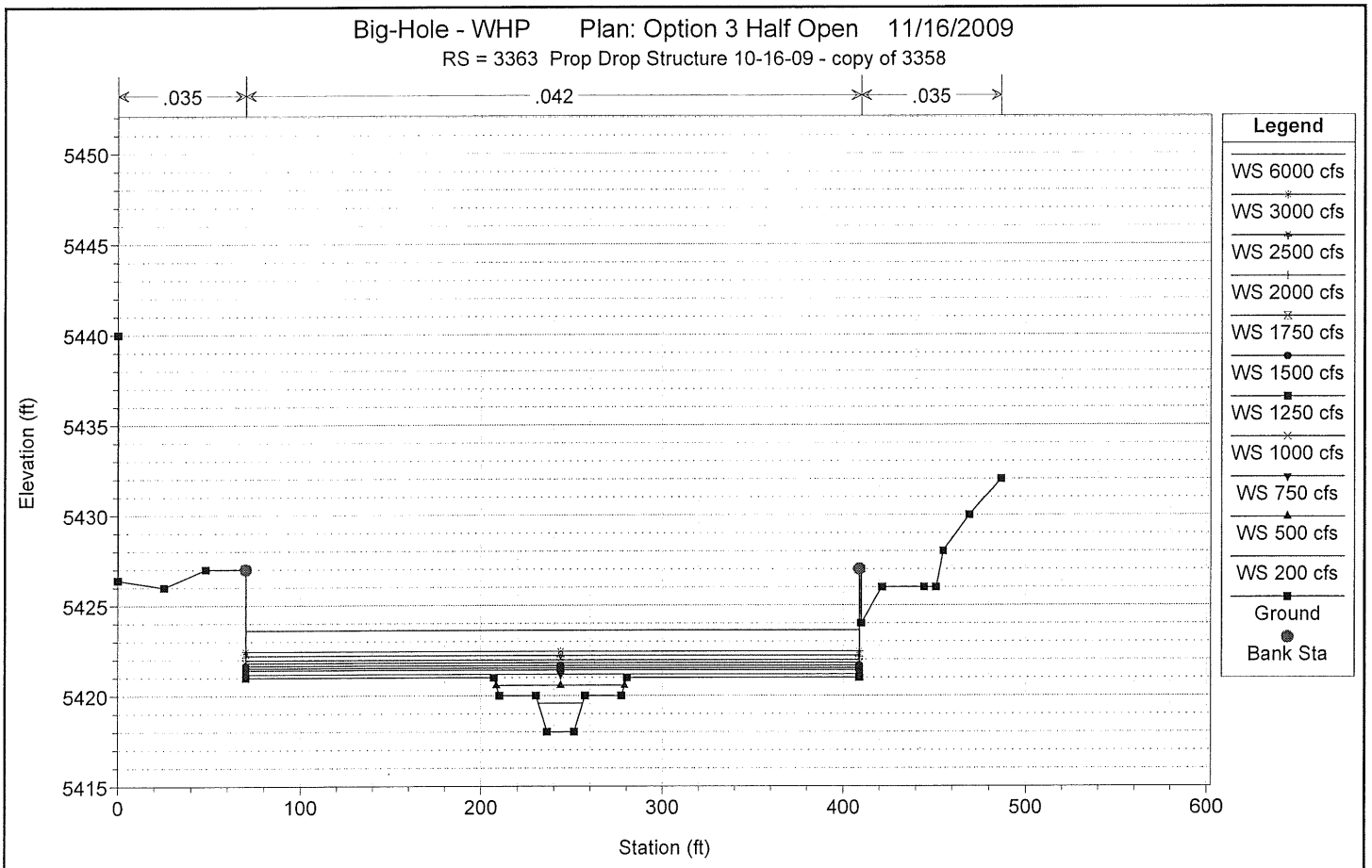


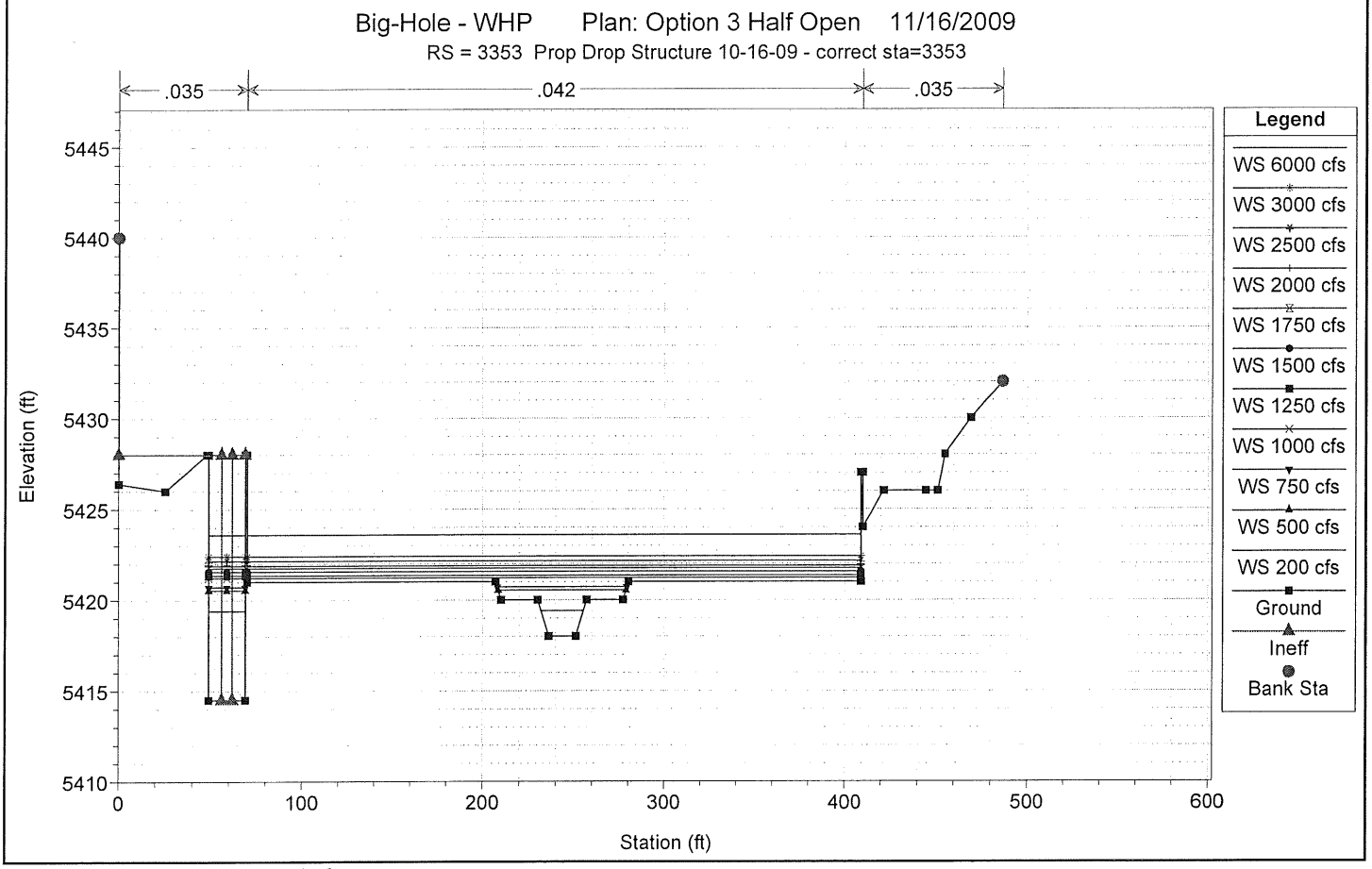
1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft

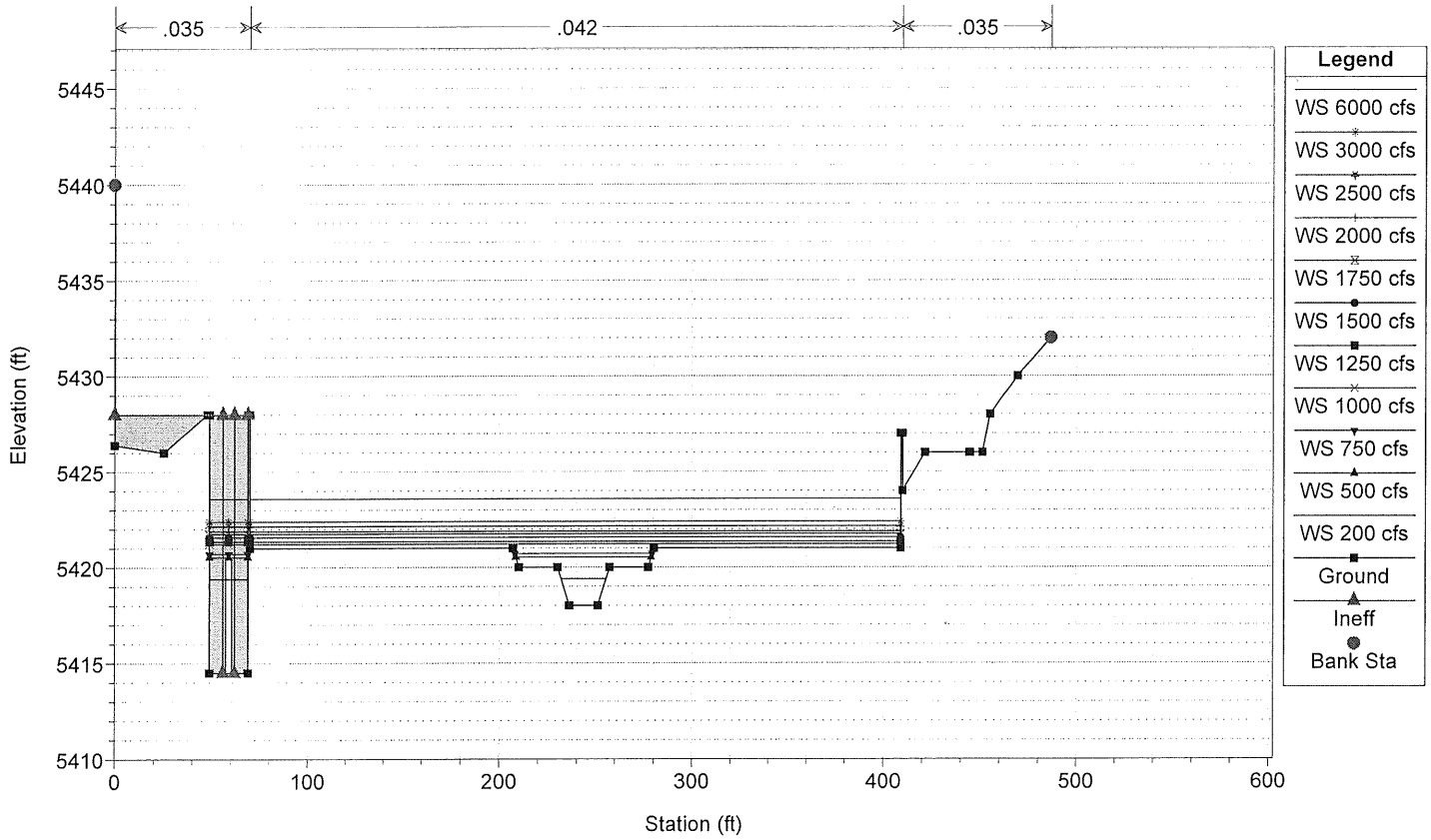




1 in Horiz. = 100 ft 1 in Vert. = 10 ft

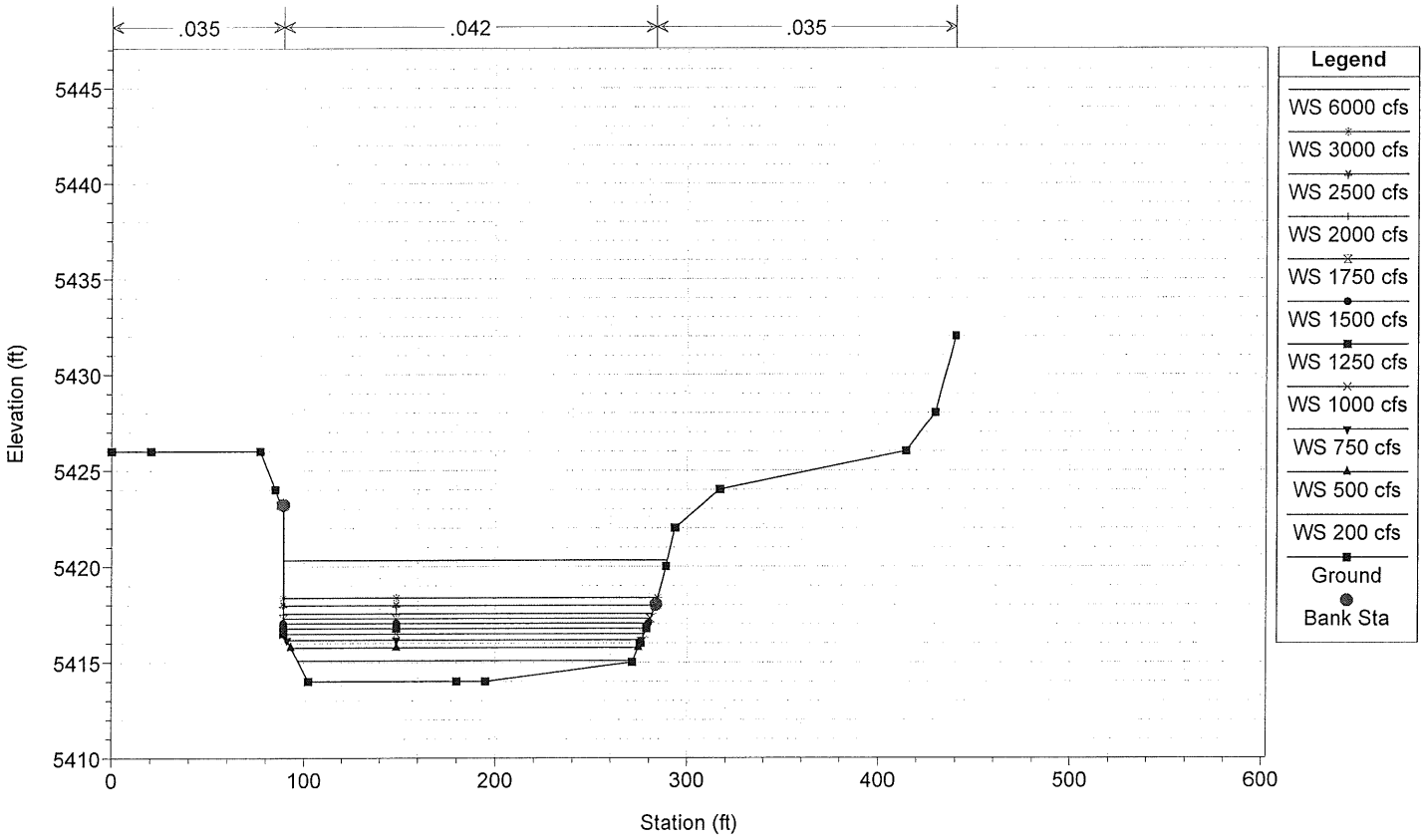
Big-Hole - WHP Plan: Option 3 Half Open 11/16/2009

RS = 3350 IS

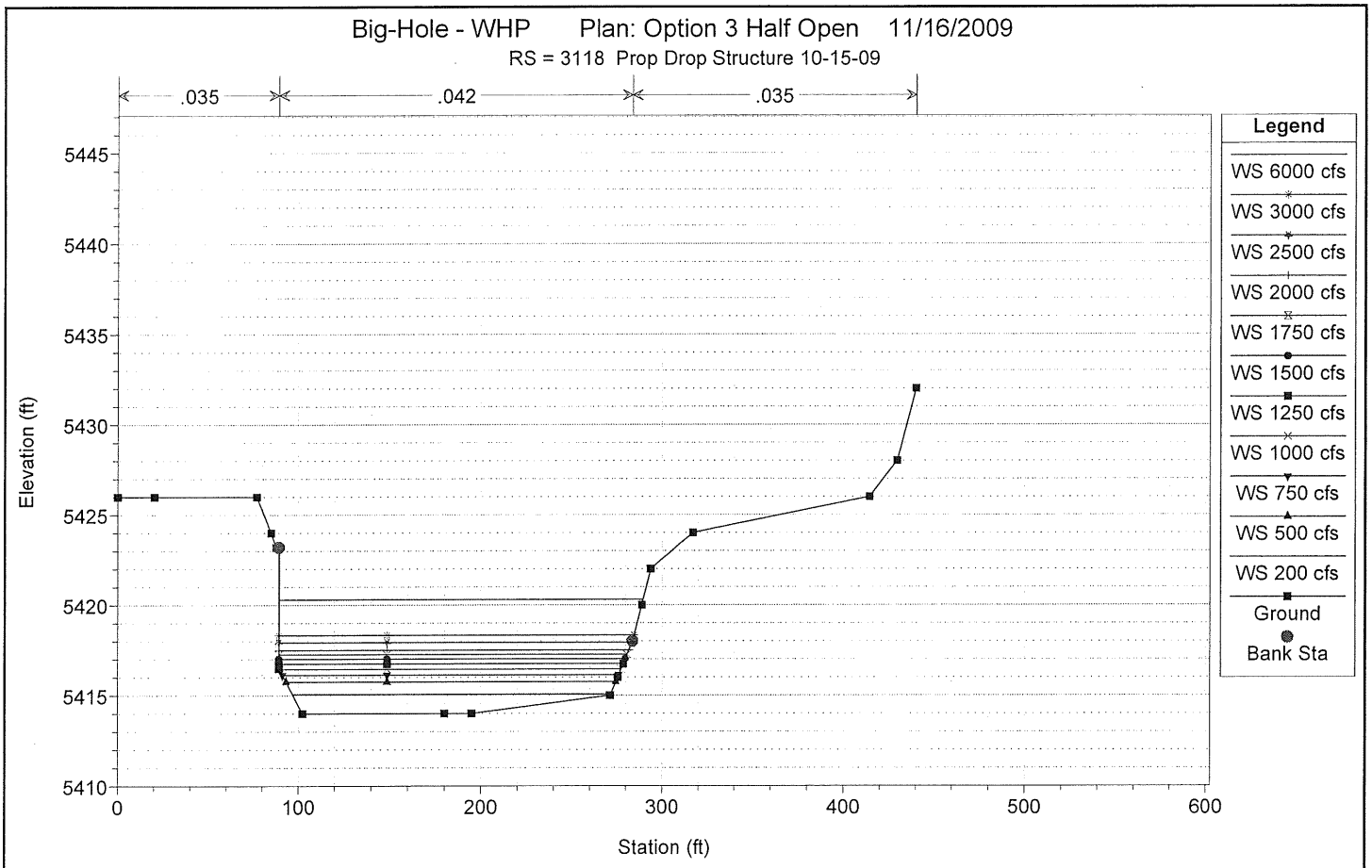


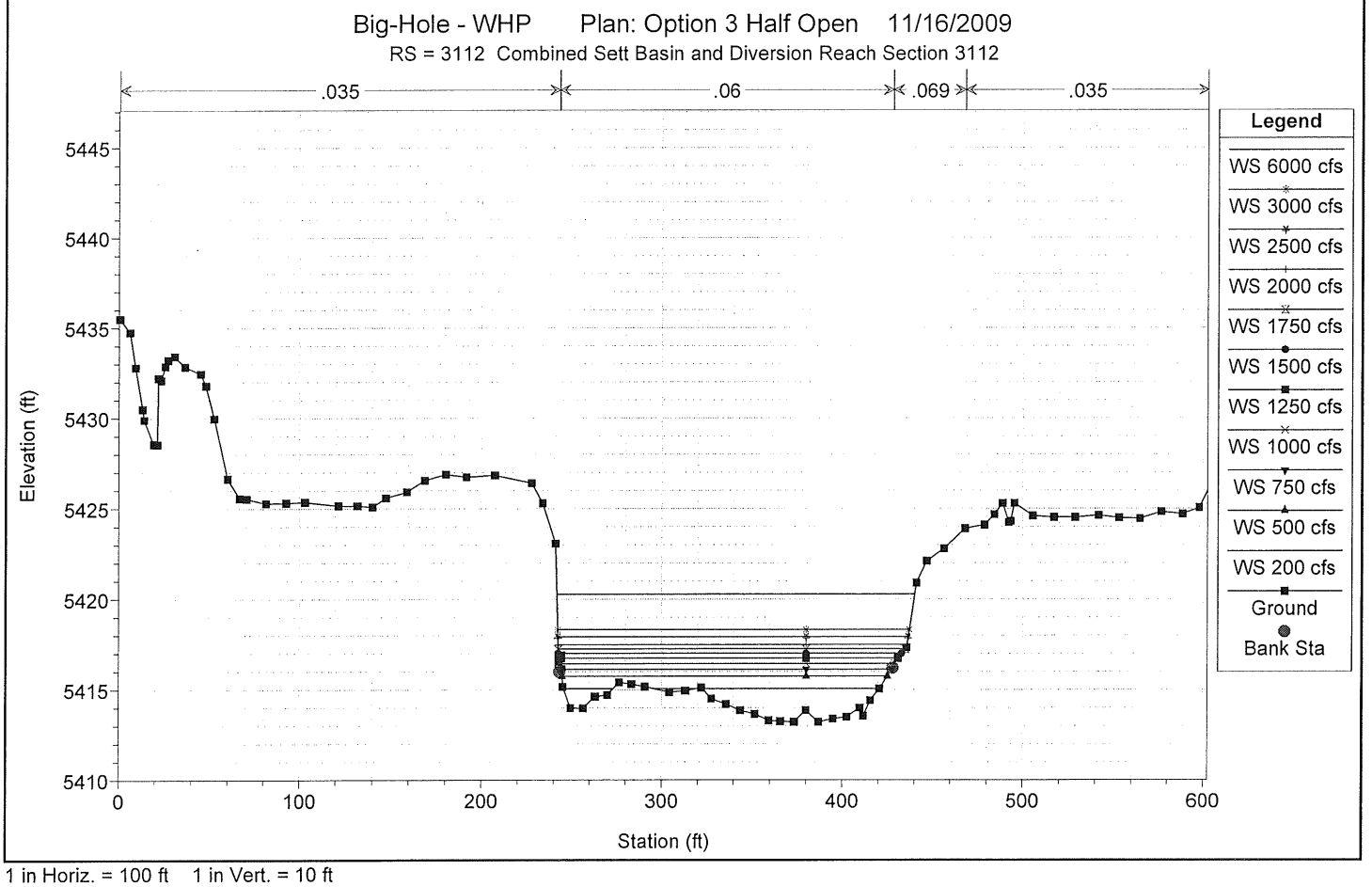
Big-Hole - WHP Plan: Option 3 Half Open 11/16/2009

RS = 3128 Prop Drop Structure 10-15-09

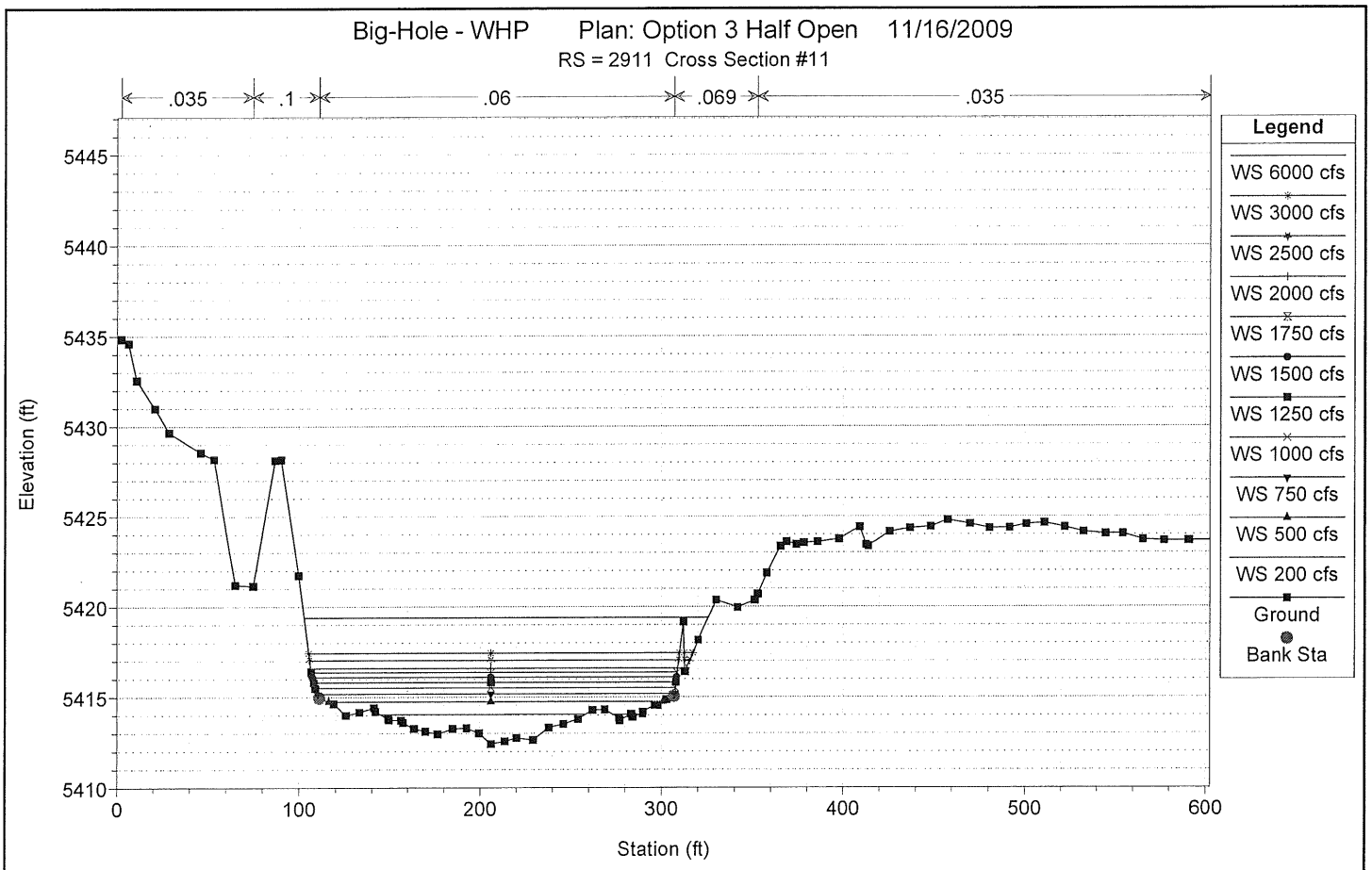


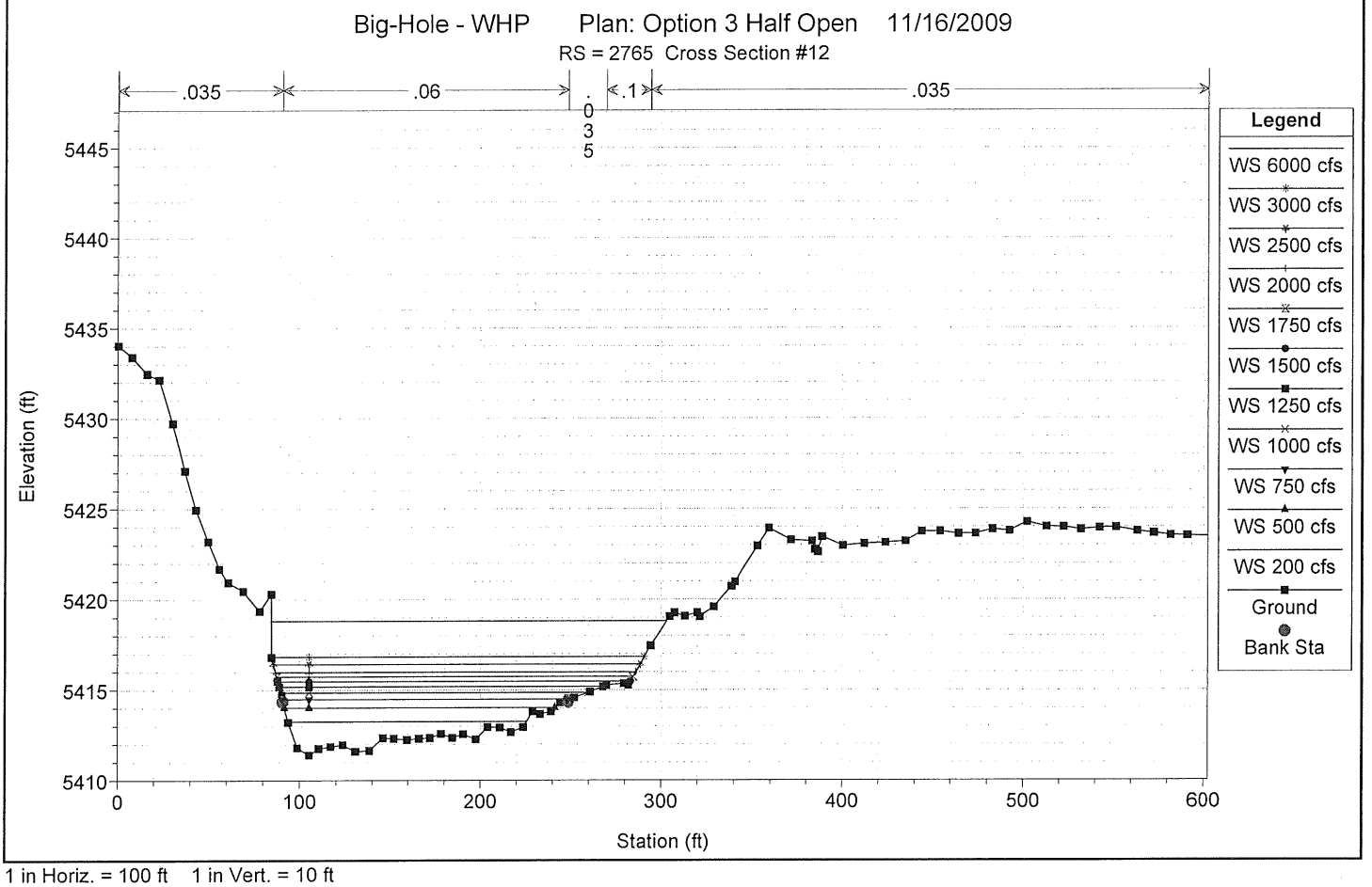
1 in Horiz. = 100 ft 1 in Vert. = 10 ft



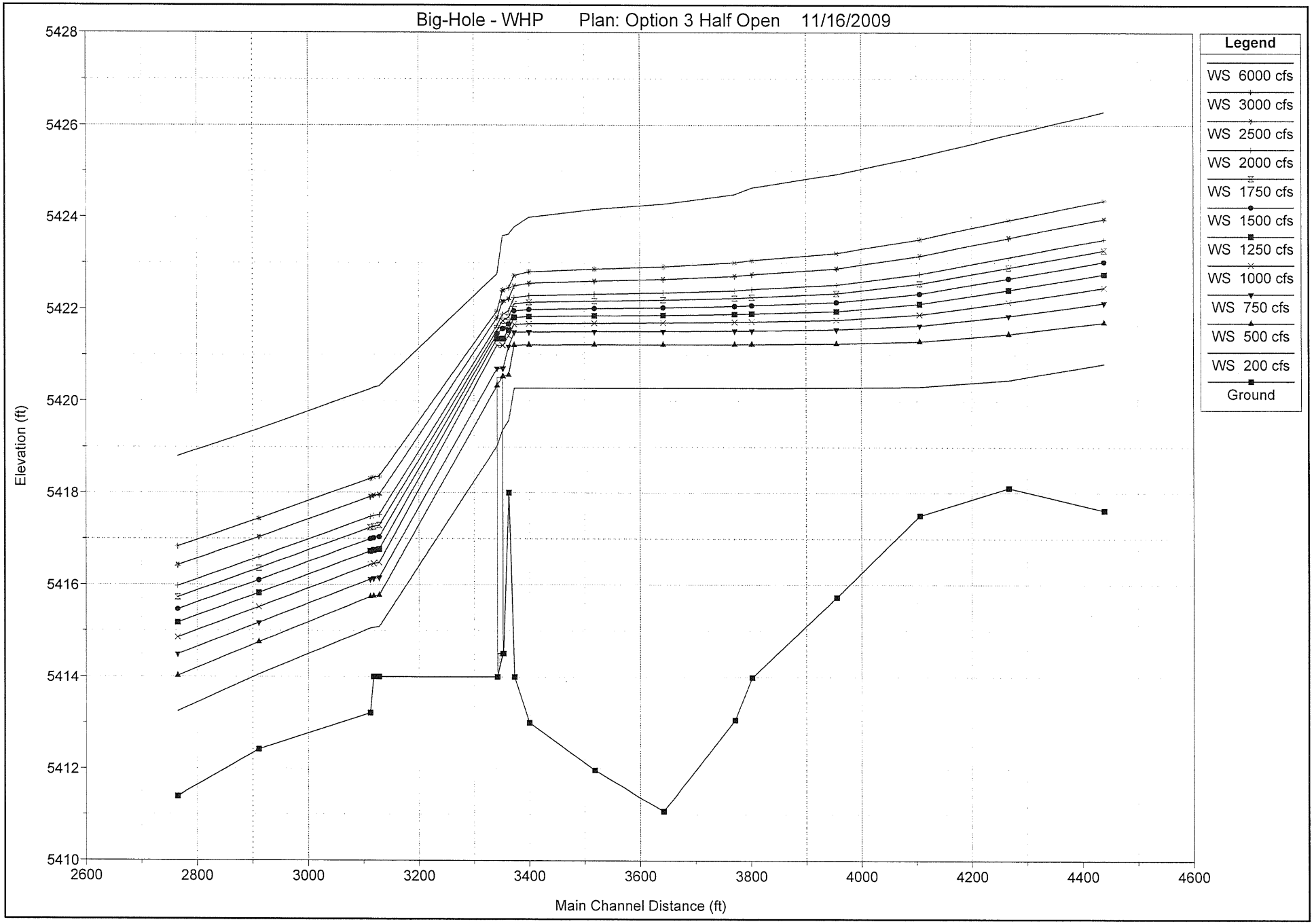


1 in Horiz. = 100 ft 1 in Vert. = 10 ft





1 in Horiz. = 100 ft 1 in Vert. = 10 ft


Big-Hole - WHP Plan: Option 3 Half Open 11/16/2009
Elevation (ft)
5428
5426
5424
5422
5420
5418
5416
5414
5412
5410
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
Main Channel Distance (ft)
Legend
WS 6000 cfs
WS 3000 cfs
WS 2500 cfs
WS 2000 cfs
WS 1750 cfs
WS 1500 cfs
WS 1250 cfs
WS 1000 cfs
WS 750 cfs
WS 500 cfs
WS 200 cfs
Ground

OPTION 3

PROJECT: BIG HOLE-WHP

PLAN: OPTION 3 MIXED (.p11)

GEOMETRY: OPTION 3 MIXED (.g11)

FLOW: MIXED FLOWS (.f07)

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	4439	200 cfs	200	5417.62	5420.9	5420.2	5420.90	0.004596	1.6	125.7	135.2	0.29
Big Hole	Upstream Chl	4439	300 cfs	300	5417.62	5421.2	5420.4	5421.27	0.004522	1.6	188.5	200.6	0.29
Big Hole	Upstream Chl	4439	400 cfs	400	5417.62	5421.5	5420.5	5421.56	0.003477	1.6	246.4	208.9	0.26
Big Hole	Upstream Chl	4439	500 cfs	500	5417.62	5421.8	5420.7	5421.82	0.002828	1.7	300.6	211.2	0.25
Big Hole	Upstream Chl	4439	600 cfs	600	5417.62	5422.0	5420.7	5422.03	0.002586	1.7	345.4	213.0	0.24
Big Hole	Upstream Chl	4439	700 cfs	700	5417.62	5422.1	5420.9	5422.17	0.002731	1.9	373.0	213.8	0.25
Big Hole	Upstream Chl	4439	800 cfs	800	5417.62	5422.3	5421.0	5422.31	0.002775	2.0	402.4	214.4	0.25
Big Hole	Upstream Chl	4439	900 cfs	900	5417.62	5422.4	5421.1	5422.45	0.002820	2.1	429.9	215.0	0.26
Big Hole	Upstream Chl	4439	1000 cfs	1000	5417.62	5422.5	5421.2	5422.57	0.002870	2.2	455.8	215.6	0.26
Big Hole	Upstream Chl	4439	1100 cfs	1100	5417.62	5422.6	5421.3	5422.70	0.002878	2.3	482.5	216.2	0.27
Big Hole	Upstream Chl	4439	1200 cfs	1200	5417.62	5422.7	5421.3	5422.83	0.002858	2.4	509.6	216.8	0.27
Big Hole	Upstream Chl	4439	1300 cfs	1300	5417.62	5422.9	5421.4	5422.97	0.002815	2.4	537.4	217.4	0.27
Big Hole	Upstream Chl	4439	1400 cfs	1400	5417.62	5423.0	5421.4	5423.10	0.002754	2.5	565.9	218.0	0.27
Big Hole	Upstream Chl	4439	1500 cfs	1500	5417.62	5423.1	5421.5	5423.24	0.002683	2.5	594.8	218.6	0.27
Big Hole	Upstream Chl	4439	1600 cfs	1600	5417.62	5423.3	5421.5	5423.38	0.002606	2.6	624.1	219.4	0.27
Big Hole	Upstream Chl	4439	1700 cfs	1700	5417.62	5423.3	5421.6	5423.42	0.002843	2.7	630.6	219.6	0.28
Big Hole	Upstream Chl	4439	1800 cfs	1800	5417.62	5423.4	5421.6	5423.52	0.002861	2.8	651.8	220.3	0.28
Big Hole	Upstream Chl	4439	1900 cfs	1900	5417.62	5423.5	5421.7	5423.63	0.002846	2.8	674.7	221.2	0.28
Big Hole	Upstream Chl	4439	2000 cfs	2000	5417.62	5423.6	5421.7	5423.74	0.002818	2.9	698.3	222.0	0.28
Big Hole	Upstream Chl	4267	200 cfs	200	5418.11	5420.6	5419.2	5420.59	0.000898	0.8	241.2	203.7	0.13
Big Hole	Upstream Chl	4267	300 cfs	300	5418.11	5421.0	5419.4	5421.00	0.000766	0.9	325.6	208.6	0.13
Big Hole	Upstream Chl	4267	400 cfs	400	5418.11	5421.3	5419.6	5421.30	0.000766	1.0	388.5	211.7	0.13
Big Hole	Upstream Chl	4267	500 cfs	500	5418.11	5421.6	5419.7	5421.58	0.000752	1.1	447.3	213.8	0.14
Big Hole	Upstream Chl	4267	600 cfs	600	5418.11	5421.8	5419.9	5421.80	0.000790	1.2	492.6	215.3	0.14
Big Hole	Upstream Chl	4267	700 cfs	700	5418.11	5421.9	5420.0	5421.90	0.000933	1.4	514.3	215.8	0.15
Big Hole	Upstream Chl	4267	800 cfs	800	5418.11	5422.0	5420.1	5422.03	0.001039	1.5	540.0	216.4	0.16
Big Hole	Upstream Chl	4267	900 cfs	900	5418.11	5422.1	5420.2	5422.15	0.001141	1.6	564.0	217.0	0.17
Big Hole	Upstream Chl	4267	1000 cfs	1000	5418.11	5422.2	5420.2	5422.25	0.001240	1.7	586.5	217.5	0.18
Big Hole	Upstream Chl	4267	1100 cfs	1100	5418.11	5422.3	5420.3	5422.37	0.001315	1.8	610.6	218.1	0.19
Big Hole	Upstream Chl	4267	1200 cfs	1200	5418.11	5422.4	5420.4	5422.50	0.001366	1.9	636.8	218.7	0.19
Big Hole	Upstream Chl	4267	1300 cfs	1300	5418.11	5422.6	5420.5	5422.63	0.001395	2.0	664.5	219.4	0.20
Big Hole	Upstream Chl	4267	1400 cfs	1400	5418.11	5422.7	5420.5	5422.76	0.001408	2.0	693.5	220.2	0.20
Big Hole	Upstream Chl	4267	1500 cfs	1500	5418.11	5422.8	5420.6	5422.90	0.001410	2.1	723.5	221.0	0.20
Big Hole	Upstream Chl	4267	1600 cfs	1600	5418.11	5423.0	5420.6	5423.04	0.001402	2.1	754.2	221.7	0.20
Big Hole	Upstream Chl	4267	1700 cfs	1700	5418.11	5423.0	5420.7	5423.05	0.001593	2.3	752.8	221.7	0.21
Big Hole	Upstream Chl	4267	1800 cfs	1800	5418.11	5423.1	5420.7	5423.14	0.001642	2.4	772.6	222.0	0.22
Big Hole	Upstream Chl	4267	1900 cfs	1900	5418.11	5423.2	5420.8	5423.25	0.001666	2.4	795.3	222.4	0.22
Big Hole	Upstream Chl	4267	2000 cfs	2000	5418.11	5423.3	5420.8	5423.36	0.001679	2.5	818.9	222.7	0.22
Big Hole	Upstream Chl	4106	200 cfs	200	5417.51	5420.5	5418.5	5420.48	0.000538	0.8	251.2	153.9	0.11
Big Hole	Upstream Chl	4106	300 cfs	300	5417.51	5420.9	5418.7	5420.88	0.000698	0.9	319.3	185.4	0.13
Big Hole	Upstream Chl	4106	400 cfs	400	5417.51	5421.2	5418.9	5421.18	0.000823	1.1	375.8	204.6	0.14
Big Hole	Upstream Chl	4106	500 cfs	500	5417.51	5421.4	5419.0	5421.45	0.000861	1.2	433.2	216.4	0.14
Big Hole	Upstream Chl	4106	600 cfs	600	5417.51	5421.6	5419.2	5421.66	0.000971	1.3	478.1	230.7	0.15
Big Hole	Upstream Chl	4106	700 cfs	700	5417.51	5421.7	5419.3	5421.74	0.001195	1.4	494.8	233.0	0.17
Big Hole	Upstream Chl	4106	800 cfs	800	5417.51	5421.8	5419.4	5421.84	0.001370	1.6	517.2	236.1	0.18
Big Hole	Upstream Chl	4106	900 cfs	900	5417.51	5421.9	5419.5	5421.93	0.001516	1.7	538.7	236.4	0.19
Big Hole	Upstream Chl	4106	1000 cfs	1000	5417.51	5422.0	5419.6	5422.02	0.001664	1.8	558.3	236.7	0.21
Big Hole	Upstream Chl	4106	1100 cfs	1100	5417.51	5422.1	5419.8	5422.13	0.001763	1.9	581.2	237.0	0.21
Big Hole	Upstream Chl	4106	1200 cfs	1200	5417.51	5422.2	5419.9	5422.24	0.001813	2.0	607.6	237.4	0.22
Big Hole	Upstream Chl	4106	1300 cfs	1300	5417.51	5422.3	5420.0	5422.37	0.001823	2.1	636.8	237.8	0.22
Big Hole	Upstream Chl	4106	1400 cfs	1400	5417.51	5422.4	5420.1	5422.51	0.001802	2.1	668.5	238.2	0.22
Big Hole	Upstream Chl	4106	1500 cfs	1500	5417.51	5422.6	5420.2	5422.65	0.001765	2.2	701.6	238.7	0.22
Big Hole	Upstream Chl	4106	1600 cfs	1600	5417.51	5422.7	5420.3	5422.79	0.001717	2.2	735.9	239.2	0.22
Big Hole	Upstream Chl	4106	1700 cfs	1700	5417.51	5422.7	5420.4	5422.76	0.002044	2.4	724.0	239.0	0.24
Big Hole	Upstream Chl	4106	1800 cfs	1800	5417.51	5422.8	5420.4	5422.84	0.002104	2.4	743.2	239.3	0.24
Big Hole	Upstream Chl	4106	1900 cfs	1900	5417.51	5422.8	5420.5	5422.95	0.002114	2.5	766.9	239.6	0.24
Big Hole	Upstream Chl	4106	2000 cfs	2000	5417.51	5423.0	5420.6	5423.06	0.002106	2.5	792.3	240.0	0.24
Big Hole	Upstream Chl	3955	200 cfs	200	5415.73	5420.5	5417.0	5420.45	0.000069	0.4	458.7	164.8	0.05
Big Hole	Upstream Chl	3955	300 cfs	300	5415.73	5420.8	5417.2	5420.85	0.000104	0.6	524.3	170.0	0.06
Big Hole	Upstream Chl	3955	400 cfs	400	5415.73	5421.1	5417.5	5421.13	0.000141	0.7	572.3	174.3	0.07
Big Hole	Upstream Chl	3955	500 cfs	500	5415.73	5421.4	5417.7	5421.40	0.000174	0.8	619.6	178.4	0.08
Big Hole	Upstream Chl	3955	600 cfs	600	5415.73	5421.6	5417.9	5421.59	0.000213	0.9	653.8	181.2	0.08
Big Hole	Upstream Chl	3955	700 cfs	700	5415.73	5421.6	5418.1	5421.66	0.000276	1.1	664.1	182.1	0.10
Big Hole	Upstream Chl	3955	800 cfs	800	5415.73	5421.7	5418.2	5421.74	0.000337	1.2	679.1	183.3	0.11
Big Hole	Upstream Chl	3955	900 cfs	900	5415.73	5421.8	5418.3	5421.82	0.000401	1.3	693.3	184.5	0.12
Big Hole	Upstream Chl	3955	1000 cfs	1000	5415.73	5421.9	5418.4	5421.90	0.000469	1.4	706.1	185.8	0.13
Big Hole	Upstream Chl	3955	1100 cfs	1100	5415.73	5421.9	5418.4	5421.99	0.000532	1.5	721.7	187.3	0.14
Big Hole	Upstream Chl	3955	1200 cfs	1200	5415.73	5422.1	5418.5	5422.09	0.000585	1.6	740.9	189.5	0.14
Big Hole	Upstream Chl	3955	1300 cfs	1300	5415.73	5422.2	5418.6	5422.21	0.000630	1.7	762.9	192.0	0.15
Big Hole	Upstream Chl	3955	1400 cfs	1400	5415.73	5422.3	5418.7	5422.35	0.000665	1.8	787.7	194.8	0.16
Big Hole	Upstream Chl	3955	1500 cfs	1500	5415.73	5422.4	5418.8	5422.48	0.000693	1.9	814.4	199.0	0.16
Big Hole	Upstream Chl	3955	1600 cfs	1600	5415.73	5422.6	5418.8	5422.63	0.000714	1.9	842.9	203.8	0.16
Big Hole	Upstream Chl	3955	1700 cfs	1700	5415.73	5422.5	5418.9	5422.56	0.000851	2.1	827.0	200.9	0.18
Big Hole	Upstream Chl	3955	1800 cfs	1800	5415.73	5422.6	5419.0	5422.64	0.000909	2.2	841.2	203.1	0.18
Big Hole	Upstream Chl	3955	1900 cfs	1900	5415.73	5422.7	5419.1	5422.73	0.000962	2.2	860.6	220.4	0.20

11/16/09

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3955	2000 cfs	2000	5415.73	5422.8	5419.1	5422.84	0.000994	2.3	883.6	229.0	0.20
Big Hole	Upstream Chl	3802	200 cfs	200	5413.99	5420.4	5415.4	5420.45	0.000019	0.3	665.2	168.7	0.03
Big Hole	Upstream Chl	3802	300 cfs	300	5413.99	5420.8	5415.6	5420.84	0.000033	0.4	732.6	176.9	0.03
Big Hole	Upstream Chl	3802	400 cfs	400	5413.99	5421.1	5415.8	5421.12	0.000049	0.5	782.1	182.4	0.04
Big Hole	Upstream Chl	3802	500 cfs	500	5413.99	5421.4	5415.9	5421.38	0.000064	0.6	832.2	195.5	0.05
Big Hole	Upstream Chl	3802	600 cfs	600	5413.99	5421.6	5416.1	5421.57	0.000083	0.7	868.8	196.0	0.06
Big Hole	Upstream Chl	3802	700 cfs	700	5413.99	5421.6	5416.2	5421.63	0.000109	0.8	879.0	196.1	0.07
Big Hole	Upstream Chl	3802	800 cfs	800	5413.99	5421.7	5416.3	5421.71	0.000136	0.9	894.2	196.4	0.07
Big Hole	Upstream Chl	3802	900 cfs	900	5413.99	5421.8	5416.4	5421.78	0.000165	1.0	908.4	196.6	0.08
Big Hole	Upstream Chl	3802	1000 cfs	1000	5413.99	5421.8	5416.5	5421.85	0.000197	1.1	920.8	196.7	0.09
Big Hole	Upstream Chl	3802	1100 cfs	1100	5413.99	5421.9	5416.6	5421.93	0.000228	1.2	936.3	197.0	0.09
Big Hole	Upstream Chl	3802	1200 cfs	1200	5413.99	5422.0	5416.7	5422.03	0.000257	1.3	955.4	197.2	0.10
Big Hole	Upstream Chl	3802	1300 cfs	1300	5413.99	5422.1	5416.7	5422.15	0.000283	1.4	977.3	197.4	0.10
Big Hole	Upstream Chl	3802	1400 cfs	1400	5413.99	5422.2	5416.8	5422.27	0.000306	1.4	1001.8	197.6	0.11
Big Hole	Upstream Chl	3802	1500 cfs	1500	5413.99	5422.4	5416.9	5422.41	0.000328	1.5	1028.1	197.8	0.11
Big Hole	Upstream Chl	3802	1600 cfs	1600	5413.99	5422.5	5417.0	5422.55	0.000346	1.6	1055.5	198.0	0.12
Big Hole	Upstream Chl	3802	1700 cfs	1700	5413.99	5422.4	5417.1	5422.47	0.000410	1.7	1037.8	197.8	0.13
Big Hole	Upstream Chl	3802	1800 cfs	1800	5413.99	5422.5	5417.1	5422.54	0.000444	1.8	1050.6	197.9	0.13
Big Hole	Upstream Chl	3802	1900 cfs	1900	5413.99	5422.6	5417.2	5422.63	0.000473	1.8	1067.6	198.1	0.14
Big Hole	Upstream Chl	3802	2000 cfs	2000	5413.99	5422.7	5417.3	5422.73	0.000498	1.9	1087.0	198.2	0.14
Big Hole	Upstream Chl	3771	200 cfs	200	5413.06	5420.4	5414.4	5420.45	0.000013	0.3	699.8	145.1	0.02
Big Hole	Upstream Chl	3771	300 cfs	300	5413.06	5420.8	5414.6	5420.84	0.000024	0.4	756.9	147.9	0.03
Big Hole	Upstream Chl	3771	400 cfs	400	5413.06	5421.1	5414.8	5421.12	0.000037	0.5	797.9	150.0	0.04
Big Hole	Upstream Chl	3771	500 cfs	500	5413.06	5421.4	5415.0	5421.38	0.000051	0.6	838.0	153.8	0.04
Big Hole	Upstream Chl	3771	600 cfs	600	5413.06	5421.6	5415.1	5421.57	0.000066	0.7	867.6	163.7	0.05
Big Hole	Upstream Chl	3771	700 cfs	700	5413.06	5421.6	5415.2	5421.62	0.000088	0.8	876.2	171.5	0.06
Big Hole	Upstream Chl	3771	800 cfs	800	5413.06	5421.7	5415.4	5421.70	0.000111	0.9	889.4	176.1	0.06
Big Hole	Upstream Chl	3771	900 cfs	900	5413.06	5421.8	5415.5	5421.78	0.000136	1.1	902.0	178.9	0.07
Big Hole	Upstream Chl	3771	1000 cfs	1000	5413.06	5421.8	5415.6	5421.84	0.000163	1.2	913.1	180.4	0.08
Big Hole	Upstream Chl	3771	1100 cfs	1100	5413.06	5421.9	5415.7	5421.92	0.000189	1.3	927.1	180.6	0.08
Big Hole	Upstream Chl	3771	1200 cfs	1200	5413.06	5422.0	5415.8	5422.02	0.000215	1.4	944.3	180.8	0.09
Big Hole	Upstream Chl	3771	1300 cfs	1300	5413.06	5422.1	5415.9	5422.14	0.000239	1.4	964.2	181.1	0.09
Big Hole	Upstream Chl	3771	1400 cfs	1400	5413.06	5422.2	5416.0	5422.26	0.000262	1.5	986.4	181.4	0.10
Big Hole	Upstream Chl	3771	1500 cfs	1500	5413.06	5422.4	5416.0	5422.40	0.000282	1.6	1010.3	181.7	0.10
Big Hole	Upstream Chl	3771	1600 cfs	1600	5413.06	5422.5	5416.1	5422.54	0.000302	1.7	1035.2	182.1	0.11
Big Hole	Upstream Chl	3771	1700 cfs	1700	5413.06	5422.4	5416.2	5422.45	0.000355	1.8	1018.3	181.8	0.11
Big Hole	Upstream Chl	3771	1800 cfs	1800	5413.06	5422.5	5416.3	5422.52	0.000387	1.9	1029.8	182.0	0.12
Big Hole	Upstream Chl	3771	1900 cfs	1900	5413.06	5422.6	5416.4	5422.61	0.000415	2.0	1045.1	182.4	0.12
Big Hole	Upstream Chl	3771	2000 cfs	2000	5413.06	5422.6	5416.5	5422.71	0.000440	2.1	1062.7	182.9	0.13
Big Hole	Upstream Chl	3642	200 cfs	200	5411.07	5420.4	5412.4	5420.45	0.000008	0.3	778.5	114.9	0.02
Big Hole	Upstream Chl	3642	300 cfs	300	5411.07	5420.8	5412.7	5420.84	0.000015	0.4	823.6	117.7	0.02
Big Hole	Upstream Chl	3642	400 cfs	400	5411.07	5421.1	5413.0	5421.11	0.000024	0.5	856.6	125.3	0.03
Big Hole	Upstream Chl	3642	500 cfs	500	5411.07	5421.4	5413.2	5421.38	0.000033	0.6	890.8	132.9	0.04
Big Hole	Upstream Chl	3642	600 cfs	600	5411.07	5421.6	5413.3	5421.56	0.000044	0.7	915.6	136.6	0.04
Big Hole	Upstream Chl	3642	700 cfs	700	5411.07	5421.6	5413.5	5421.61	0.000059	0.8	922.4	137.6	0.05
Big Hole	Upstream Chl	3642	800 cfs	800	5411.07	5421.7	5413.6	5421.69	0.000075	0.9	932.7	139.1	0.05
Big Hole	Upstream Chl	3642	900 cfs	900	5411.07	5421.7	5413.8	5421.76	0.000092	1.0	942.3	141.3	0.06
Big Hole	Upstream Chl	3642	1000 cfs	1000	5411.07	5421.8	5413.9	5421.83	0.000111	1.1	950.7	144.0	0.06
Big Hole	Upstream Chl	3642	1100 cfs	1100	5411.07	5421.9	5414.0	5421.90	0.000130	1.2	961.7	149.3	0.07
Big Hole	Upstream Chl	3642	1200 cfs	1200	5411.07	5422.0	5414.1	5422.00	0.000149	1.3	975.7	155.1	0.08
Big Hole	Upstream Chl	3642	1300 cfs	1300	5411.07	5422.1	5414.2	5422.11	0.000168	1.4	992.6	157.2	0.08
Big Hole	Upstream Chl	3642	1400 cfs	1400	5411.07	5422.2	5414.3	5422.23	0.000186	1.4	1011.5	158.4	0.08
Big Hole	Upstream Chl	3642	1500 cfs	1500	5411.07	5422.3	5414.4	5422.37	0.000202	1.5	1032.0	159.7	0.09
Big Hole	Upstream Chl	3642	1600 cfs	1600	5411.07	5422.5	5414.5	5422.51	0.000218	1.6	1053.7	161.7	0.09
Big Hole	Upstream Chl	3642	1700 cfs	1700	5411.07	5422.4	5414.6	5422.41	0.000256	1.7	1038.0	160.1	0.10
Big Hole	Upstream Chl	3642	1800 cfs	1800	5411.07	5422.4	5414.7	5422.48	0.000281	1.8	1047.5	161.1	0.10
Big Hole	Upstream Chl	3642	1900 cfs	1900	5411.07	5422.5	5414.8	5422.56	0.000303	1.9	1060.6	162.4	0.11
Big Hole	Upstream Chl	3642	2000 cfs	2000	5411.07	5422.6	5414.9	5422.66	0.000323	2.0	1075.9	163.9	0.11
Big Hole	Upstream Chl	3518	200 cfs	200	5411.97	5420.4	5413.0	5420.45	0.000006	0.2	910.6	132.4	0.01
Big Hole	Upstream Chl	3518	300 cfs	300	5411.97	5420.8	5413.2	5420.83	0.000011	0.3	962.4	134.8	0.02
Big Hole	Upstream Chl	3518	400 cfs	400	5411.97	5421.1	5413.3	5421.11	0.000018	0.4	999.4	136.4	0.03
Big Hole	Upstream Chl	3518	500 cfs	500	5411.97	5421.4	5413.5	5421.37	0.000025	0.5	1035.5	138.0	0.03
Big Hole	Upstream Chl	3518	600 cfs	600	5411.97	5421.6	5413.6	5421.56	0.000033	0.6	1060.9	139.1	0.04
Big Hole	Upstream Chl	3518	700 cfs	700	5411.97	5421.6	5413.7	5421.61	0.000044	0.7	1067.6	139.3	0.04
Big Hole	Upstream Chl	3518	800 cfs	800	5411.97	5421.7	5413.8	5421.68	0.000056	0.7	1077.8	139.8	0.05
Big Hole	Upstream Chl	3518	900 cfs	900	5411.97	5421.7	5413.9	5421.75	0.000069	0.8	1087.3	140.2	0.05
Big Hole	Upstream Chl	3518	1000 cfs	1000	5411.97	5421.8	5414.0	5421.81	0.000083	0.9	1095.4	140.5	0.06
Big Hole	Upstream Chl	3518	1100 cfs	1100	5411.97	5421.9	5414.1	5421.89	0.000098	1.0	1105.7	141.4	0.06
Big Hole	Upstream Chl	3518	1200 cfs	1200	5411.97	5422.0	5414.2	5421.98	0.000112	1.1	1118.7	143.0	0.07
Big Hole	Upstream Chl	3518	1300 cfs	1300	5411.97	5422.1	5414.3	5422.09	0.000126	1.2	1133.9	144.9	0.07
Big Hole	Upstream Chl	3518	1400 cfs	1400	5411.97	5422.2	5414.4	5422.21	0.000140	1.2	1151.6	154.0	0.07
Big Hole	Upstream Chl	3518	1500 cfs	1500	5411.97	5422.3	5414.4	5422.34	0.000153	1.3	1171.7	158.2	0.08
Big Hole	Upstream Chl	3518	1600 cfs	1600	5411.97	5422.4	5414.5	5422.48	0.000165	1.4	1192.9	160.2	0.08
Big Hole	Upstream Chl	3518	1700 cfs	1700	5411.97	5422.3	5414.6	5422.38	0.000194	1.5	1176.9	158.7	0.09

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3518	1800 cfs	1800	5411.97	5422.4	5414.7	5422.44	0.000212	1.5	1186.0	159.5	0.09
Big Hole	Upstream Chl	3518	1900 cfs	1900	5411.97	5422.5	5414.8	5422.53	0.000230	1.6	1198.8	160.8	0.09
Big Hole	Upstream Chl	3518	2000 cfs	2000	5411.97	5422.6	5414.9	5422.62	0.000246	1.7	1213.6	162.1	0.10
Big Hole	Upstream Chl	3400	200 cfs	200	5413.00	5420.4	5414.0	5420.45	0.000007	0.2	875.1	149.0	0.02
Big Hole	Upstream Chl	3400	300 cfs	300	5413.00	5420.8	5414.1	5420.83	0.000014	0.3	933.1	150.2	0.02
Big Hole	Upstream Chl	3400	400 cfs	400	5413.00	5421.1	5414.3	5421.11	0.000021	0.4	974.0	151.1	0.03
Big Hole	Upstream Chl	3400	500 cfs	500	5413.00	5421.4	5414.4	5421.37	0.000029	0.5	1013.8	152.0	0.03
Big Hole	Upstream Chl	3400	600 cfs	600	5413.00	5421.5	5414.5	5421.55	0.000038	0.6	1041.5	152.6	0.04
Big Hole	Upstream Chl	3400	700 cfs	700	5413.00	5421.6	5414.6	5421.60	0.000051	0.7	1048.7	152.8	0.04
Big Hole	Upstream Chl	3400	800 cfs	800	5413.00	5421.7	5414.7	5421.68	0.000064	0.8	1059.6	153.0	0.05
Big Hole	Upstream Chl	3400	900 cfs	900	5413.00	5421.7	5414.9	5421.74	0.000079	0.9	1069.7	153.2	0.05
Big Hole	Upstream Chl	3400	1000 cfs	1000	5413.00	5421.8	5414.9	5421.80	0.000095	0.9	1078.3	153.4	0.06
Big Hole	Upstream Chl	3400	1100 cfs	1100	5413.00	5421.9	5415.0	5421.88	0.000112	1.0	1089.2	153.6	0.06
Big Hole	Upstream Chl	3400	1200 cfs	1200	5413.00	5421.9	5415.1	5421.97	0.000128	1.1	1103.0	153.9	0.07
Big Hole	Upstream Chl	3400	1300 cfs	1300	5413.00	5422.1	5415.2	5422.07	0.000143	1.2	1119.1	154.3	0.07
Big Hole	Upstream Chl	3400	1400 cfs	1400	5413.00	5422.2	5415.3	5422.19	0.000157	1.2	1137.2	154.6	0.08
Big Hole	Upstream Chl	3400	1500 cfs	1500	5413.00	5422.3	5415.4	5422.32	0.000171	1.3	1156.8	155.1	0.08
Big Hole	Upstream Chl	3400	1600 cfs	1600	5413.00	5422.4	5415.5	5422.46	0.000184	1.4	1177.2	155.5	0.08
Big Hole	Upstream Chl	3400	1700 cfs	1700	5413.00	5422.3	5415.6	5422.36	0.000217	1.5	1161.0	155.1	0.09
Big Hole	Upstream Chl	3400	1800 cfs	1800	5413.00	5422.4	5415.6	5422.42	0.000238	1.6	1169.6	155.3	0.10
Big Hole	Upstream Chl	3400	1900 cfs	1900	5413.00	5422.5	5415.7	5422.50	0.000257	1.6	1181.6	155.6	0.10
Big Hole	Upstream Chl	3400	2000 cfs	2000	5413.00	5422.5	5415.8	5422.59	0.000274	1.7	1195.6	155.9	0.10
Big Hole	Upstream Chl	3373	200 cfs	200	5414.00	5420.4	5415.5	5420.45	0.000011	0.3	610.1	153.5	0.03
Big Hole	Upstream Chl	3373	300 cfs	300	5414.00	5420.8	5415.8	5420.83	0.000018	0.5	669.6	154.8	0.04
Big Hole	Upstream Chl	3373	400 cfs	400	5414.00	5421.1	5416.1	5421.11	0.000027	0.6	711.6	155.7	0.05
Big Hole	Upstream Chl	3373	500 cfs	500	5414.00	5421.4	5416.3	5421.37	0.000035	0.7	752.4	156.5	0.05
Big Hole	Upstream Chl	3373	600 cfs	600	5414.00	5421.5	5416.5	5421.55	0.000045	0.8	780.7	157.1	0.06
Big Hole	Upstream Chl	3373	700 cfs	700	5414.00	5421.6	5416.6	5421.60	0.000060	0.9	787.8	157.3	0.07
Big Hole	Upstream Chl	3373	800 cfs	800	5414.00	5421.7	5416.8	5421.67	0.000075	1.0	798.7	157.5	0.08
Big Hole	Upstream Chl	3373	900 cfs	900	5414.00	5421.7	5416.9	5421.74	0.000091	1.1	808.8	157.7	0.09
Big Hole	Upstream Chl	3373	1000 cfs	1000	5414.00	5421.8	5417.0	5421.80	0.000108	1.2	817.2	157.9	0.09
Big Hole	Upstream Chl	3373	1100 cfs	1100	5414.00	5421.8	5417.1	5421.87	0.000126	1.4	828.1	158.1	0.10
Big Hole	Upstream Chl	3373	1200 cfs	1200	5414.00	5421.9	5417.2	5421.96	0.000142	1.5	842.0	158.4	0.11
Big Hole	Upstream Chl	3373	1300 cfs	1300	5414.00	5422.0	5417.3	5422.07	0.000157	1.5	858.1	158.8	0.11
Big Hole	Upstream Chl	3373	1400 cfs	1400	5414.00	5422.1	5417.4	5422.19	0.000170	1.6	876.5	159.3	0.12
Big Hole	Upstream Chl	3373	1500 cfs	1500	5414.00	5422.3	5417.5	5422.32	0.000182	1.7	896.3	159.8	0.12
Big Hole	Upstream Chl	3373	1600 cfs	1600	5414.00	5422.4	5417.7	5422.45	0.000193	1.8	917.2	160.3	0.13
Big Hole	Upstream Chl	3373	1700 cfs	1700	5414.00	5422.3	5417.7	5422.35	0.000232	1.9	899.6	159.9	0.14
Big Hole	Upstream Chl	3373	1800 cfs	1800	5414.00	5422.3	5417.8	5422.41	0.000252	2.0	908.0	160.1	0.14
Big Hole	Upstream Chl	3373	1900 cfs	1900	5414.00	5422.4	5417.9	5422.49	0.000270	2.1	920.0	160.4	0.15
Big Hole	Upstream Chl	3373	2000 cfs	2000	5414.00	5422.5	5418.0	5422.58	0.000285	2.2	934.1	160.7	0.15
Big Hole	Upstream Chl	3363	200 cfs	200	5418.00	5420.2	5419.6	5420.43	0.011550	3.4	58.7	68.5	0.65
Big Hole	Upstream Chl	3363	300 cfs	300	5418.00	5420.6	5420.2	5420.81	0.008069	3.6	84.5	70.7	0.57
Big Hole	Upstream Chl	3363	400 cfs	400	5418.00	5420.8	5420.4	5421.08	0.008486	4.0	99.6	72.0	0.60
Big Hole	Upstream Chl	3363	500 cfs	500	5418.00	5421.3	5420.6	5421.36	0.010030	2.5	200.7	338.9	0.57
Big Hole	Upstream Chl	3363	600 cfs	600	5418.00	5421.5	5420.7	5421.54	0.005380	2.2	270.0	338.9	0.44
Big Hole	Upstream Chl	3363	700 cfs	700	5418.00	5421.5	5421.2	5421.59	0.006623	2.5	278.3	338.9	0.49
Big Hole	Upstream Chl	3363	800 cfs	800	5418.00	5421.5	5421.2	5421.66	0.006916	2.7	297.7	338.9	0.51
Big Hole	Upstream Chl	3363	900 cfs	900	5418.00	5421.6	5421.3	5421.73	0.007223	2.9	315.4	338.9	0.52
Big Hole	Upstream Chl	3363	1000 cfs	1000	5418.00	5421.6	5421.3	5421.78	0.007803	3.0	328.3	338.9	0.55
Big Hole	Upstream Chl	3363	1100 cfs	1100	5418.00	5421.7	5421.3	5421.85	0.007670	3.1	349.5	338.9	0.55
Big Hole	Upstream Chl	3363	1200 cfs	1200	5418.00	5421.8	5421.4	5421.95	0.006894	3.2	380.2	338.9	0.53
Big Hole	Upstream Chl	3363	1300 cfs	1300	5418.00	5421.9	5421.4	5422.05	0.005915	3.1	417.8	338.9	0.49
Big Hole	Upstream Chl	3363	1400 cfs	1400	5418.00	5422.0	5421.5	5422.17	0.004947	3.0	461.0	338.9	0.46
Big Hole	Upstream Chl	3363	1500 cfs	1500	5418.00	5422.2	5421.5	5422.30	0.004132	3.0	507.3	338.9	0.43
Big Hole	Upstream Chl	3363	1600 cfs	1600	5418.00	5422.3	5421.5	5422.44	0.003475	2.9	555.6	338.9	0.40
Big Hole	Upstream Chl	3363	1700 cfs	1700	5418.00	5422.2	5421.6	5422.33	0.005465	3.4	502.9	338.9	0.49
Big Hole	Upstream Chl	3363	1800 cfs	1800	5418.00	5422.2	5421.6	5422.39	0.005508	3.5	519.2	338.9	0.49
Big Hole	Upstream Chl	3363	1900 cfs	1900	5418.00	5422.3	5421.6	5422.47	0.005192	3.5	546.1	338.9	0.48
Big Hole	Upstream Chl	3363	2000 cfs	2000	5418.00	5422.4	5421.7	5422.56	0.004754	3.5	578.3	338.9	0.47
Big Hole	Upstream Chl	3353	200 cfs	200	5418.00	5419.6	5419.6	5420.22	0.024420	6.4	31.2	24.5	1.00
Big Hole	Upstream Chl	3353	300 cfs	300	5418.00	5420.2	5420.2	5420.65	0.028472	5.3	57.1	68.3	1.01
Big Hole	Upstream Chl	3353	400 cfs	400	5418.00	5420.4	5420.4	5420.92	0.025545	5.7	70.6	69.5	0.99
Big Hole	Upstream Chl	3353	500 cfs	500	5418.00	5420.6	5420.6	5421.16	0.025021	6.1	81.6	70.5	1.00
Big Hole	Upstream Chl	3353	600 cfs	600	5418.00	5420.7	5420.7	5421.38	0.025071	6.6	91.5	71.3	1.02
Big Hole	Upstream Chl	3353	700 cfs	700	5418.00	5421.2	5421.2	5421.44	0.039322	4.3	163.0	338.9	1.09
Big Hole	Upstream Chl	3353	800 cfs	800	5418.00	5421.2	5421.2	5421.51	0.036211	4.4	181.0	338.9	1.07
Big Hole	Upstream Chl	3353	900 cfs	900	5418.00	5421.3	5421.3	5421.57	0.032766	4.5	200.2	338.9	1.03
Big Hole	Upstream Chl	3353	1000 cfs	1000	5418.00	5421.4	5421.3	5421.65	0.021550	4.1	241.9	338.9	0.86
Big Hole	Upstream Chl	3353	1100 cfs	1100	5418.00	5421.5	5421.3	5421.74	0.014865	3.8	286.4	338.9	0.74
Big Hole	Upstream Chl	3353	1200 cfs	1200	5418.00	5421.7	5421.4	5421.86	0.010550	3.6	334.6	338.9	0.64
Big Hole	Upstream Chl	3353	1300 cfs	1300	5418.00	5421.8	5421.4	5421.98	0.007805	3.4	384.4	338.9	0.56
Big Hole	Upstream Chl	3353	1400 cfs	1400	5418.00	5422.0	5421.5	5422.12	0.005961	3.2	435.8	338.9	0.50
Big Hole	Upstream Chl	3353	1500 cfs	1500	5418.00	5422.1	5421.5	5422.26	0.004707	3.1	487.8	338.9	0.45

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3353	1600 cfs	1600	5418.00	5422.3	5421.5	5422.40	0.003819	3.0	540.1	338.9	0.41
Big Hole	Upstream Chl	3353	1700 cfs	1700	5418.00	5422.1	5421.6	5422.27	0.006671	3.6	473.6	338.9	0.54
Big Hole	Upstream Chl	3353	1800 cfs	1800	5418.00	5422.1	5421.6	5422.33	0.006665	3.7	490.3	338.9	0.54
Big Hole	Upstream Chl	3353	1900 cfs	1900	5418.00	5422.2	5421.7	5422.41	0.006098	3.7	520.2	338.9	0.52
Big Hole	Upstream Chl	3353	2000 cfs	2000	5418.00	5422.3	5421.7	5422.51	0.005419	3.6	556.0	338.9	0.49
Big Hole	Upstream Chl	3318	200 cfs	200	5416.50	5417.5	5417.8	5418.67	0.092233	8.8	22.7	30.6	1.80
Big Hole	Upstream Chl	3318	300 cfs	300	5416.50	5417.8	5418.2	5419.07	0.071876	9.1	32.9	34.8	1.65
Big Hole	Upstream Chl	3318	400 cfs	400	5416.50	5418.0	5418.5	5419.46	0.066269	9.6	41.5	37.8	1.62
Big Hole	Upstream Chl	3318	500 cfs	500	5416.50	5418.2	5418.7	5419.79	0.059024	10.0	50.1	39.7	1.57
Big Hole	Upstream Chl	3318	600 cfs	600	5416.50	5418.5	5418.9	5420.07	0.052547	10.2	58.9	41.6	1.51
Big Hole	Upstream Chl	3318	700 cfs	700	5416.50	5418.9	5419.1	5420.14	0.031129	8.9	78.4	45.4	1.20
Big Hole	Upstream Chl	3318	800 cfs	800	5416.50	5419.2	5419.3	5420.37	0.025348	8.7	92.3	47.9	1.10
Big Hole	Upstream Chl	3318	900 cfs	900	5416.50	5419.5	5419.5	5420.60	0.020633	8.4	107.7	50.5	1.01
Big Hole	Upstream Chl	3318	1000 cfs	1000	5416.50	5419.7	5419.7	5420.83	0.020243	8.6	116.8	52.0	1.01
Big Hole	Upstream Chl	3318	1100 cfs	1100	5416.50	5419.9	5419.9	5421.05	0.019909	8.8	125.6	53.5	1.01
Big Hole	Upstream Chl	3318	1200 cfs	1200	5416.50	5420.0	5420.0	5421.26	0.019678	8.9	134.2	54.8	1.01
Big Hole	Upstream Chl	3318	1300 cfs	1300	5416.50	5420.2	5420.2	5421.46	0.019435	9.1	142.6	56.1	1.01
Big Hole	Upstream Chl	3318	1400 cfs	1400	5416.50	5420.3	5420.3	5421.65	0.019245	9.3	150.9	57.3	1.01
Big Hole	Upstream Chl	3318	1500 cfs	1500	5416.50	5420.5	5420.5	5421.84	0.018978	9.4	159.3	58.5	1.01
Big Hole	Upstream Chl	3318	1600 cfs	1600	5416.50	5420.6	5420.6	5422.02	0.018782	9.6	167.4	59.7	1.01
Big Hole	Upstream Chl	3318	1700 cfs	1700	5416.50	5421.5	5421.3	5421.88	0.018204	5.1	330.1	292.8	0.85
Big Hole	Upstream Chl	3318	1800 cfs	1800	5416.50	5421.7	5421.4	5422.02	0.011215	4.6	395.3	292.8	0.69
Big Hole	Upstream Chl	3318	1900 cfs	1900	5416.50	5421.9	5421.4	5422.16	0.008055	4.2	451.2	292.8	0.60
Big Hole	Upstream Chl	3318	2000 cfs	2000	5416.50	5422.1	5421.4	5422.30	0.006319	4.0	500.7	292.8	0.54
Big Hole	Upstream Chl	3308	200 cfs	200	5416.07	5417.3	5417.4	5417.92	0.041528	6.5	30.6	35.4	1.24
Big Hole	Upstream Chl	3308	300 cfs	300	5416.07	5417.5	5417.7	5418.40	0.045852	7.7	39.1	38.3	1.34
Big Hole	Upstream Chl	3308	400 cfs	400	5416.07	5417.7	5418.0	5418.81	0.047742	8.5	47.2	40.8	1.39
Big Hole	Upstream Chl	3308	500 cfs	500	5416.07	5417.9	5418.2	5419.18	0.049871	9.2	54.3	43.0	1.44
Big Hole	Upstream Chl	3308	600 cfs	600	5416.07	5418.0	5418.5	5419.50	0.050513	9.8	61.5	44.9	1.47
Big Hole	Upstream Chl	3308	700 cfs	700	5416.07	5418.2	5418.6	5419.75	0.045078	9.9	70.8	46.6	1.41
Big Hole	Upstream Chl	3308	800 cfs	800	5416.07	5418.4	5418.8	5419.99	0.042720	10.1	79.0	48.1	1.39
Big Hole	Upstream Chl	3308	900 cfs	900	5416.07	5418.5	5419.0	5420.25	0.042090	10.5	86.0	49.3	1.40
Big Hole	Upstream Chl	3308	1000 cfs	1000	5416.07	5418.7	5419.2	5420.48	0.041231	10.7	93.1	50.5	1.39
Big Hole	Upstream Chl	3308	1100 cfs	1100	5416.07	5418.8	5419.3	5420.70	0.040454	11.0	100.1	51.7	1.39
Big Hole	Upstream Chl	3308	1200 cfs	1200	5416.07	5419.0	5419.5	5420.91	0.039758	11.2	106.9	52.8	1.39
Big Hole	Upstream Chl	3308	1300 cfs	1300	5416.07	5419.1	5419.6	5421.11	0.039106	11.4	113.6	53.8	1.39
Big Hole	Upstream Chl	3308	1400 cfs	1400	5416.07	5419.2	5419.8	5421.31	0.038468	11.6	120.3	54.9	1.38
Big Hole	Upstream Chl	3308	1500 cfs	1500	5416.07	5419.3	5419.9	5421.49	0.037931	11.8	126.9	55.9	1.38
Big Hole	Upstream Chl	3308	1600 cfs	1600	5416.07	5419.4	5420.0	5421.67	0.037452	12.0	133.3	56.9	1.38
Big Hole	Upstream Chl	3308	1700 cfs	1700	5416.07	5420.2	5420.2	5421.60	0.018647	9.6	177.9	63.1	1.00
Big Hole	Upstream Chl	3308	1800 cfs	1800	5416.07	5420.3	5420.3	5421.76	0.018487	9.7	185.8	64.2	1.00
Big Hole	Upstream Chl	3308	1900 cfs	1900	5416.07	5420.4	5420.4	5421.92	0.018405	9.8	193.4	65.2	1.01
Big Hole	Upstream Chl	3308	2000 cfs	2000	5416.07	5420.5	5420.5	5422.07	0.018225	9.9	201.3	66.2	1.00
Big Hole	Upstream Chl	3283	200 cfs	200	5415.00	5417.2	5416.3	5417.32	0.002538	2.4	84.1	54.3	0.34
Big Hole	Upstream Chl	3283	300 cfs	300	5415.00	5417.5	5416.6	5417.66	0.003415	3.0	100.3	57.3	0.40
Big Hole	Upstream Chl	3283	400 cfs	400	5415.00	5417.8	5416.8	5417.95	0.004131	3.5	114.5	59.8	0.44
Big Hole	Upstream Chl	3283	500 cfs	500	5415.00	5418.0	5417.0	5418.21	0.004761	3.9	127.3	61.9	0.48
Big Hole	Upstream Chl	3283	600 cfs	600	5415.00	5418.2	5417.2	5418.45	0.005308	4.3	138.9	63.5	0.52
Big Hole	Upstream Chl	3283	700 cfs	700	5415.00	5418.3	5417.4	5418.66	0.005810	4.7	149.6	64.9	0.54
Big Hole	Upstream Chl	3283	800 cfs	800	5415.00	5418.5	5417.6	5418.86	0.006317	5.0	159.3	66.2	0.57
Big Hole	Upstream Chl	3283	900 cfs	900	5415.00	5418.6	5417.8	5419.05	0.006776	5.3	168.6	67.4	0.59
Big Hole	Upstream Chl	3283	1000 cfs	1000	5415.00	5418.7	5417.9	5419.23	0.007246	5.6	177.2	68.5	0.62
Big Hole	Upstream Chl	3283	1100 cfs	1100	5415.00	5418.9	5418.1	5419.40	0.007670	5.9	185.6	69.5	0.64
Big Hole	Upstream Chl	3283	1200 cfs	1200	5415.00	5419.0	5418.2	5419.57	0.008106	6.2	193.3	70.4	0.66
Big Hole	Upstream Chl	3283	1300 cfs	1300	5415.00	5419.1	5418.3	5419.73	0.008499	6.5	201.1	71.4	0.68
Big Hole	Upstream Chl	3283	1400 cfs	1400	5415.00	5417.8	5418.5	5420.02	0.047278	11.9	117.2	60.2	1.51
Big Hole	Upstream Chl	3283	1500 cfs	1500	5415.00	5417.9	5418.6	5420.21	0.047271	12.2	123.0	61.2	1.52
Big Hole	Upstream Chl	3283	1600 cfs	1600	5415.00	5418.0	5418.7	5420.44	0.049527	12.6	126.6	61.8	1.56
Big Hole	Upstream Chl	3283	1700 cfs	1700	5415.00	5419.5	5418.8	5420.32	0.009857	7.4	230.2	74.8	0.74
Big Hole	Upstream Chl	3283	1800 cfs	1800	5415.00	5419.6	5418.9	5420.46	0.010212	7.6	236.7	75.5	0.76
Big Hole	Upstream Chl	3283	1900 cfs	1900	5415.00	5419.6	5419.0	5420.59	0.010622	7.8	242.4	76.1	0.77
Big Hole	Upstream Chl	3283	2000 cfs	2000	5415.00	5419.7	5419.2	5420.72	0.011013	8.1	248.1	76.8	0.79
Big Hole	Upstream Chl	3273	200 cfs	200	5415.00	5417.2	5416.0	5417.29	0.001267	1.8	109.4	62.2	0.24
Big Hole	Upstream Chl	3273	300 cfs	300	5415.00	5417.5	5416.2	5417.61	0.001786	2.3	128.1	64.9	0.29
Big Hole	Upstream Chl	3273	400 cfs	400	5415.00	5417.8	5416.5	5417.90	0.002228	2.8	144.5	67.2	0.33
Big Hole	Upstream Chl	3273	500 cfs	500	5415.00	5418.0	5416.7	5418.14	0.002630	3.1	159.0	69.2	0.37
Big Hole	Upstream Chl	3273	600 cfs	600	5415.00	5418.2	5416.9	5418.37	0.002996	3.5	172.2	70.8	0.39
Big Hole	Upstream Chl	3273	700 cfs	700	5415.00	5418.3	5417.0	5418.57	0.003335	3.8	184.4	72.2	0.42
Big Hole	Upstream Chl	3273	800 cfs	800	5415.00	5418.5	5417.2	5418.76	0.003670	4.1	195.6	73.5	0.44
Big Hole	Upstream Chl	3273	900 cfs	900	5415.00	5418.6	5417.3	5418.94	0.003982	4.4	206.2	74.8	0.46
Big Hole	Upstream Chl	3273	1000 cfs	1000	5415.00	5418.8	5417.5	5419.11	0.004275	4.6	216.3	75.9	0.48
Big Hole	Upstream Chl	3273	1100 cfs	1100	5415.00	5418.9	5417.6	5419.27	0.004555	4.9	226.0	77.0	0.50
Big Hole	Upstream Chl	3273	1200 cfs	1200	5415.00	5419.0	5417.8	5419.43	0.004815	5.1	235.5	78.0	0.52
Big Hole	Upstream Chl	3273	1300 cfs	1300	5415.00	5419.1	5417.9	5419.58	0.005067	5.3	244.6	79.0	0.53

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3273	1400 cfs	1400	5415.00	5419.3	5418.0	5419.73	0.005300	5.5	253.5	79.9	0.55
Big Hole	Upstream Chl	3273	1500 cfs	1500	5415.00	5419.4	5418.1	5419.87	0.005533	5.7	262.0	80.8	0.56
Big Hole	Upstream Chl	3273	1600 cfs	1600	5415.00	5419.5	5418.3	5420.01	0.005746	5.9	270.5	81.7	0.57
Big Hole	Upstream Chl	3273	1700 cfs	1700	5415.00	5419.6	5418.4	5420.14	0.005956	6.1	278.7	82.6	0.59
Big Hole	Upstream Chl	3273	1800 cfs	1800	5415.00	5419.7	5418.5	5420.27	0.006182	6.3	286.3	83.3	0.60
Big Hole	Upstream Chl	3273	1900 cfs	1900	5415.00	5419.7	5418.6	5420.39	0.006434	6.5	293.2	84.0	0.61
Big Hole	Upstream Chl	3273	2000 cfs	2000	5415.00	5419.8	5418.7	5420.51	0.006651	6.7	300.4	84.8	0.62
Big Hole	Upstream Chl	3235	200 cfs	200	5415.00	5417.2	5416.0	5417.23	0.000873	1.4	144.6	94.9	0.20
Big Hole	Upstream Chl	3235	300 cfs	300	5415.00	5417.5	5416.2	5417.54	0.001136	1.7	172.6	97.8	0.23
Big Hole	Upstream Chl	3235	400 cfs	400	5415.00	5417.7	5416.4	5417.80	0.001344	2.0	197.0	100.3	0.26
Big Hole	Upstream Chl	3235	500 cfs	500	5415.00	5418.0	5416.5	5418.03	0.001528	2.3	218.6	102.4	0.28
Big Hole	Upstream Chl	3235	600 cfs	600	5415.00	5418.1	5416.7	5418.24	0.001694	2.5	238.2	104.3	0.29
Big Hole	Upstream Chl	3235	700 cfs	700	5415.00	5418.3	5416.8	5418.43	0.001849	2.7	256.2	106.0	0.31
Big Hole	Upstream Chl	3235	800 cfs	800	5415.00	5418.5	5417.0	5418.60	0.001997	2.9	272.8	107.6	0.32
Big Hole	Upstream Chl	3235	900 cfs	900	5415.00	5418.6	5417.1	5418.77	0.002132	3.1	288.7	109.0	0.34
Big Hole	Upstream Chl	3235	1000 cfs	1000	5415.00	5418.8	5417.2	5418.92	0.002260	3.3	303.7	110.4	0.35
Big Hole	Upstream Chl	3235	1100 cfs	1100	5415.00	5418.9	5417.3	5419.07	0.002375	3.5	318.4	111.7	0.36
Big Hole	Upstream Chl	3235	1200 cfs	1200	5415.00	5419.0	5417.4	5419.21	0.002486	3.6	332.4	113.0	0.37
Big Hole	Upstream Chl	3235	1300 cfs	1300	5415.00	5419.1	5417.5	5419.35	0.002586	3.8	346.1	114.2	0.38
Big Hole	Upstream Chl	3235	1400 cfs	1400	5415.00	5419.2	5417.6	5419.48	0.002681	3.9	359.5	115.3	0.39
Big Hole	Upstream Chl	3235	1500 cfs	1500	5415.00	5419.4	5417.7	5419.61	0.002771	4.0	372.4	116.5	0.40
Big Hole	Upstream Chl	3235	1600 cfs	1600	5415.00	5419.5	5417.8	5419.73	0.002855	4.2	385.1	117.5	0.40
Big Hole	Upstream Chl	3235	1700 cfs	1700	5415.00	5419.6	5417.8	5419.85	0.002936	4.3	397.4	118.6	0.41
Big Hole	Upstream Chl	3235	1800 cfs	1800	5415.00	5419.7	5417.9	5419.97	0.003012	4.4	409.6	119.6	0.42
Big Hole	Upstream Chl	3235	1900 cfs	1900	5415.00	5419.8	5418.0	5420.09	0.003083	4.5	421.6	120.6	0.42
Big Hole	Upstream Chl	3235	2000 cfs	2000	5415.00	5419.9	5418.1	5420.20	0.003155	4.6	433.2	121.6	0.43
Big Hole	Upstream Chl	3233	200 cfs	200	5416.00	5416.9	5416.9	5417.20	0.021527	4.2	47.7	65.6	0.87
Big Hole	Upstream Chl	3233	300 cfs	300	5416.00	5417.1	5417.1	5417.50	0.026570	5.1	58.7	70.3	0.99
Big Hole	Upstream Chl	3233	400 cfs	400	5416.00	5417.3	5417.3	5417.75	0.026599	5.6	71.7	75.3	1.01
Big Hole	Upstream Chl	3233	500 cfs	500	5416.00	5417.4	5417.4	5417.98	0.025844	5.9	84.7	80.0	1.01
Big Hole	Upstream Chl	3233	600 cfs	600	5416.00	5417.6	5417.6	5418.18	0.025079	6.2	97.4	84.3	1.01
Big Hole	Upstream Chl	3233	700 cfs	700	5416.00	5417.7	5417.7	5418.37	0.024340	6.4	109.8	88.3	1.01
Big Hole	Upstream Chl	3233	800 cfs	800	5416.00	5417.9	5417.9	5418.54	0.023738	6.6	121.9	92.0	1.01
Big Hole	Upstream Chl	3233	900 cfs	900	5416.00	5418.0	5418.0	5418.70	0.023636	6.8	132.8	95.3	1.01
Big Hole	Upstream Chl	3233	1000 cfs	1000	5416.00	5418.1	5418.1	5418.85	0.023059	7.0	143.6	97.0	1.01
Big Hole	Upstream Chl	3233	1100 cfs	1100	5416.00	5418.2	5418.2	5419.00	0.022716	7.2	153.6	98.4	1.01
Big Hole	Upstream Chl	3233	1200 cfs	1200	5416.00	5418.3	5418.3	5419.14	0.022094	7.3	164.1	99.9	1.01
Big Hole	Upstream Chl	3233	1300 cfs	1300	5416.00	5418.4	5418.4	5419.27	0.021862	7.5	173.7	101.2	1.01
Big Hole	Upstream Chl	3233	1400 cfs	1400	5416.00	5418.5	5418.5	5419.40	0.021593	7.6	183.2	102.5	1.01
Big Hole	Upstream Chl	3233	1500 cfs	1500	5416.00	5418.6	5418.6	5419.53	0.021353	7.8	192.5	103.7	1.01
Big Hole	Upstream Chl	3233	1600 cfs	1600	5416.00	5418.7	5418.7	5419.65	0.021049	7.9	201.9	104.9	1.01
Big Hole	Upstream Chl	3233	1700 cfs	1700	5416.00	5418.8	5418.8	5419.77	0.020820	8.1	211.0	106.1	1.01
Big Hole	Upstream Chl	3233	1800 cfs	1800	5416.00	5418.8	5418.8	5419.89	0.020646	8.2	219.9	107.3	1.01
Big Hole	Upstream Chl	3233	1900 cfs	1900	5416.00	5418.9	5418.9	5420.00	0.020567	8.3	228.3	108.3	1.01
Big Hole	Upstream Chl	3233	2000 cfs	2000	5416.00	5419.0	5419.0	5420.11	0.020291	8.4	237.4	109.5	1.01
Big Hole	Upstream Chl	3223	200 cfs	200	5416.00	5416.7	5416.7	5416.94	0.031030	4.3	46.6	81.5	1.00
Big Hole	Upstream Chl	3223	300 cfs	300	5416.00	5416.8	5416.8	5417.20	0.029326	4.8	62.2	87.5	1.01
Big Hole	Upstream Chl	3223	400 cfs	400	5416.00	5416.9	5417.0	5417.44	0.037230	5.7	69.7	90.2	1.15
Big Hole	Upstream Chl	3223	500 cfs	500	5416.00	5417.0	5417.1	5417.65	0.039240	6.3	79.4	93.3	1.20
Big Hole	Upstream Chl	3223	600 cfs	600	5416.00	5417.1	5417.3	5417.85	0.042181	6.9	87.3	94.9	1.26
Big Hole	Upstream Chl	3223	700 cfs	700	5416.00	5417.2	5417.4	5418.03	0.042196	7.2	96.6	96.8	1.28
Big Hole	Upstream Chl	3223	800 cfs	800	5416.00	5417.3	5417.5	5418.20	0.042255	7.6	105.3	98.6	1.29
Big Hole	Upstream Chl	3223	900 cfs	900	5416.00	5417.4	5417.6	5418.36	0.041753	7.9	114.3	100.4	1.30
Big Hole	Upstream Chl	3223	1000 cfs	1000	5416.00	5417.5	5417.7	5418.51	0.042518	8.2	121.8	101.9	1.32
Big Hole	Upstream Chl	3223	1100 cfs	1100	5416.00	5417.5	5417.8	5418.66	0.042445	8.5	129.8	103.4	1.33
Big Hole	Upstream Chl	3223	1200 cfs	1200	5416.00	5417.6	5417.9	5418.80	0.042403	8.7	137.6	104.9	1.34
Big Hole	Upstream Chl	3223	1300 cfs	1300	5416.00	5417.7	5418.0	5418.94	0.042239	8.9	145.3	106.4	1.35
Big Hole	Upstream Chl	3223	1400 cfs	1400	5416.00	5417.8	5418.1	5419.07	0.041997	9.1	153.0	107.8	1.35
Big Hole	Upstream Chl	3223	1500 cfs	1500	5416.00	5417.8	5418.2	5419.19	0.041829	9.3	160.5	109.2	1.36
Big Hole	Upstream Chl	3223	1600 cfs	1600	5416.00	5417.9	5418.3	5419.31	0.041585	9.5	167.9	110.5	1.36
Big Hole	Upstream Chl	3223	1700 cfs	1700	5416.00	5418.0	5418.4	5419.43	0.041439	9.7	175.2	111.8	1.37
Big Hole	Upstream Chl	3223	1800 cfs	1800	5416.00	5418.0	5418.4	5419.54	0.041359	9.9	182.3	113.2	1.37
Big Hole	Upstream Chl	3223	1900 cfs	1900	5416.00	5418.1	5418.5	5419.66	0.042014	10.1	188.3	114.6	1.39
Big Hole	Upstream Chl	3223	2000 cfs	2000	5416.00	5418.1	5418.6	5419.77	0.042108	10.3	195.1	116.1	1.39
Big Hole	Upstream Chl	3193	200 cfs	200	5414.00	5415.1	5414.9	5415.22	0.013299	3.0	66.0	103.1	0.67
Big Hole	Upstream Chl	3193	300 cfs	300	5414.00	5415.4	5415.1	5415.53	0.008687	3.0	98.9	112.0	0.57
Big Hole	Upstream Chl	3193	400 cfs	400	5414.00	5415.6	5415.2	5415.75	0.008218	3.3	121.9	117.8	0.57
Big Hole	Upstream Chl	3193	500 cfs	500	5414.00	5415.8	5415.3	5415.95	0.007933	3.5	143.3	122.9	0.57
Big Hole	Upstream Chl	3193	600 cfs	600	5414.00	5415.9	5415.5	5416.14	0.007704	3.7	163.8	127.7	0.57
Big Hole	Upstream Chl	3193	700 cfs	700	5414.00	5416.1	5415.6	5416.31	0.007434	3.8	183.5	131.0	0.57
Big Hole	Upstream Chl	3193	800 cfs	800	5414.00	5416.2	5415.7	5416.46	0.007369	4.0	200.5	132.9	0.57
Big Hole	Upstream Chl	3193	900 cfs	900	5414.00	5416.3	5415.8	5416.60	0.007168	4.1	218.2	134.9	0.57
Big Hole	Upstream Chl	3193	1000 cfs	1000	5414.00	5416.5	5415.9	5416.74	0.007128	4.3	234.1	136.7	0.58
Big Hole	Upstream Chl	3193	1100 cfs	1100	5414.00	5416.6	5416.0	5416.87	0.007040	4.4	250.1	138.4	0.58

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

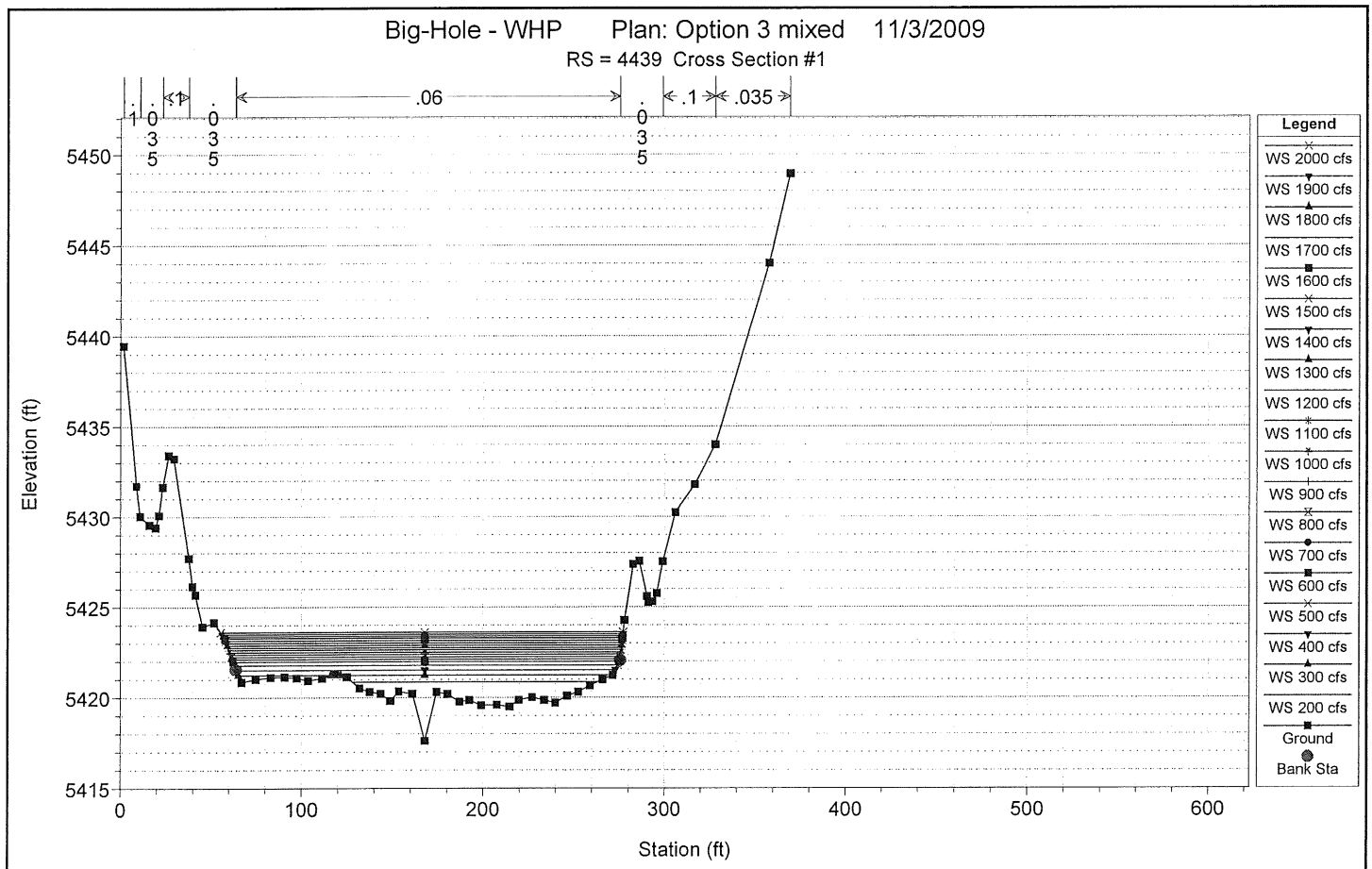
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3193	1200 cfs	1200	5414.00	5416.7	5416.0	5417.00	0.006946	4.5	265.9	140.1	0.58
Big Hole	Upstream Chl	3193	1300 cfs	1300	5414.00	5416.8	5416.1	5417.13	0.006862	4.6	281.3	141.8	0.58
Big Hole	Upstream Chl	3193	1400 cfs	1400	5414.00	5415.7	5416.2	5417.46	0.083820	10.8	129.7	119.7	1.83
Big Hole	Upstream Chl	3193	1500 cfs	1500	5414.00	5417.0	5416.3	5417.37	0.006720	4.8	311.2	144.9	0.58
Big Hole	Upstream Chl	3193	1600 cfs	1600	5414.00	5417.1	5416.4	5417.48	0.006664	4.9	325.6	146.4	0.58
Big Hole	Upstream Chl	3193	1700 cfs	1700	5414.00	5415.8	5416.4	5417.82	0.081054	11.4	149.4	124.4	1.83
Big Hole	Upstream Chl	3193	1800 cfs	1800	5414.00	5415.9	5416.5	5417.94	0.080817	11.6	155.5	125.8	1.84
Big Hole	Upstream Chl	3193	1900 cfs	1900	5414.00	5415.9	5416.6	5418.06	0.080545	11.8	161.5	127.2	1.84
Big Hole	Upstream Chl	3193	2000 cfs	2000	5414.00	5416.0	5416.6	5418.17	0.080258	11.9	167.4	128.5	1.84
Big Hole	Upstream Chl	3178	200 cfs	200	5413.00	5415.1	5414.1	5415.14	0.001161	1.3	152.0	133.2	0.22
Big Hole	Upstream Chl	3178	300 cfs	300	5413.00	5415.4	5414.3	5415.45	0.001276	1.5	194.3	143.7	0.23
Big Hole	Upstream Chl	3178	400 cfs	400	5413.00	5415.6	5414.5	5415.67	0.001490	1.8	224.7	150.9	0.26
Big Hole	Upstream Chl	3178	500 cfs	500	5413.00	5415.8	5414.6	5415.87	0.001657	2.0	253.0	157.2	0.27
Big Hole	Upstream Chl	3178	600 cfs	600	5413.00	5416.0	5414.7	5416.05	0.001790	2.1	279.8	163.0	0.29
Big Hole	Upstream Chl	3178	700 cfs	700	5413.00	5416.1	5414.9	5416.21	0.001869	2.3	305.7	166.8	0.30
Big Hole	Upstream Chl	3178	800 cfs	800	5413.00	5416.3	5415.0	5416.36	0.001969	2.4	328.4	169.7	0.31
Big Hole	Upstream Chl	3178	900 cfs	900	5413.00	5416.4	5415.1	5416.51	0.002013	2.6	352.1	172.0	0.31
Big Hole	Upstream Chl	3178	1000 cfs	1000	5413.00	5416.5	5415.2	5416.64	0.002065	2.7	373.2	173.1	0.32
Big Hole	Upstream Chl	3178	1100 cfs	1100	5413.00	5416.6	5415.3	5416.77	0.002098	2.8	394.3	174.1	0.33
Big Hole	Upstream Chl	3178	1200 cfs	1200	5413.00	5416.8	5415.3	5416.90	0.002123	2.9	415.0	175.1	0.33
Big Hole	Upstream Chl	3178	1300 cfs	1300	5413.00	5416.9	5415.4	5417.02	0.002148	3.0	435.0	176.1	0.34
Big Hole	Upstream Chl	3178	1400 cfs	1400	5413.00	5417.0	5415.5	5417.14	0.002169	3.1	454.6	177.0	0.34
Big Hole	Upstream Chl	3178	1500 cfs	1500	5413.00	5417.1	5415.6	5417.25	0.002185	3.2	473.4	177.5	0.34
Big Hole	Upstream Chl	3178	1600 cfs	1600	5413.00	5417.2	5415.6	5417.37	0.002198	3.3	491.8	177.9	0.34
Big Hole	Upstream Chl	3178	1700 cfs	1700	5413.00	5417.3	5415.7	5417.48	0.002209	3.3	509.8	178.3	0.35
Big Hole	Upstream Chl	3178	1800 cfs	1800	5413.00	5417.4	5415.8	5417.58	0.002221	3.4	527.3	178.7	0.35
Big Hole	Upstream Chl	3178	1900 cfs	1900	5413.00	5417.5	5415.9	5417.69	0.002233	3.5	544.4	179.1	0.35
Big Hole	Upstream Chl	3178	2000 cfs	2000	5413.00	5417.6	5415.9	5417.79	0.002243	3.6	561.3	179.5	0.36
Big Hole	Upstream Chl	3168	200 cfs	200	5413.00	5415.1	5413.7	5415.13	0.000362	0.9	234.1	163.0	0.13
Big Hole	Upstream Chl	3168	300 cfs	300	5413.00	5415.4	5413.9	5415.44	0.000438	1.1	284.8	166.7	0.14
Big Hole	Upstream Chl	3168	400 cfs	400	5413.00	5415.6	5414.0	5415.66	0.000540	1.3	319.9	169.2	0.16
Big Hole	Upstream Chl	3168	500 cfs	500	5413.00	5415.8	5414.2	5415.85	0.000628	1.4	351.5	171.4	0.18
Big Hole	Upstream Chl	3168	600 cfs	600	5413.00	5416.0	5414.3	5416.03	0.000705	1.6	380.6	173.4	0.19
Big Hole	Upstream Chl	3168	700 cfs	700	5413.00	5416.1	5414.5	5416.19	0.000766	1.7	408.1	174.2	0.20
Big Hole	Upstream Chl	3168	800 cfs	800	5413.00	5416.3	5414.5	5416.33	0.000833	1.9	431.9	174.8	0.21
Big Hole	Upstream Chl	3168	900 cfs	900	5413.00	5416.4	5414.6	5416.48	0.000883	2.0	456.2	175.4	0.22
Big Hole	Upstream Chl	3168	1000 cfs	1000	5413.00	5416.5	5414.7	5416.61	0.000938	2.1	477.9	175.9	0.22
Big Hole	Upstream Chl	3168	1100 cfs	1100	5413.00	5416.7	5414.8	5416.74	0.000984	2.2	499.5	176.4	0.23
Big Hole	Upstream Chl	3168	1200 cfs	1200	5413.00	5416.8	5414.8	5416.87	0.001026	2.3	520.6	176.9	0.24
Big Hole	Upstream Chl	3168	1300 cfs	1300	5413.00	5416.9	5414.9	5416.99	0.001064	2.4	540.9	177.4	0.24
Big Hole	Upstream Chl	3168	1400 cfs	1400	5413.00	5417.0	5415.0	5417.11	0.001100	2.5	560.7	177.8	0.25
Big Hole	Upstream Chl	3168	1500 cfs	1500	5413.00	5417.1	5415.0	5417.22	0.001134	2.6	579.8	178.3	0.25
Big Hole	Upstream Chl	3168	1600 cfs	1600	5413.00	5417.2	5415.1	5417.33	0.001165	2.7	598.4	178.7	0.26
Big Hole	Upstream Chl	3168	1700 cfs	1700	5413.00	5417.3	5415.2	5417.44	0.001195	2.8	616.6	179.1	0.26
Big Hole	Upstream Chl	3168	1800 cfs	1800	5413.00	5417.4	5415.2	5417.55	0.001224	2.8	634.3	179.5	0.27
Big Hole	Upstream Chl	3168	1900 cfs	1900	5413.00	5417.5	5415.3	5417.65	0.001251	2.9	651.6	179.9	0.27
Big Hole	Upstream Chl	3168	2000 cfs	2000	5413.00	5417.6	5415.4	5417.75	0.001276	3.0	668.6	180.3	0.27
Big Hole	Upstream Chl	3130	200 cfs	200	5413.00	5415.1	5413.7	5415.12	0.000222	0.7	280.6	177.5	0.10
Big Hole	Upstream Chl	3130	300 cfs	300	5413.00	5415.4	5413.8	5415.43	0.000282	0.9	335.2	179.6	0.12
Big Hole	Upstream Chl	3130	400 cfs	400	5413.00	5415.6	5414.0	5415.64	0.000357	1.1	372.4	181.0	0.13
Big Hole	Upstream Chl	3130	500 cfs	500	5413.00	5415.8	5414.1	5415.83	0.000423	1.2	405.8	182.3	0.15
Big Hole	Upstream Chl	3130	600 cfs	600	5413.00	5416.0	5414.2	5416.00	0.000483	1.4	436.4	183.5	0.16
Big Hole	Upstream Chl	3130	700 cfs	700	5413.00	5416.1	5414.2	5416.16	0.000534	1.5	465.3	184.2	0.17
Big Hole	Upstream Chl	3130	800 cfs	800	5413.00	5416.3	5414.3	5416.31	0.000589	1.6	490.2	184.8	0.18
Big Hole	Upstream Chl	3130	900 cfs	900	5413.00	5416.4	5414.4	5416.45	0.000633	1.7	515.8	185.3	0.18
Big Hole	Upstream Chl	3130	1000 cfs	1000	5413.00	5416.5	5414.5	5416.58	0.000680	1.9	538.5	185.8	0.19
Big Hole	Upstream Chl	3130	1100 cfs	1100	5413.00	5416.6	5414.6	5416.71	0.000720	2.0	561.1	186.3	0.20
Big Hole	Upstream Chl	3130	1200 cfs	1200	5413.00	5416.8	5414.6	5416.83	0.000757	2.1	583.2	186.8	0.21
Big Hole	Upstream Chl	3130	1300 cfs	1300	5413.00	5416.9	5414.7	5416.95	0.000791	2.2	604.5	187.2	0.21
Big Hole	Upstream Chl	3130	1400 cfs	1400	5413.00	5417.0	5414.7	5417.07	0.000823	2.2	625.3	187.7	0.22
Big Hole	Upstream Chl	3130	1500 cfs	1500	5413.00	5417.1	5414.8	5417.18	0.000854	2.3	645.4	188.1	0.22
Big Hole	Upstream Chl	3130	1600 cfs	1600	5413.00	5417.2	5414.9	5417.29	0.000882	2.4	665.0	188.5	0.23
Big Hole	Upstream Chl	3130	1700 cfs	1700	5413.00	5417.3	5414.9	5417.40	0.000910	2.5	684.0	188.9	0.23
Big Hole	Upstream Chl	3130	1800 cfs	1800	5413.00	5417.4	5415.0	5417.50	0.000936	2.6	702.7	189.3	0.23
Big Hole	Upstream Chl	3130	1900 cfs	1900	5413.00	5417.5	5415.0	5417.60	0.000961	2.6	720.8	189.7	0.24
Big Hole	Upstream Chl	3130	2000 cfs	2000	5413.00	5417.6	5415.1	5417.70	0.000984	2.7	738.8	190.1	0.24
Big Hole	Upstream Chl	3128	200 cfs	200	5414.00	5415.1	5414.5	5415.11	0.001817	1.3	148.2	175.0	0.26
Big Hole	Upstream Chl	3128	300 cfs	300	5414.00	5415.4	5414.6	5415.42	0.001492	1.5	201.9	177.9	0.25
Big Hole	Upstream Chl	3128	400 cfs	400	5414.00	5415.6	5414.7	5415.63	0.001556	1.7	238.0	179.8	0.26
Big Hole	Upstream Chl	3128	500 cfs	500	5414.00	5415.8	5414.8	5415.82	0.001610	1.8	270.3	181.5	0.27
Big Hole	Upstream Chl	3128	600 cfs	600	5414.00	5415.9	5414.9	5416.00	0.001653	2.0	300.3	183.1	0.27
Big Hole	Upstream Chl	3128	700 cfs	700	5414.00	5416.1	5415.0	5416.16	0.001683	2.1	328.6	184.5	0.28
Big Hole	Upstream Chl	3128	800 cfs	800	5414.00	5416.2	5415.1	5416.30	0.001750	2.3	352.8	185.7	0.29
Big Hole	Upstream Chl	3128	900 cfs	900	5414.00	5416.4	5415.2	5416.44	0.001775	2.4	378.1	187.0	0.29

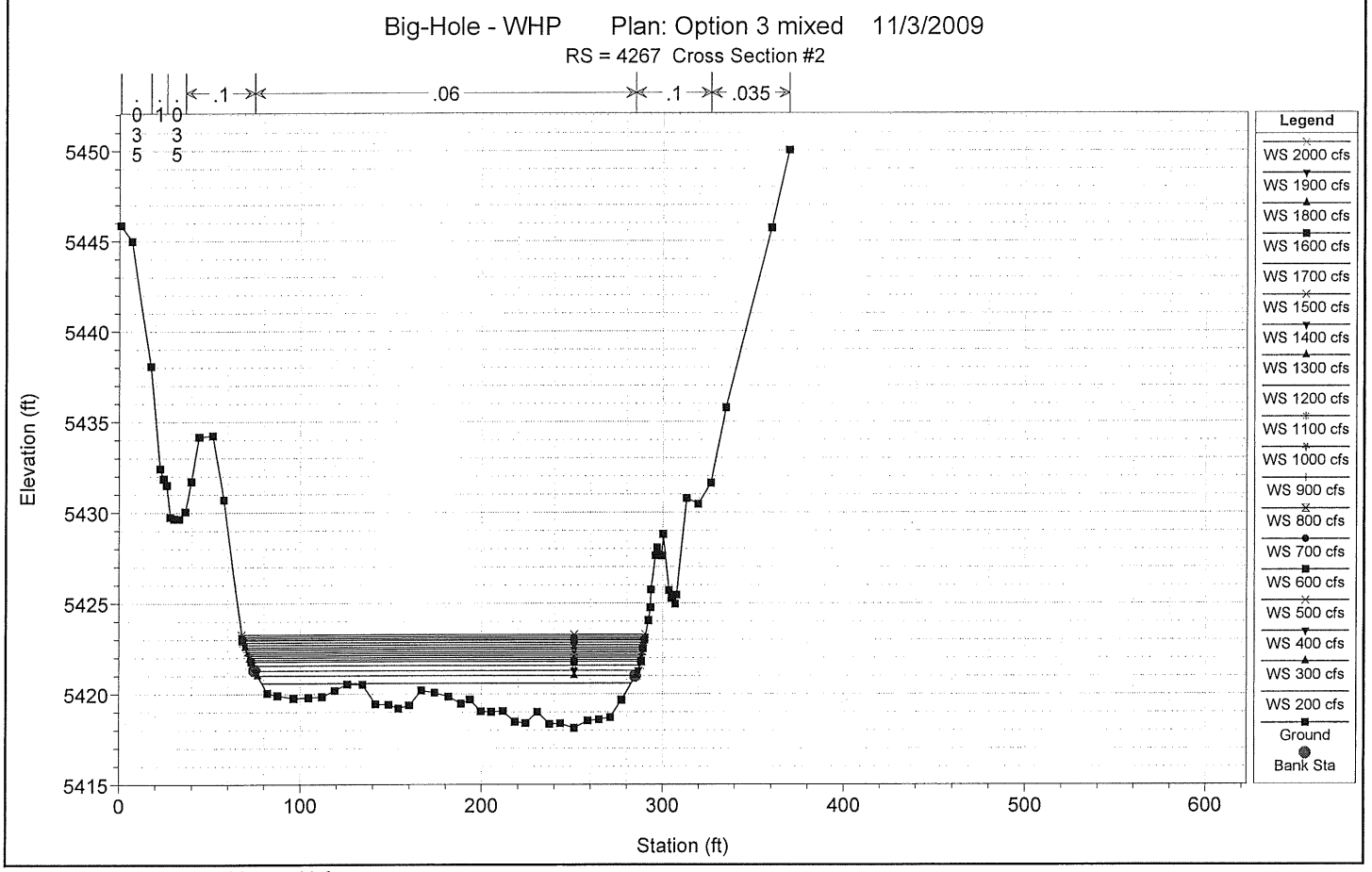
HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	3128	1000 cfs	1000	5414.00	5416.5	5415.2	5416.57	0.001823	2.5	400.6	188.1	0.30
Big Hole	Upstream Chl	3128	1100 cfs	1100	5414.00	5416.6	5415.3	5416.70	0.001847	2.6	423.1	188.7	0.31
Big Hole	Upstream Chl	3128	1200 cfs	1200	5414.00	5416.7	5415.4	5416.82	0.001865	2.7	445.1	189.2	0.31
Big Hole	Upstream Chl	3128	1300 cfs	1300	5414.00	5416.8	5415.4	5416.94	0.001882	2.8	466.3	189.7	0.31
Big Hole	Upstream Chl	3128	1400 cfs	1400	5414.00	5416.9	5415.5	5417.06	0.001897	2.9	486.9	190.1	0.32
Big Hole	Upstream Chl	3128	1500 cfs	1500	5414.00	5417.0	5415.6	5417.17	0.001910	3.0	507.0	190.5	0.32
Big Hole	Upstream Chl	3128	1600 cfs	1600	5414.00	5417.1	5415.6	5417.28	0.001924	3.0	526.5	191.0	0.32
Big Hole	Upstream Chl	3128	1700 cfs	1700	5414.00	5417.2	5415.7	5417.39	0.001936	3.1	545.5	191.4	0.33
Big Hole	Upstream Chl	3128	1800 cfs	1800	5414.00	5417.3	5415.7	5417.49	0.001948	3.2	564.1	191.8	0.33
Big Hole	Upstream Chl	3128	1900 cfs	1900	5414.00	5417.4	5415.8	5417.60	0.001960	3.3	582.2	192.2	0.33
Big Hole	Upstream Chl	3128	2000 cfs	2000	5414.00	5417.5	5415.8	5417.70	0.001970	3.3	600.2	192.5	0.33
Big Hole	Upstream Chl	3118	200 cfs	200	5414.00	5415.1	5414.5	5415.09	0.001969	1.4	144.6	174.8	0.27
Big Hole	Upstream Chl	3118	300 cfs	300	5414.00	5415.4	5414.6	5415.41	0.001565	1.5	199.0	177.8	0.25
Big Hole	Upstream Chl	3118	400 cfs	400	5414.00	5415.6	5414.7	5415.62	0.001625	1.7	234.8	179.6	0.26
Big Hole	Upstream Chl	3118	500 cfs	500	5414.00	5415.8	5414.8	5415.81	0.001674	1.9	267.1	181.3	0.27
Big Hole	Upstream Chl	3118	600 cfs	600	5414.00	5415.9	5414.9	5415.98	0.001714	2.0	296.9	182.9	0.28
Big Hole	Upstream Chl	3118	700 cfs	700	5414.00	5416.1	5415.0	5416.14	0.001742	2.2	325.1	184.3	0.29
Big Hole	Upstream Chl	3118	800 cfs	800	5414.00	5416.2	5415.1	5416.28	0.001810	2.3	349.1	185.5	0.29
Big Hole	Upstream Chl	3118	900 cfs	900	5414.00	5416.3	5415.2	5416.42	0.001834	2.4	374.3	186.8	0.30
Big Hole	Upstream Chl	3118	1000 cfs	1000	5414.00	5416.5	5415.2	5416.55	0.001881	2.5	396.6	187.9	0.31
Big Hole	Upstream Chl	3118	1100 cfs	1100	5414.00	5416.6	5415.3	5416.68	0.001906	2.6	419.1	188.6	0.31
Big Hole	Upstream Chl	3118	1200 cfs	1200	5414.00	5416.7	5415.4	5416.80	0.001923	2.7	440.9	189.1	0.31
Big Hole	Upstream Chl	3118	1300 cfs	1300	5414.00	5416.8	5415.4	5416.92	0.001938	2.8	462.1	189.6	0.32
Big Hole	Upstream Chl	3118	1400 cfs	1400	5414.00	5416.9	5415.5	5417.04	0.001950	2.9	482.8	190.0	0.32
Big Hole	Upstream Chl	3118	1500 cfs	1500	5414.00	5417.0	5415.6	5417.15	0.001963	3.0	502.7	190.5	0.32
Big Hole	Upstream Chl	3118	1600 cfs	1600	5414.00	5417.1	5415.6	5417.26	0.001976	3.1	522.2	190.9	0.33
Big Hole	Upstream Chl	3118	1700 cfs	1700	5414.00	5417.2	5415.7	5417.37	0.001988	3.1	541.1	191.3	0.33
Big Hole	Upstream Chl	3118	1800 cfs	1800	5414.00	5417.3	5415.7	5417.47	0.001998	3.2	559.7	191.7	0.33
Big Hole	Upstream Chl	3118	1900 cfs	1900	5414.00	5417.4	5415.8	5417.57	0.002009	3.3	577.8	192.1	0.33
Big Hole	Upstream Chl	3118	2000 cfs	2000	5414.00	5417.5	5415.8	5417.67	0.002018	3.4	595.6	192.4	0.34
Big Hole	Upstream Chl	3112	200 cfs	200	5413.21	5415.1	5414.1	5415.08	0.002991	1.3	148.5	149.3	0.24
Big Hole	Upstream Chl	3112	300 cfs	300	5413.21	5415.4	5414.3	5415.40	0.003146	1.5	198.7	174.6	0.25
Big Hole	Upstream Chl	3112	400 cfs	400	5413.21	5415.6	5414.5	5415.60	0.003346	1.7	234.3	179.2	0.26
Big Hole	Upstream Chl	3112	500 cfs	500	5413.21	5415.7	5414.6	5415.79	0.003445	1.9	266.3	180.5	0.27
Big Hole	Upstream Chl	3112	600 cfs	600	5413.21	5415.9	5414.7	5415.96	0.003526	2.0	295.9	181.6	0.28
Big Hole	Upstream Chl	3112	700 cfs	700	5413.21	5416.1	5414.9	5416.13	0.003586	2.2	323.8	182.9	0.29
Big Hole	Upstream Chl	3112	800 cfs	800	5413.21	5416.2	5415.0	5416.27	0.003736	2.3	347.4	184.1	0.30
Big Hole	Upstream Chl	3112	900 cfs	900	5413.21	5416.3	5415.1	5416.41	0.003768	2.4	372.3	185.2	0.30
Big Hole	Upstream Chl	3112	1000 cfs	1000	5413.21	5416.4	5415.2	5416.54	0.003854	2.5	394.3	186.0	0.31
Big Hole	Upstream Chl	3112	1100 cfs	1100	5413.21	5416.6	5415.3	5416.66	0.003903	2.6	416.5	186.8	0.31
Big Hole	Upstream Chl	3112	1200 cfs	1200	5413.21	5416.7	5415.4	5416.79	0.003941	2.7	438.0	187.5	0.31
Big Hole	Upstream Chl	3112	1300 cfs	1300	5413.21	5416.8	5415.4	5416.91	0.003975	2.8	459.0	188.3	0.32
Big Hole	Upstream Chl	3112	1400 cfs	1400	5413.21	5416.9	5415.5	5417.02	0.004003	2.9	479.4	189.4	0.32
Big Hole	Upstream Chl	3112	1500 cfs	1500	5413.21	5417.0	5415.5	5417.14	0.004025	3.0	499.3	190.3	0.32
Big Hole	Upstream Chl	3112	1600 cfs	1600	5413.21	5417.1	5415.6	5417.24	0.004044	3.1	518.6	191.2	0.33
Big Hole	Upstream Chl	3112	1700 cfs	1700	5413.21	5417.2	5415.6	5417.35	0.004064	3.2	537.5	192.0	0.33
Big Hole	Upstream Chl	3112	1800 cfs	1800	5413.21	5417.3	5415.7	5417.46	0.004080	3.3	556.1	192.9	0.33
Big Hole	Upstream Chl	3112	1900 cfs	1900	5413.21	5417.4	5415.8	5417.56	0.004094	3.3	574.3	193.2	0.33
Big Hole	Upstream Chl	3112	2000 cfs	2000	5413.21	5417.5	5415.8	5417.66	0.004108	3.4	592.2	193.4	0.34
Big Hole	Upstream Chl	2911	200 cfs	200	5412.42	5414.1	5413.6	5414.11	0.008912	2.0	101.6	131.3	0.39
Big Hole	Upstream Chl	2911	300 cfs	300	5412.42	5414.3	5413.7	5414.40	0.008794	2.1	143.3	167.1	0.40
Big Hole	Upstream Chl	2911	400 cfs	400	5412.42	5414.6	5413.9	5414.64	0.007523	2.2	183.1	178.3	0.38
Big Hole	Upstream Chl	2911	500 cfs	500	5412.42	5414.7	5414.0	5414.83	0.007015	2.3	216.8	184.7	0.38
Big Hole	Upstream Chl	2911	600 cfs	600	5412.42	5414.9	5414.2	5415.02	0.006568	2.4	250.6	192.0	0.37
Big Hole	Upstream Chl	2911	700 cfs	700	5412.42	5415.1	5414.3	5415.19	0.006199	2.5	282.0	196.5	0.36
Big Hole	Upstream Chl	2911	800 cfs	800	5412.42	5415.2	5414.4	5415.35	0.005754	2.6	312.6	197.4	0.36
Big Hole	Upstream Chl	2911	900 cfs	900	5412.42	5415.4	5414.4	5415.49	0.005529	2.7	339.7	198.2	0.36
Big Hole	Upstream Chl	2911	1000 cfs	1000	5412.42	5415.5	5414.5	5415.63	0.005371	2.7	365.3	198.8	0.35
Big Hole	Upstream Chl	2911	1100 cfs	1100	5412.42	5415.6	5414.6	5415.76	0.005213	2.8	390.6	199.3	0.35
Big Hole	Upstream Chl	2911	1200 cfs	1200	5412.42	5415.8	5414.7	5415.89	0.005083	2.9	414.9	199.8	0.35
Big Hole	Upstream Chl	2911	1300 cfs	1300	5412.42	5415.9	5414.7	5416.02	0.004976	3.0	438.5	200.2	0.35
Big Hole	Upstream Chl	2911	1400 cfs	1400	5412.42	5416.0	5414.8	5416.13	0.004892	3.0	461.1	200.6	0.35
Big Hole	Upstream Chl	2911	1500 cfs	1500	5412.42	5416.1	5414.8	5416.25	0.004830	3.1	482.7	201.0	0.35
Big Hole	Upstream Chl	2911	1600 cfs	1600	5412.42	5416.2	5414.9	5416.36	0.004778	3.2	503.8	201.4	0.35
Big Hole	Upstream Chl	2911	1700 cfs	1700	5412.42	5416.3	5415.0	5416.47	0.004734	3.3	524.2	201.8	0.35
Big Hole	Upstream Chl	2911	1800 cfs	1800	5412.42	5416.4	5415.0	5416.58	0.004697	3.3	544.2	202.2	0.35
Big Hole	Upstream Chl	2911	1900 cfs	1900	5412.42	5416.5	5415.1	5416.68	0.004664	3.4	563.6	202.8	0.35
Big Hole	Upstream Chl	2911	2000 cfs	2000	5412.42	5416.6	5415.1	5416.78	0.004634	3.5	582.8	203.5	0.36
Big Hole	Upstream Chl	2765	200 cfs	200	5411.40	5413.2	5412.6	5413.28	0.003899	1.5	130.4	131.7	0.27
Big Hole	Upstream Chl	2765	300 cfs	300	5411.40	5413.5	5412.7	5413.57	0.003897	1.8	167.6	134.0	0.28
Big Hole	Upstream Chl	2765	400 cfs	400	5411.40	5413.8	5412.9	5413.86	0.003907	1.9	206.4	146.9	0.29
Big Hole	Upstream Chl	2765	500 cfs	500	5411.40	5414.0	5413.0	5414.08	0.003899	2.1	237.9	149.6	0.29
Big Hole	Upstream Chl	2765	600 cfs	600	5411.40	5414.2	5413.1	5414.29	0.003901	2.2	267.2	152.1	0.30
Big Hole	Upstream Chl	2765	700 cfs	700	5411.40	5414.4	5413.2	5414.48	0.003908	2.4	295.4	156.2	0.30

HEC-RAS Plan: Opt 3 Mixed Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Big Hole	Upstream Chl	2765	800 cfs	800	5411.40	5414.6	5413.3	5414.66	0.003906	2.5	322.5	161.4	0.31
Big Hole	Upstream Chl	2765	900 cfs	900	5411.40	5414.7	5413.4	5414.82	0.003906	2.6	346.8	165.6	0.31
Big Hole	Upstream Chl	2765	1000 cfs	1000	5411.40	5414.9	5413.5	5414.97	0.003904	2.7	370.4	169.8	0.31
Big Hole	Upstream Chl	2765	1100 cfs	1100	5411.40	5415.0	5413.5	5415.11	0.003905	2.8	393.4	173.6	0.32
Big Hole	Upstream Chl	2765	1200 cfs	1200	5411.40	5415.1	5413.6	5415.25	0.003905	2.9	415.8	177.0	0.32
Big Hole	Upstream Chl	2765	1300 cfs	1300	5411.40	5415.2	5413.7	5415.38	0.003904	3.0	437.7	180.4	0.32
Big Hole	Upstream Chl	2765	1400 cfs	1400	5411.40	5415.4	5413.8	5415.50	0.003901	3.1	459.6	194.1	0.32
Big Hole	Upstream Chl	2765	1500 cfs	1500	5411.40	5415.5	5413.9	5415.62	0.003902	3.2	481.2	195.0	0.33
Big Hole	Upstream Chl	2765	1600 cfs	1600	5411.40	5415.6	5413.9	5415.73	0.003905	3.2	502.1	195.9	0.33
Big Hole	Upstream Chl	2765	1700 cfs	1700	5411.40	5415.7	5414.0	5415.84	0.003903	3.3	522.6	196.8	0.33
Big Hole	Upstream Chl	2765	1800 cfs	1800	5411.40	5415.8	5414.1	5415.95	0.003904	3.4	542.6	197.6	0.33
Big Hole	Upstream Chl	2765	1900 cfs	1900	5411.40	5415.9	5414.1	5416.06	0.003903	3.5	562.1	198.4	0.33
Big Hole	Upstream Chl	2765	2000 cfs	2000	5411.40	5416.0	5414.2	5416.16	0.003902	3.5	581.2	199.2	0.33





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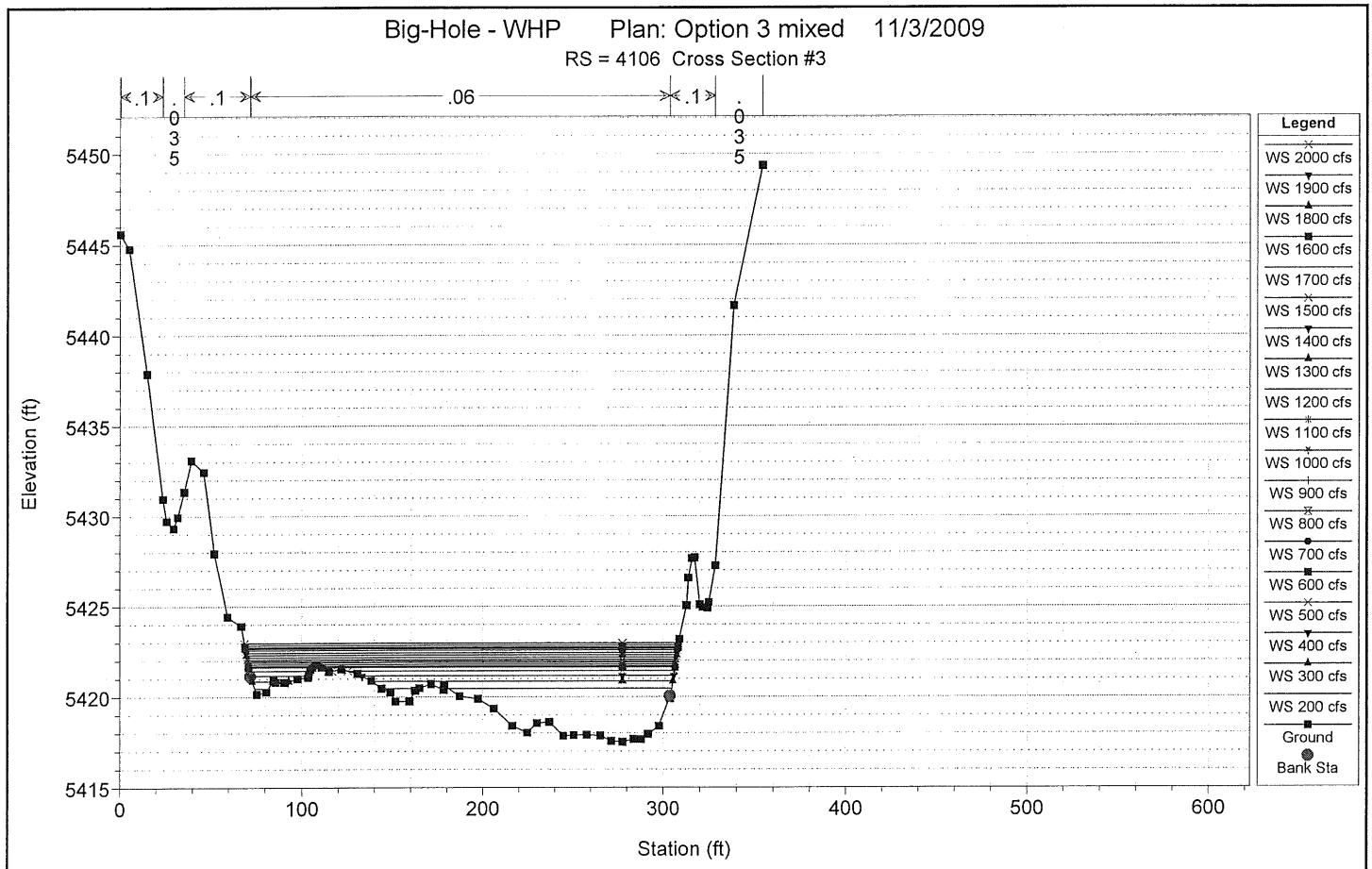

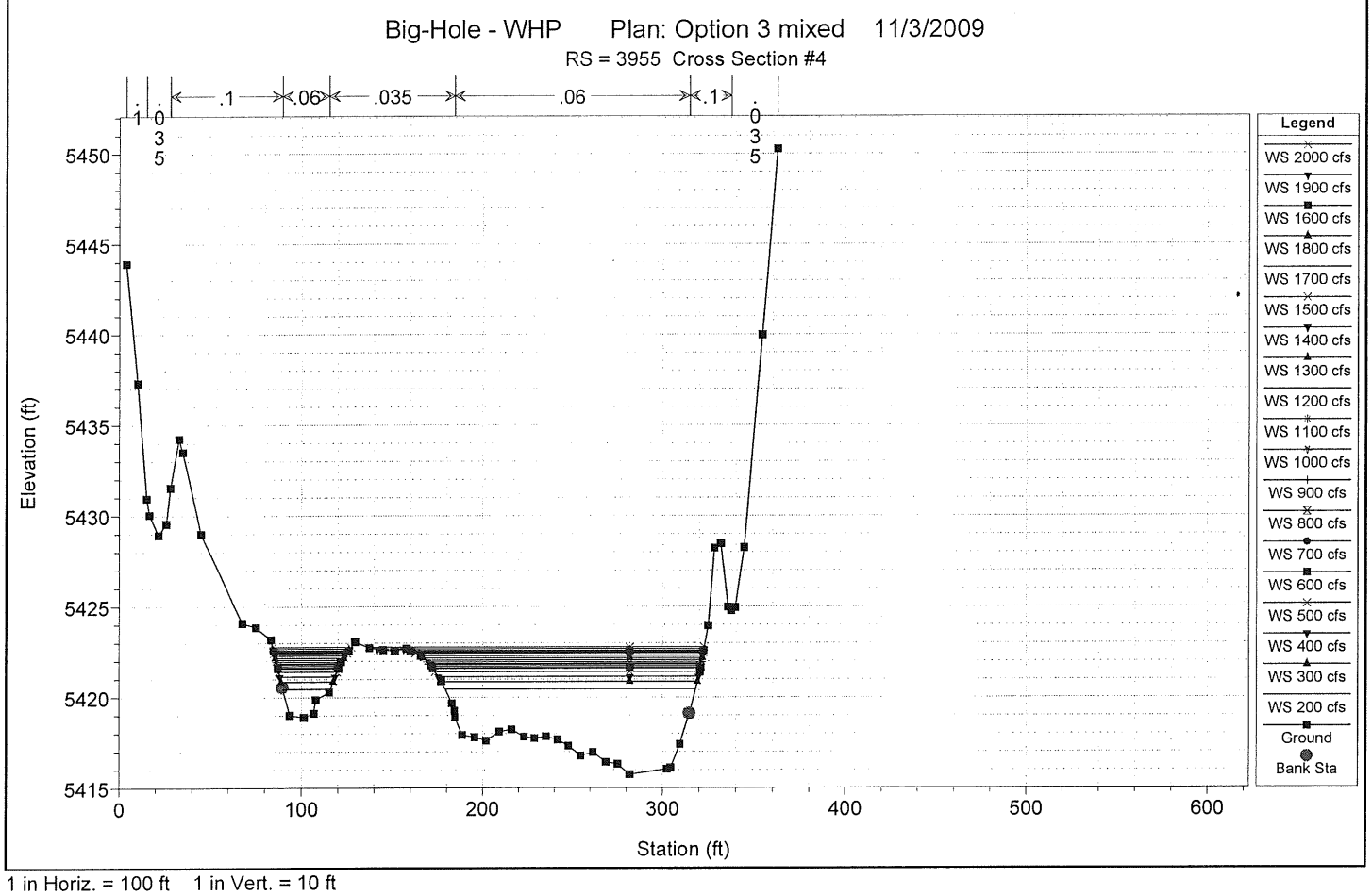

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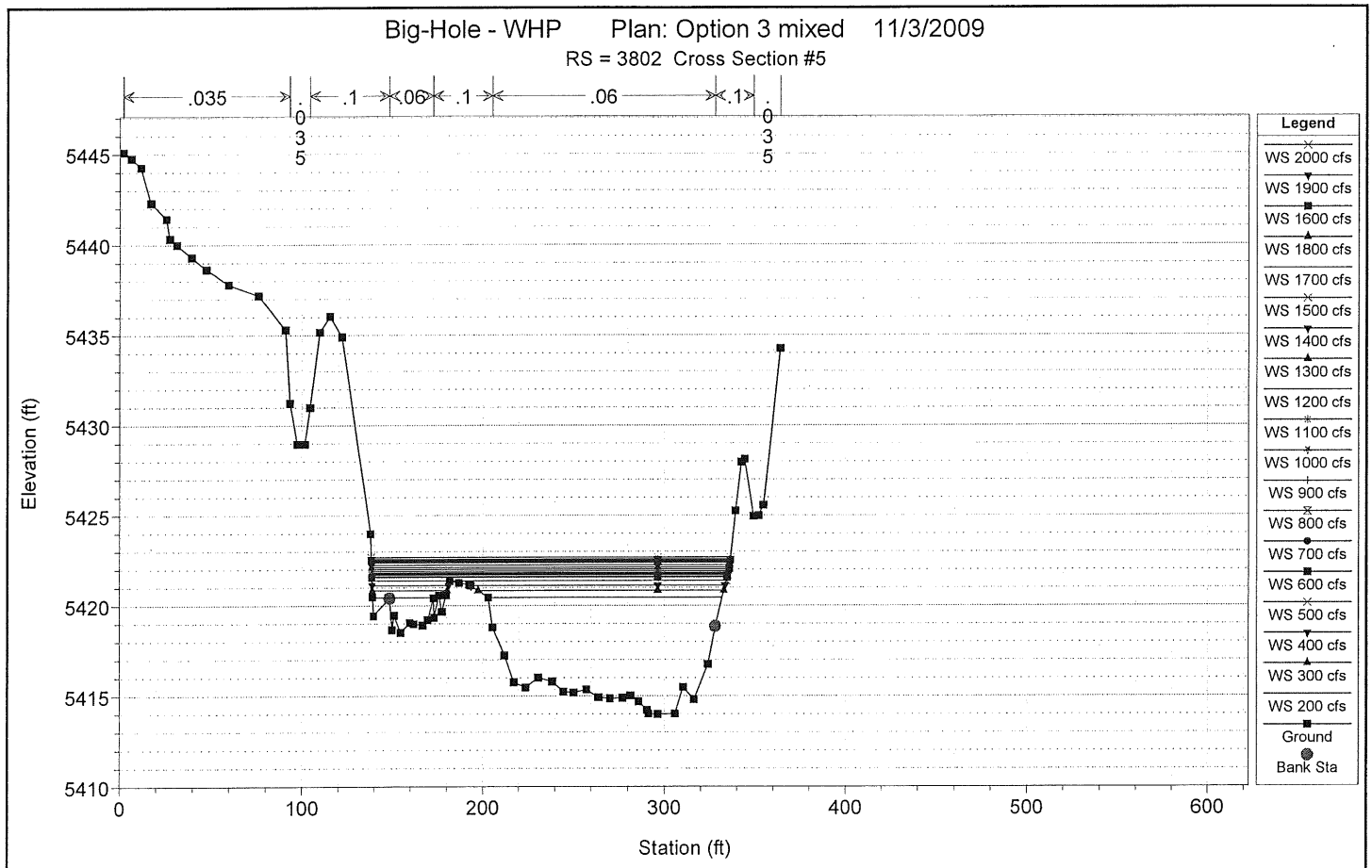

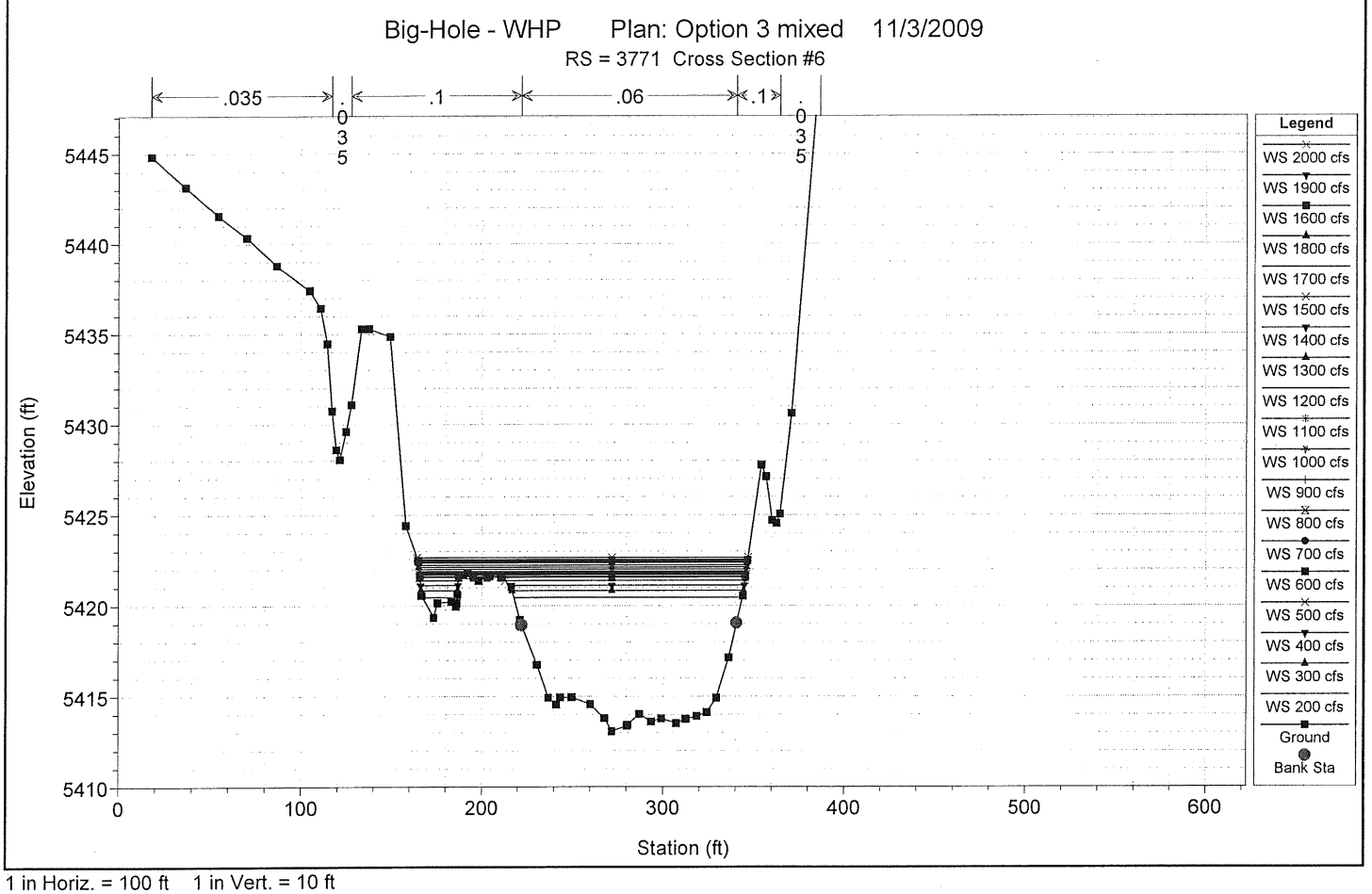

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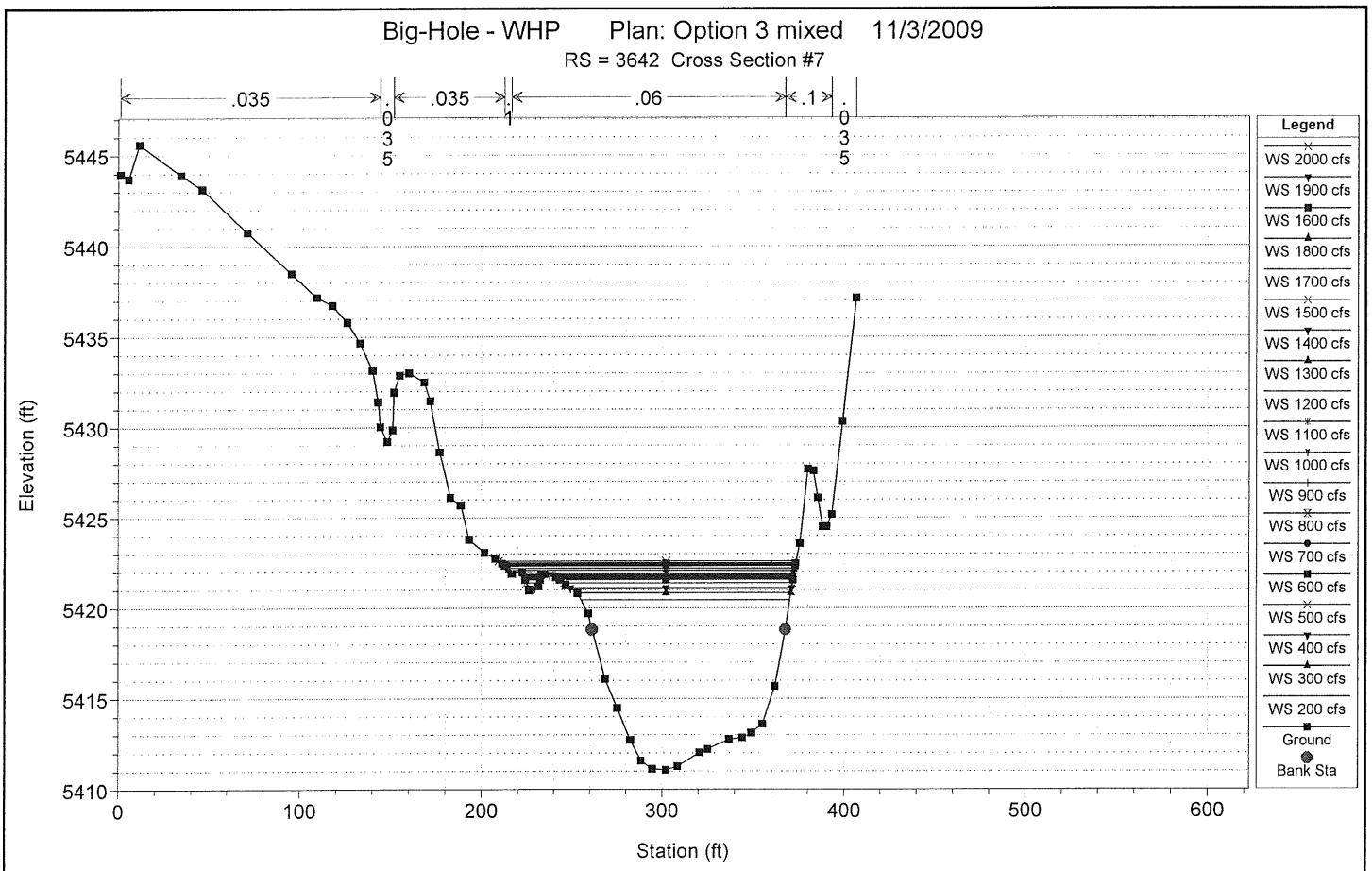

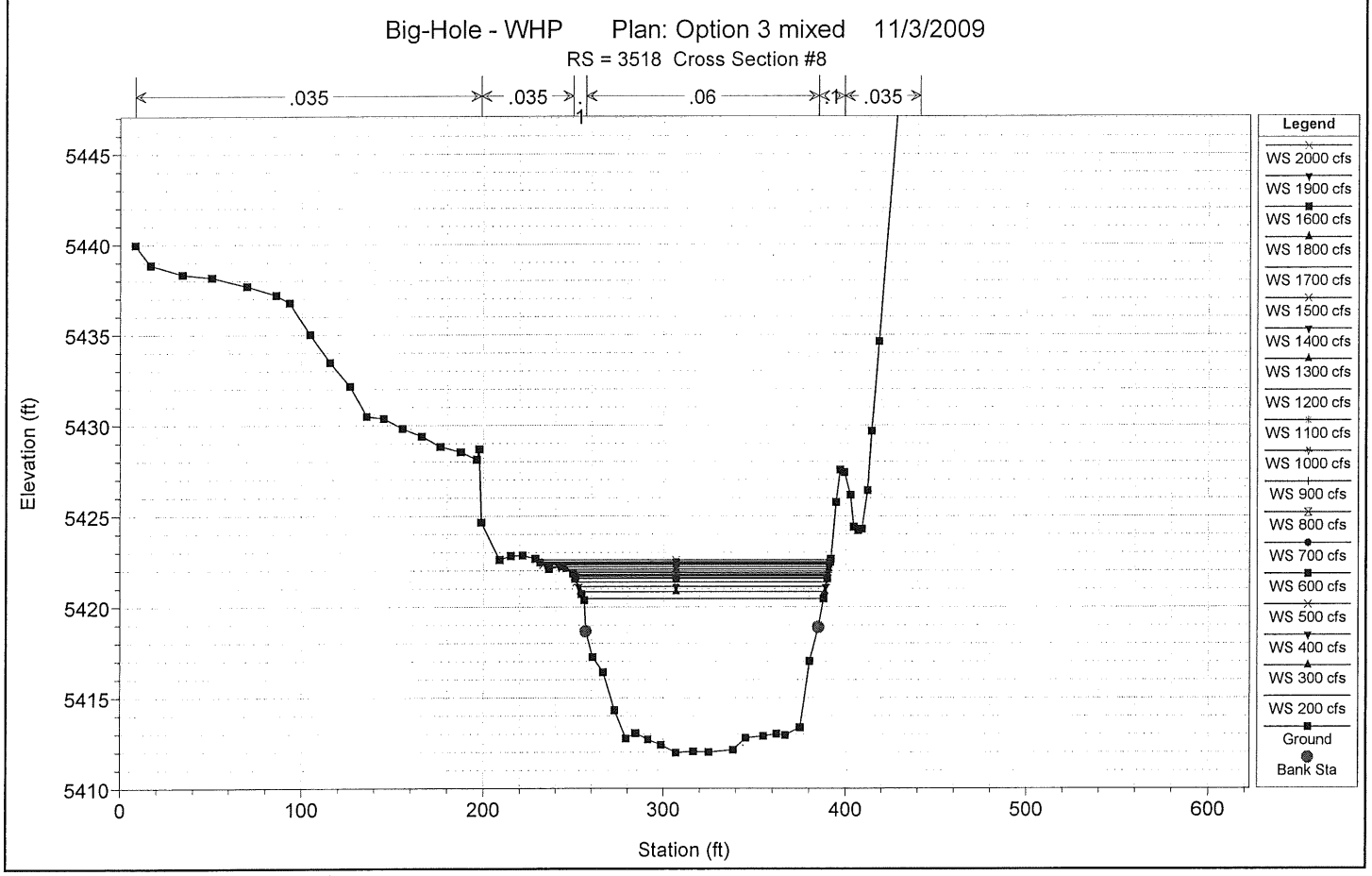

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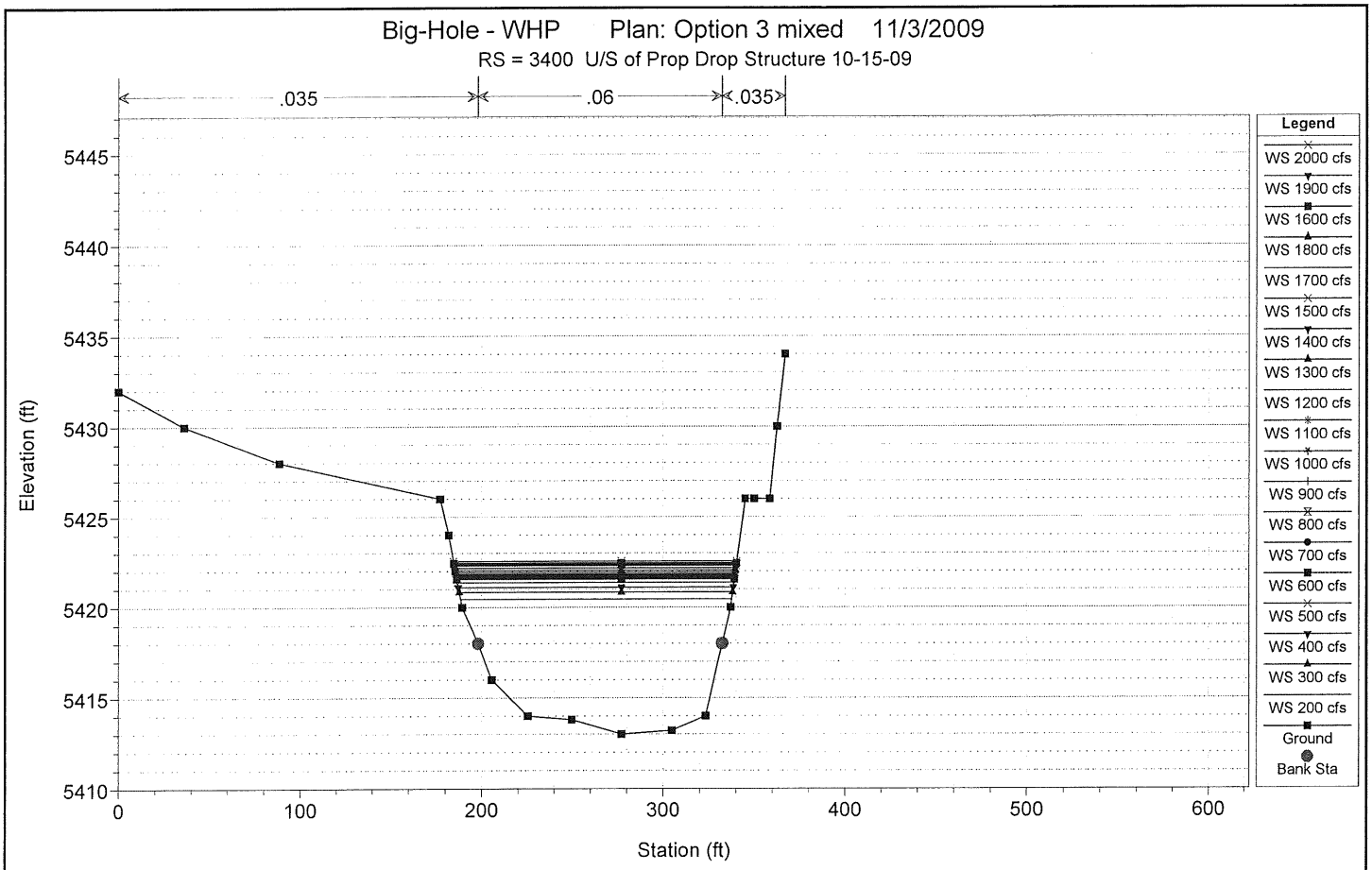

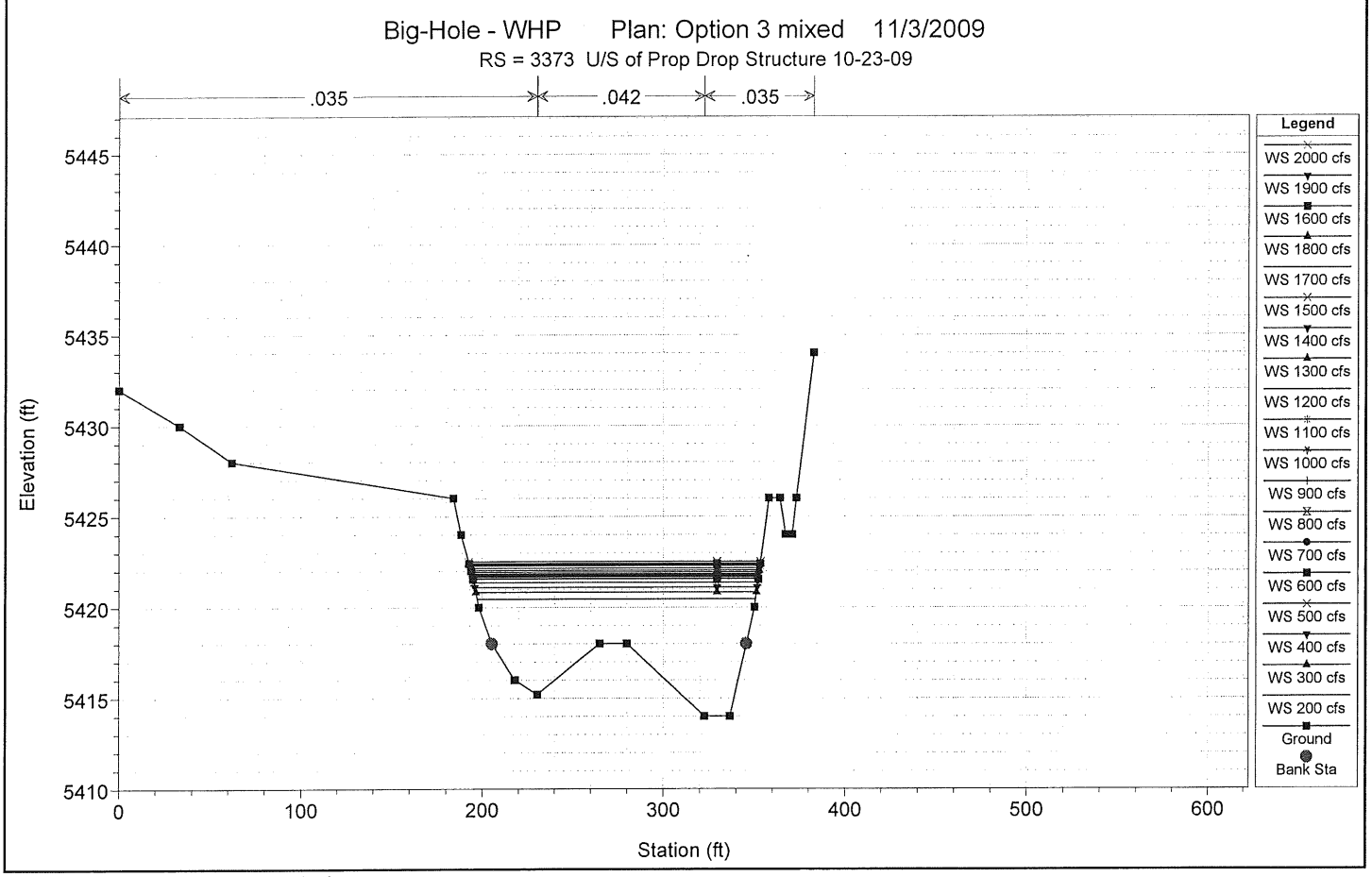

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Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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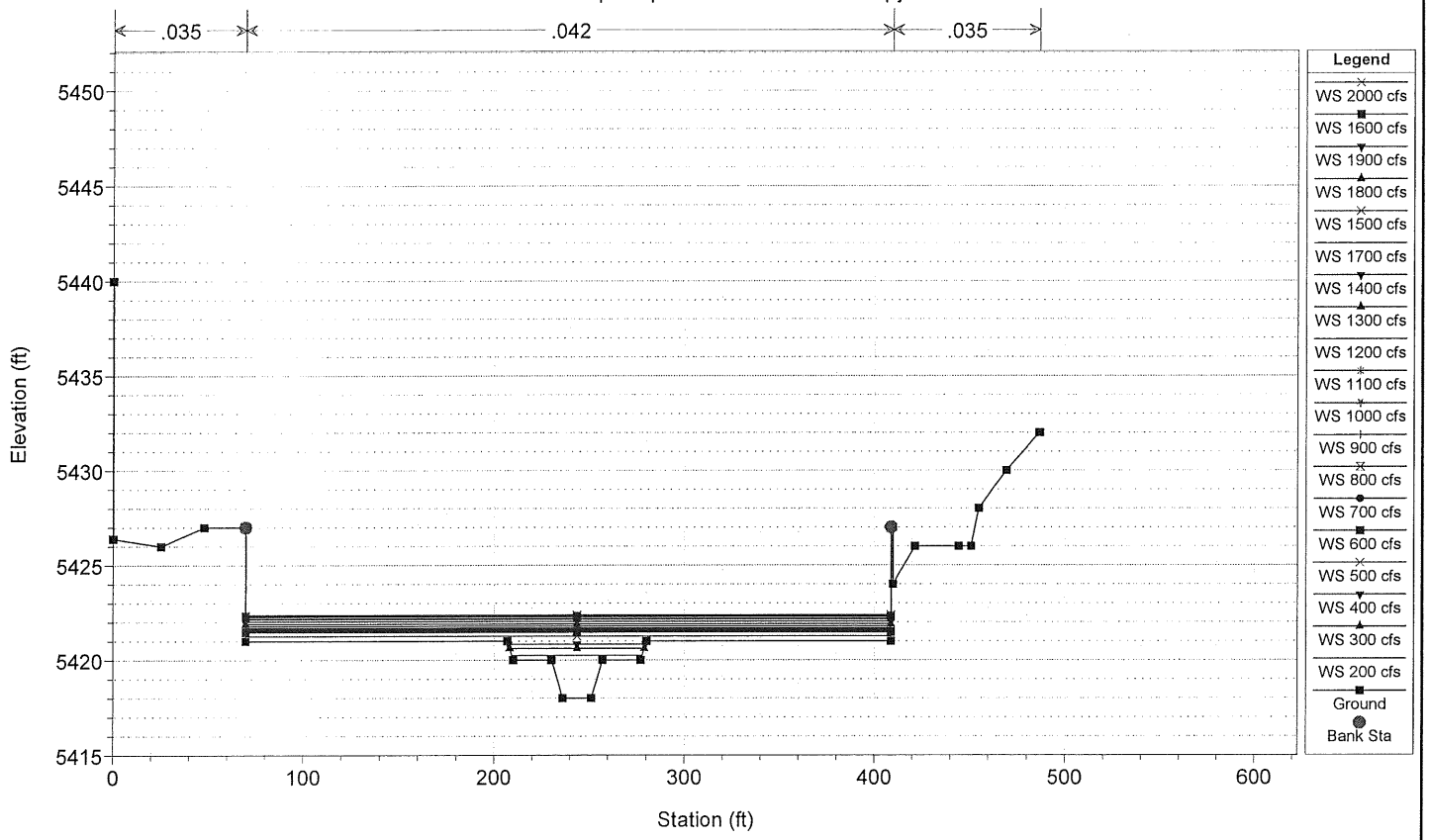

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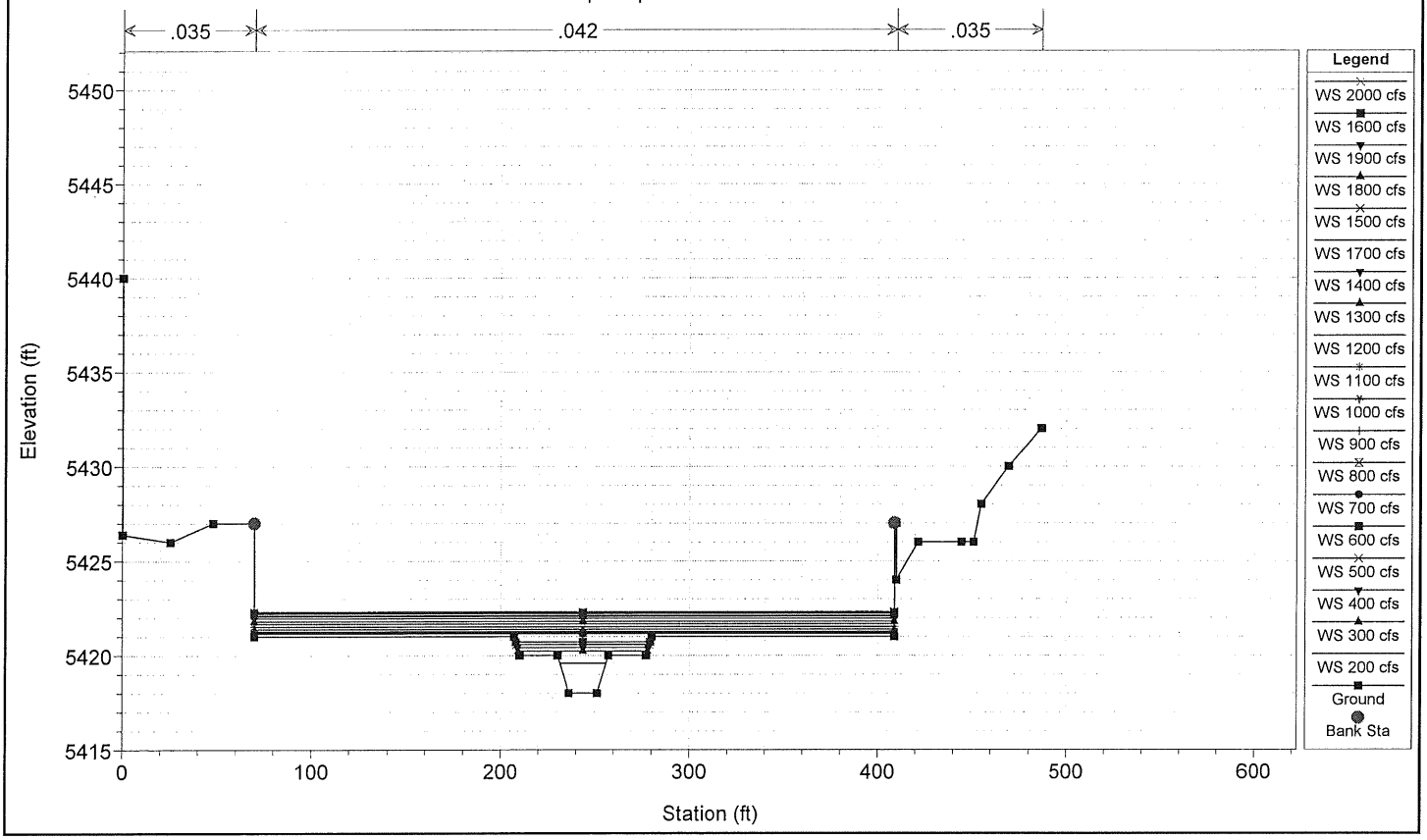

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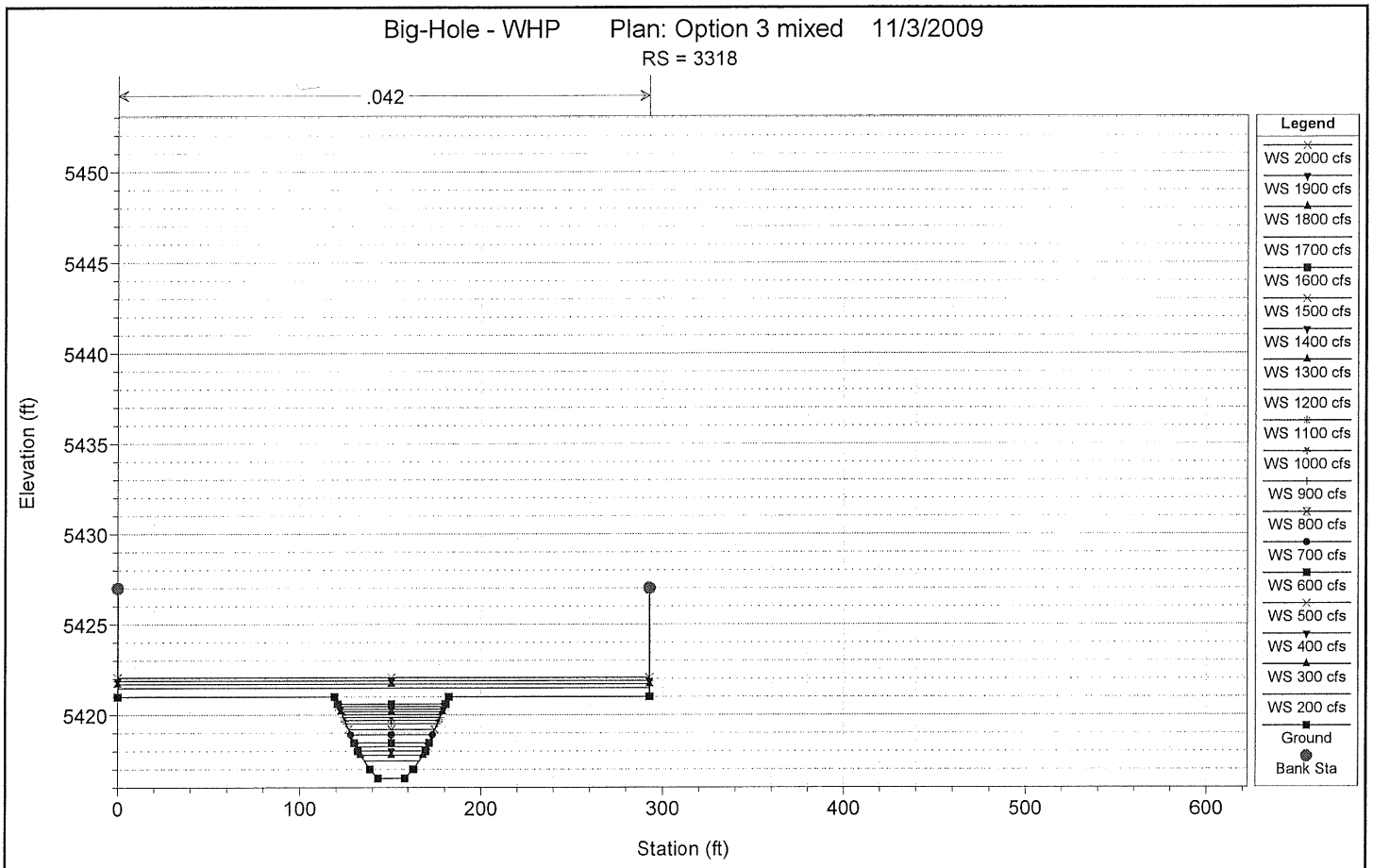

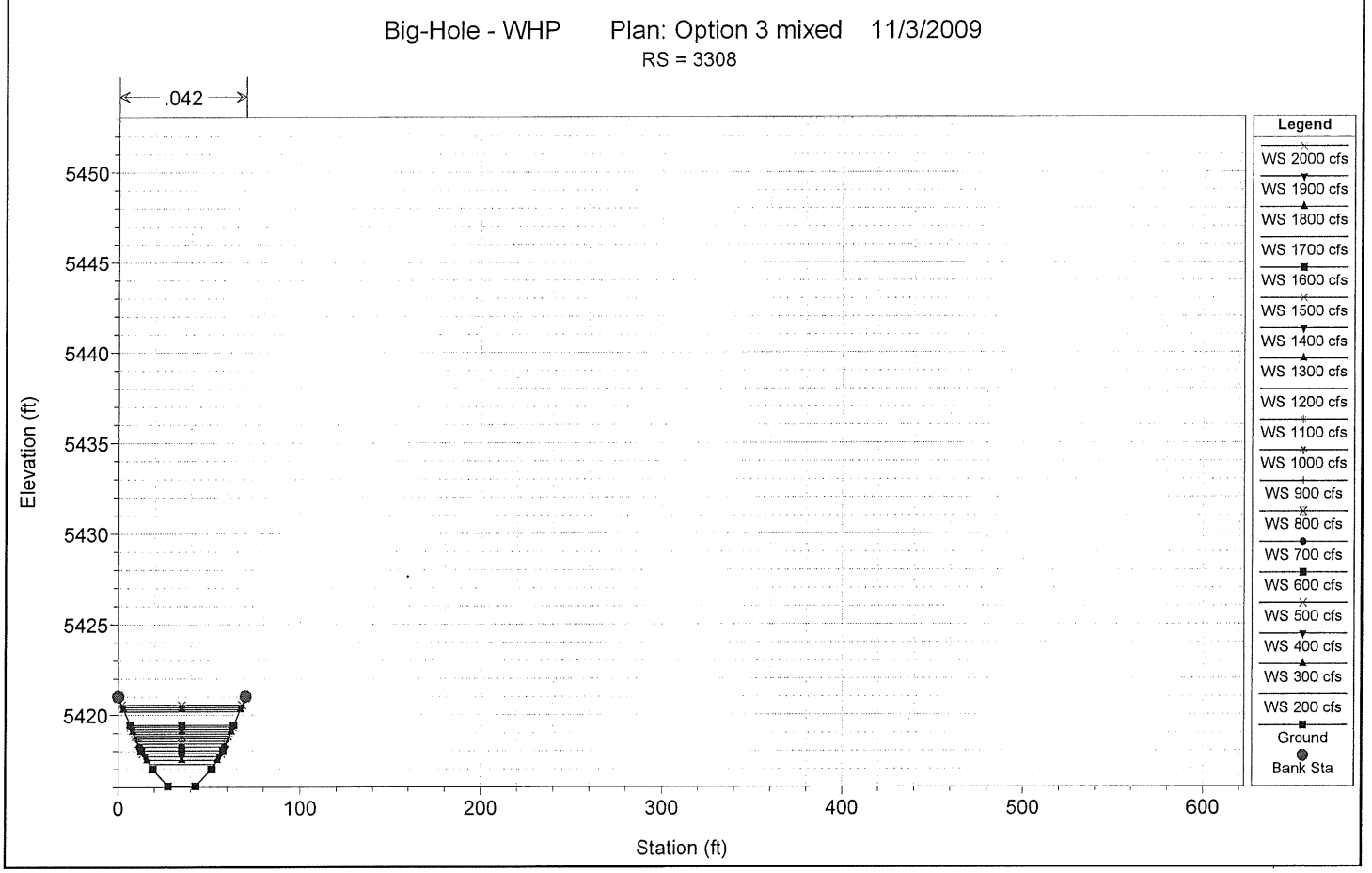

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Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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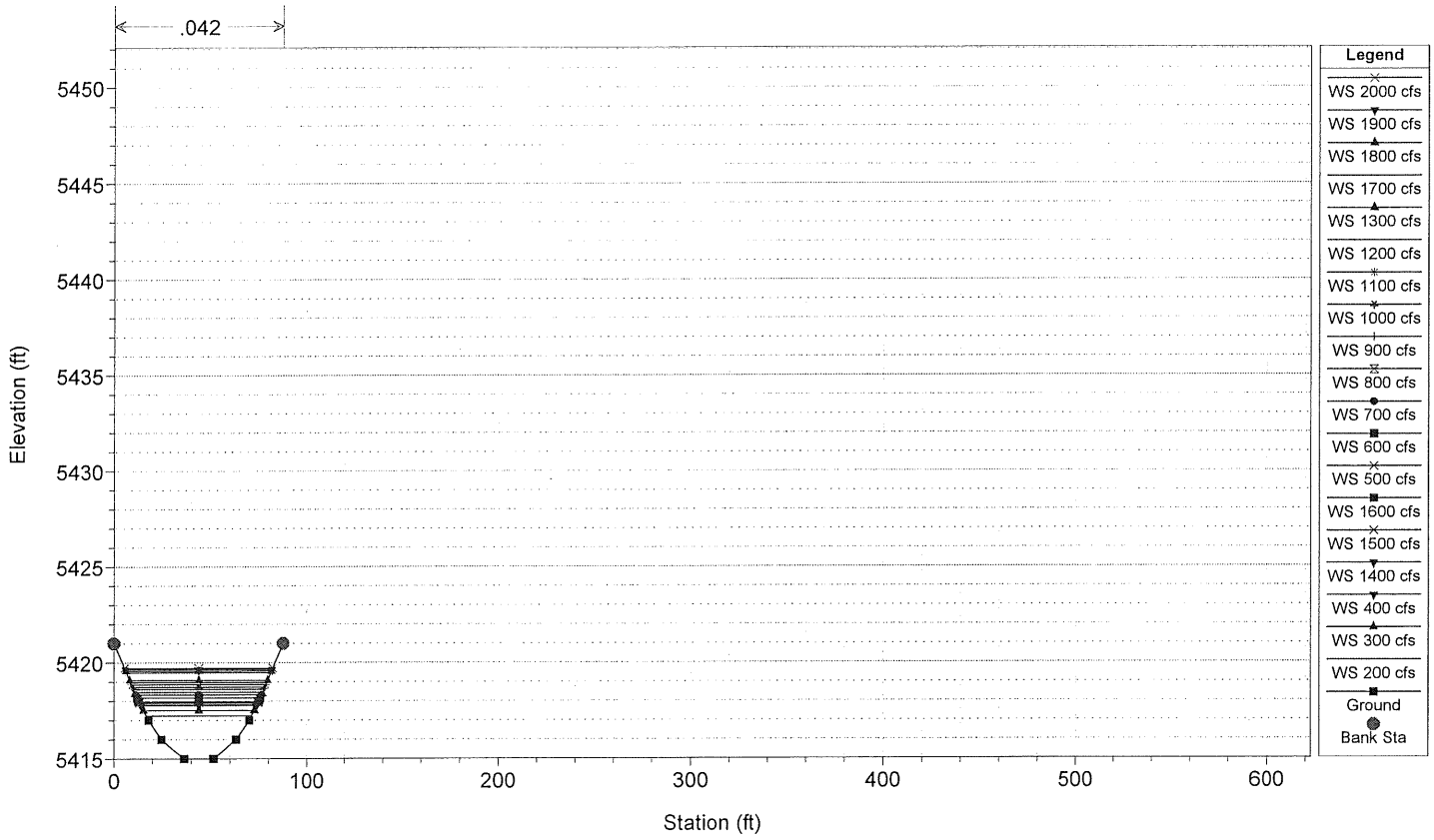

Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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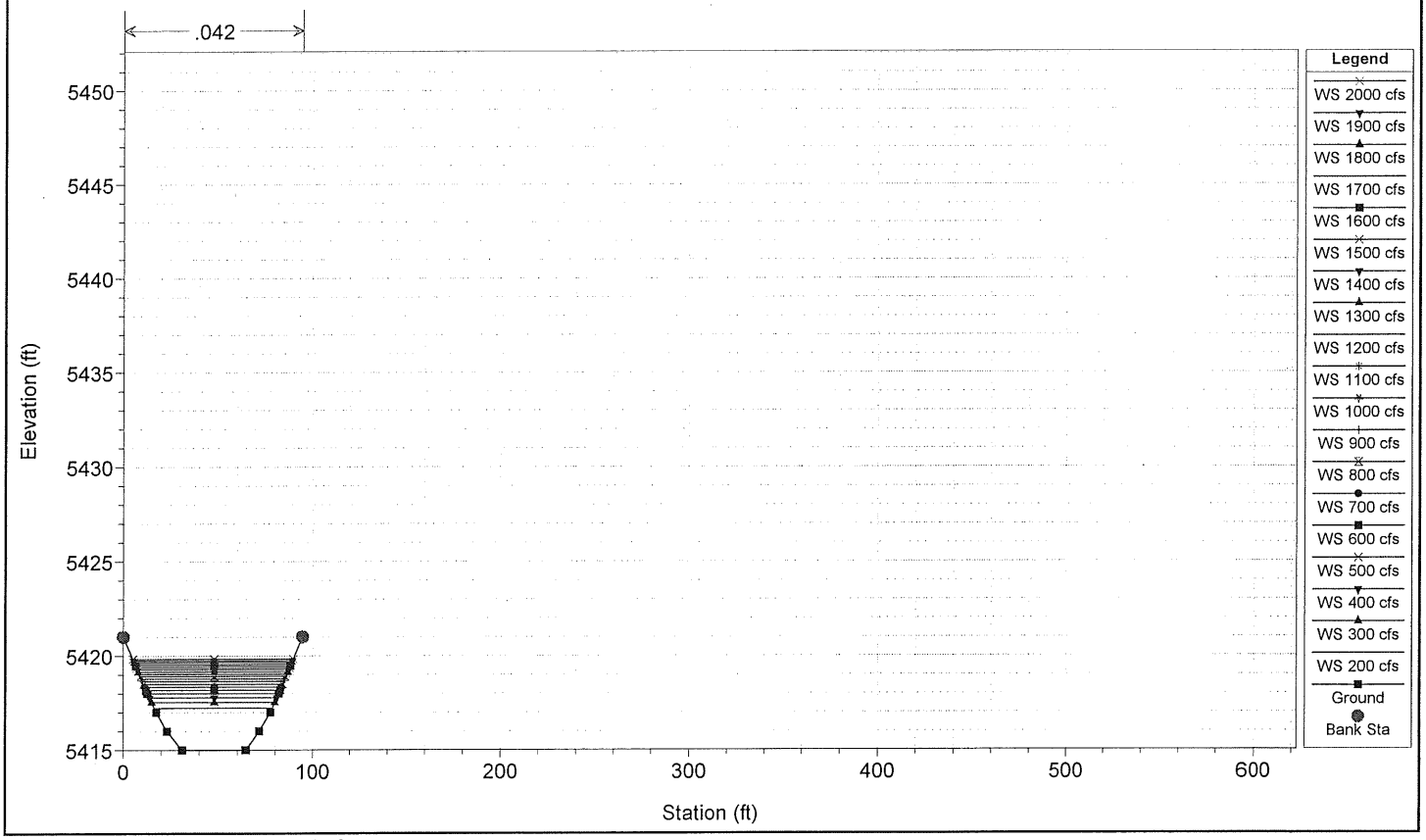

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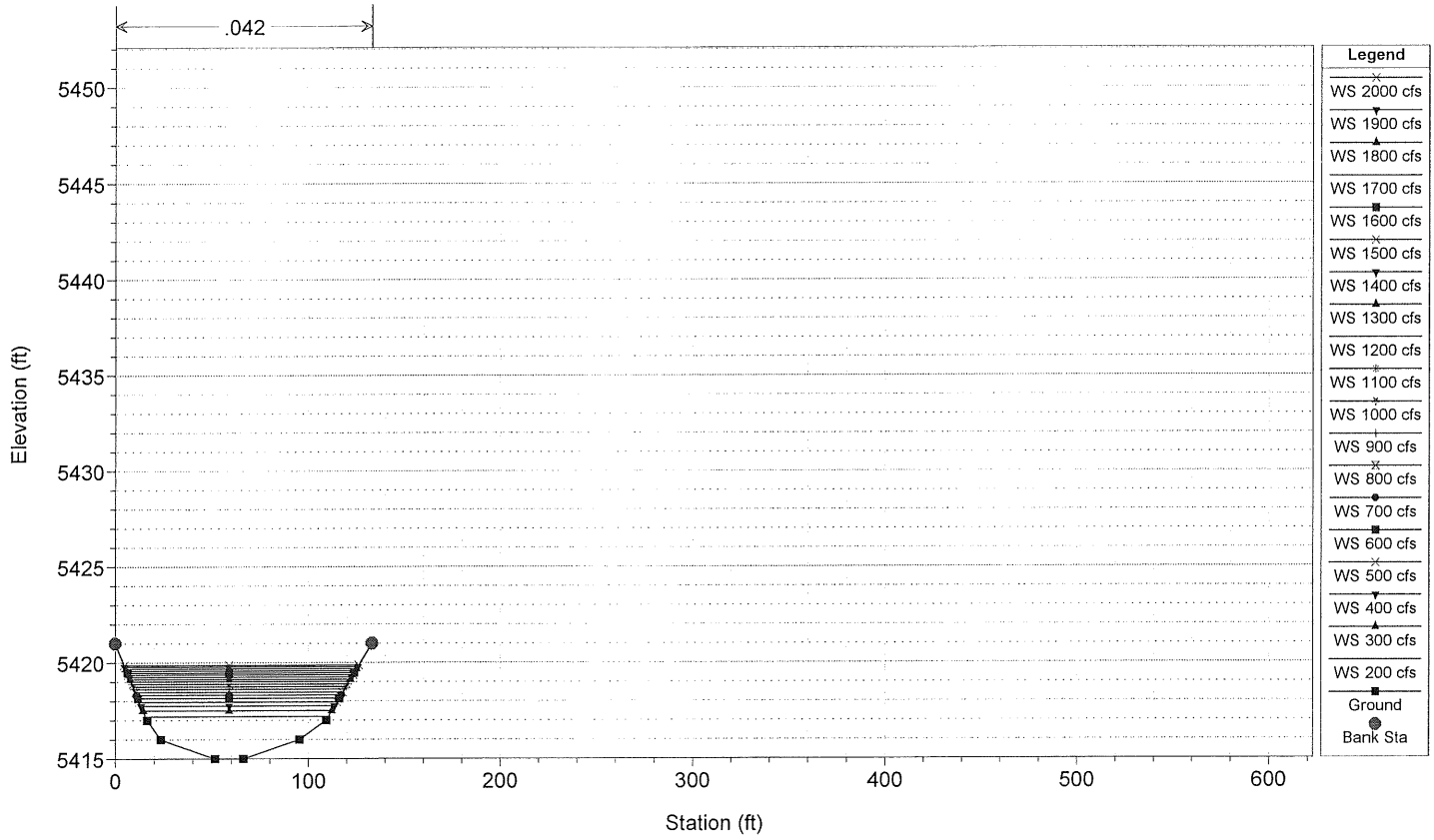

Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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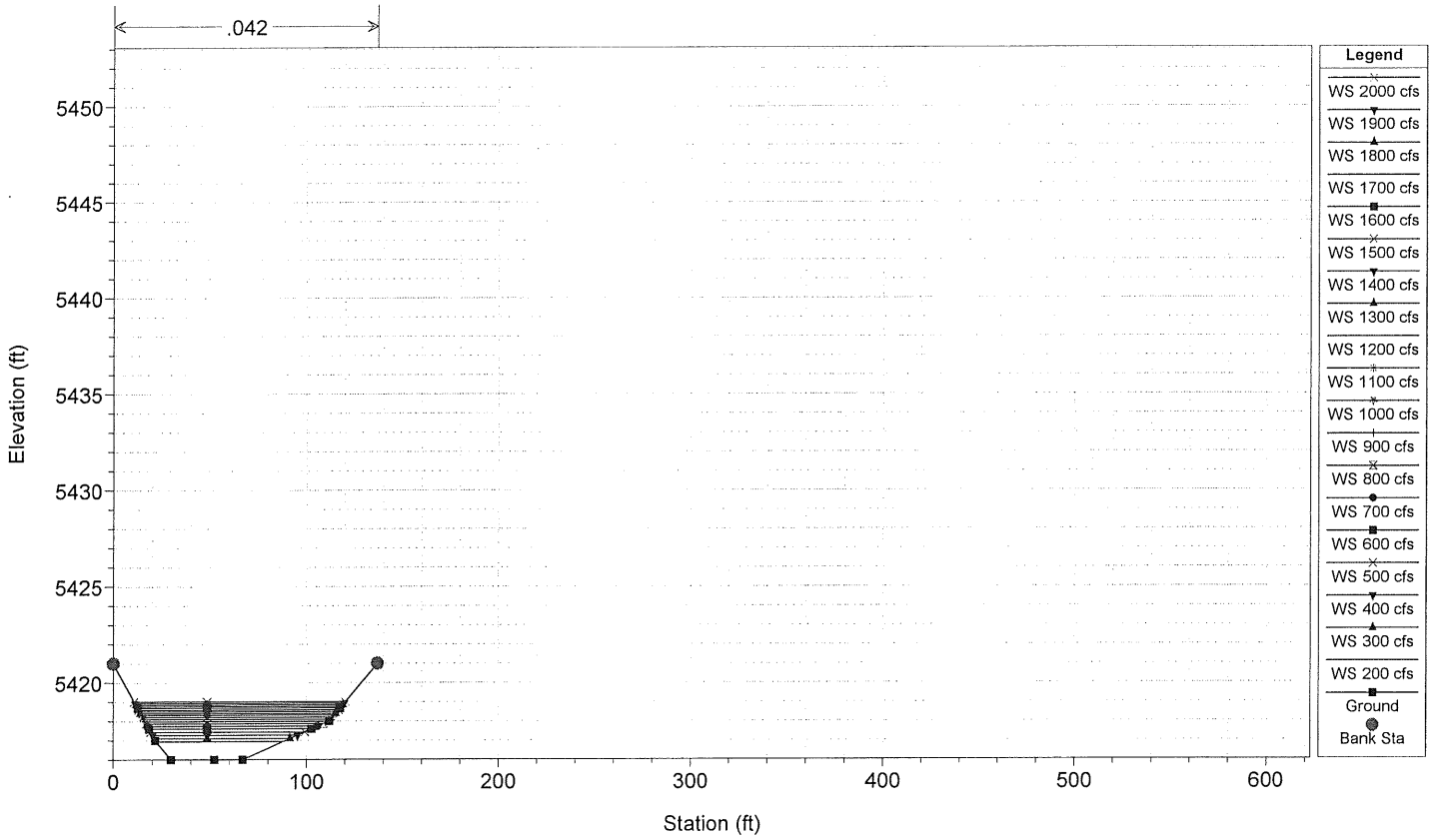

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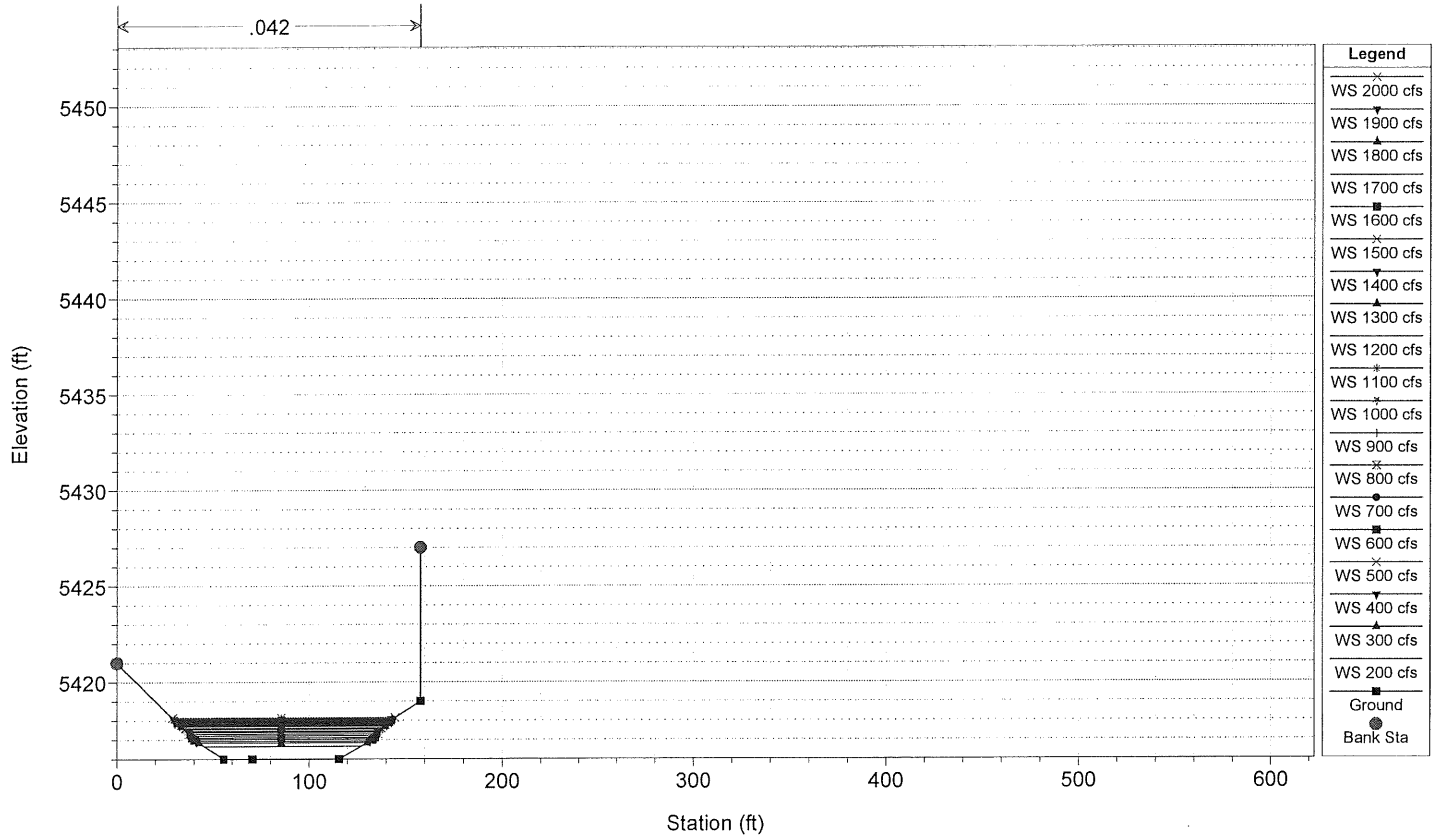

Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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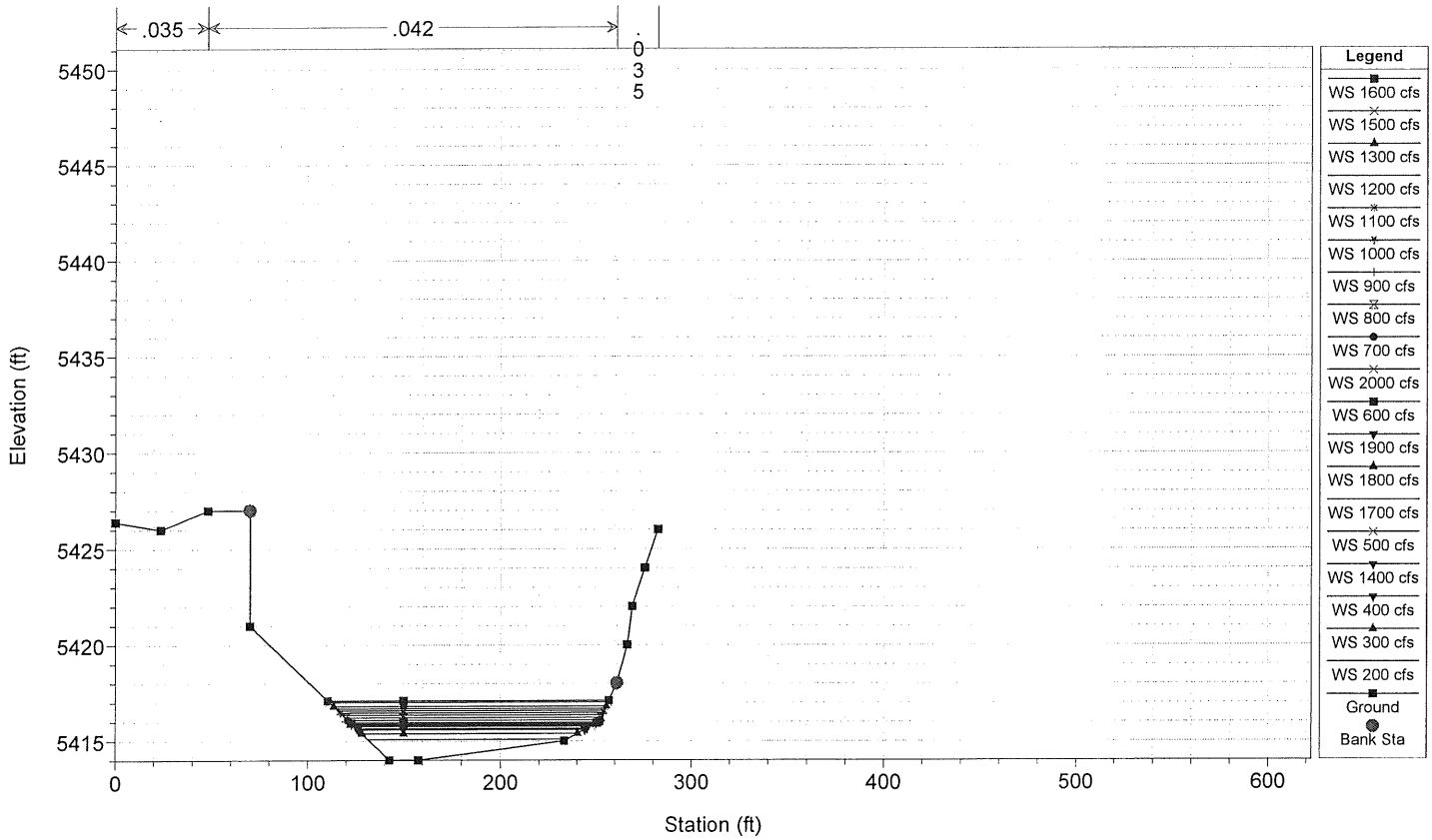

1 in Horiz. = 100 ft 1 in Vert. = 10 ft

Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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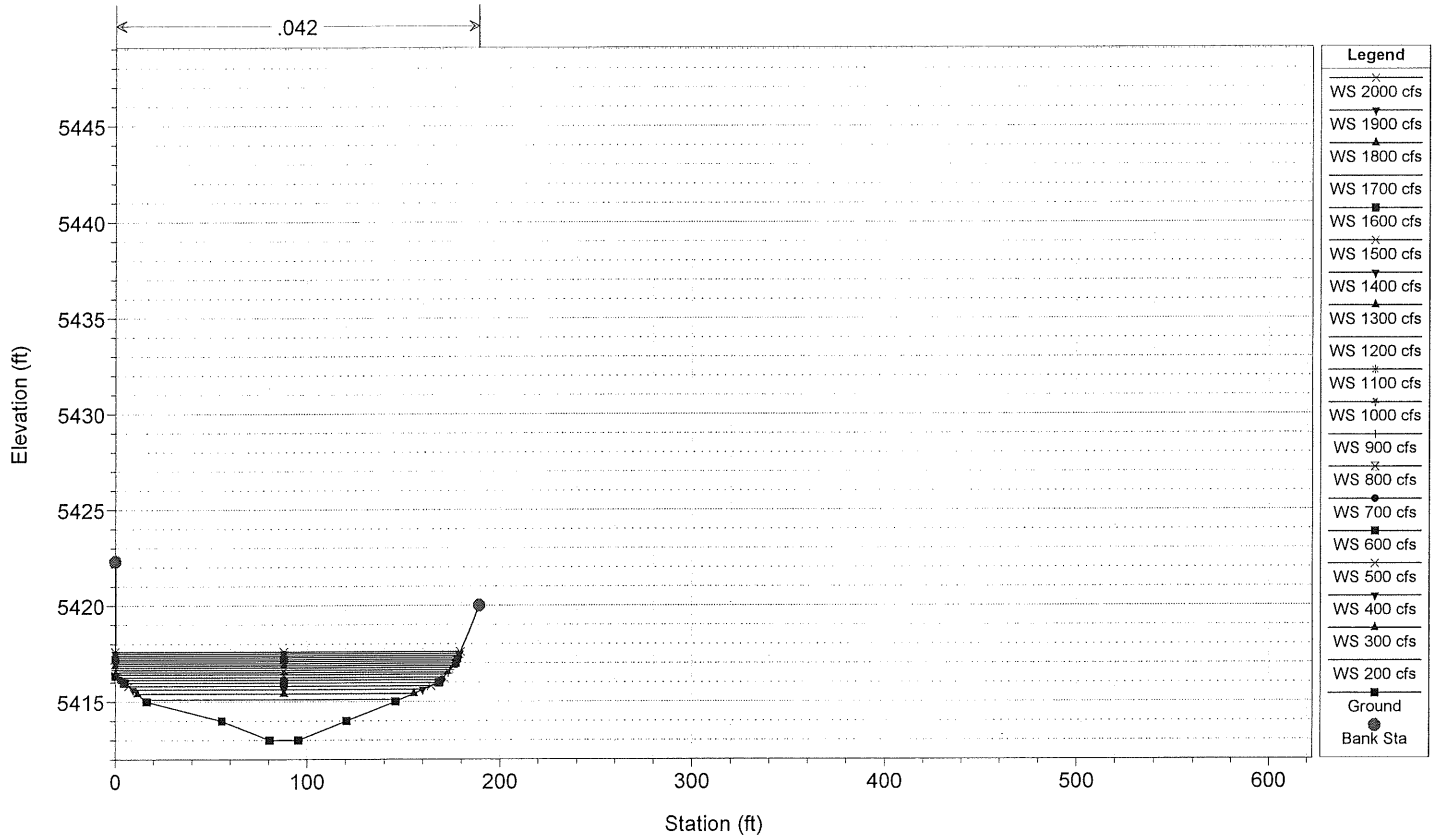

Big-Hole - WHP Plan: Option 3 mixed 11/3/2009

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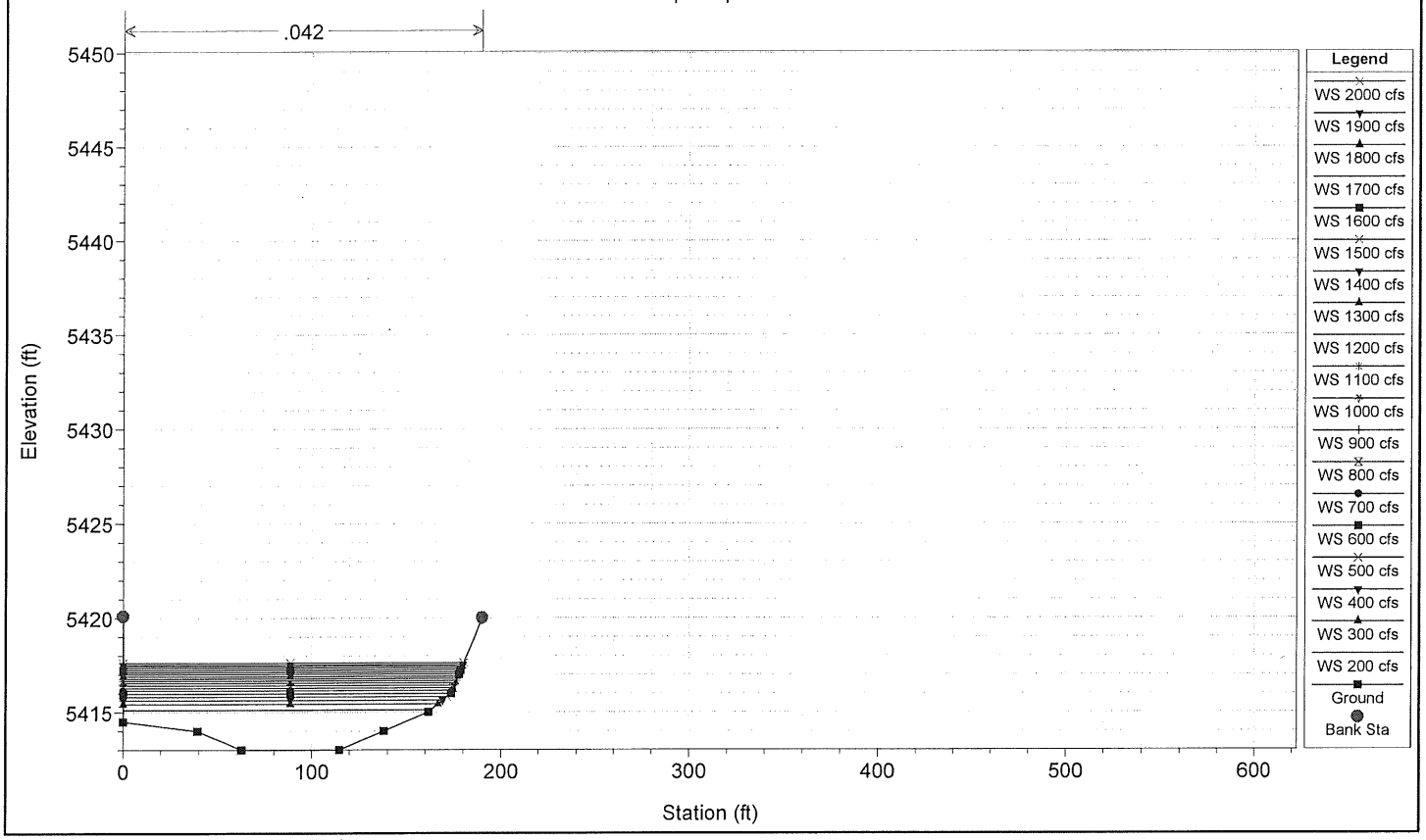

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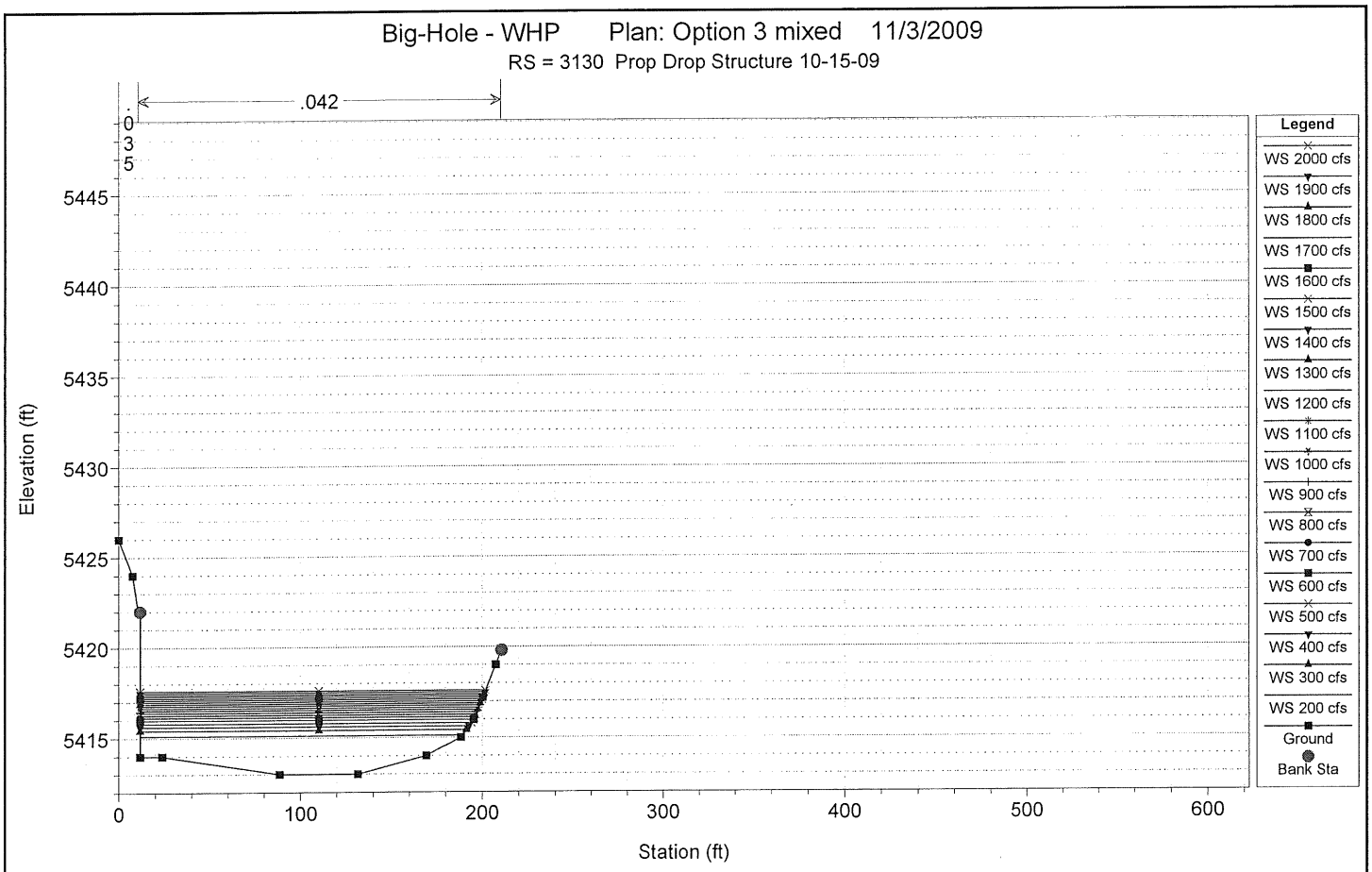

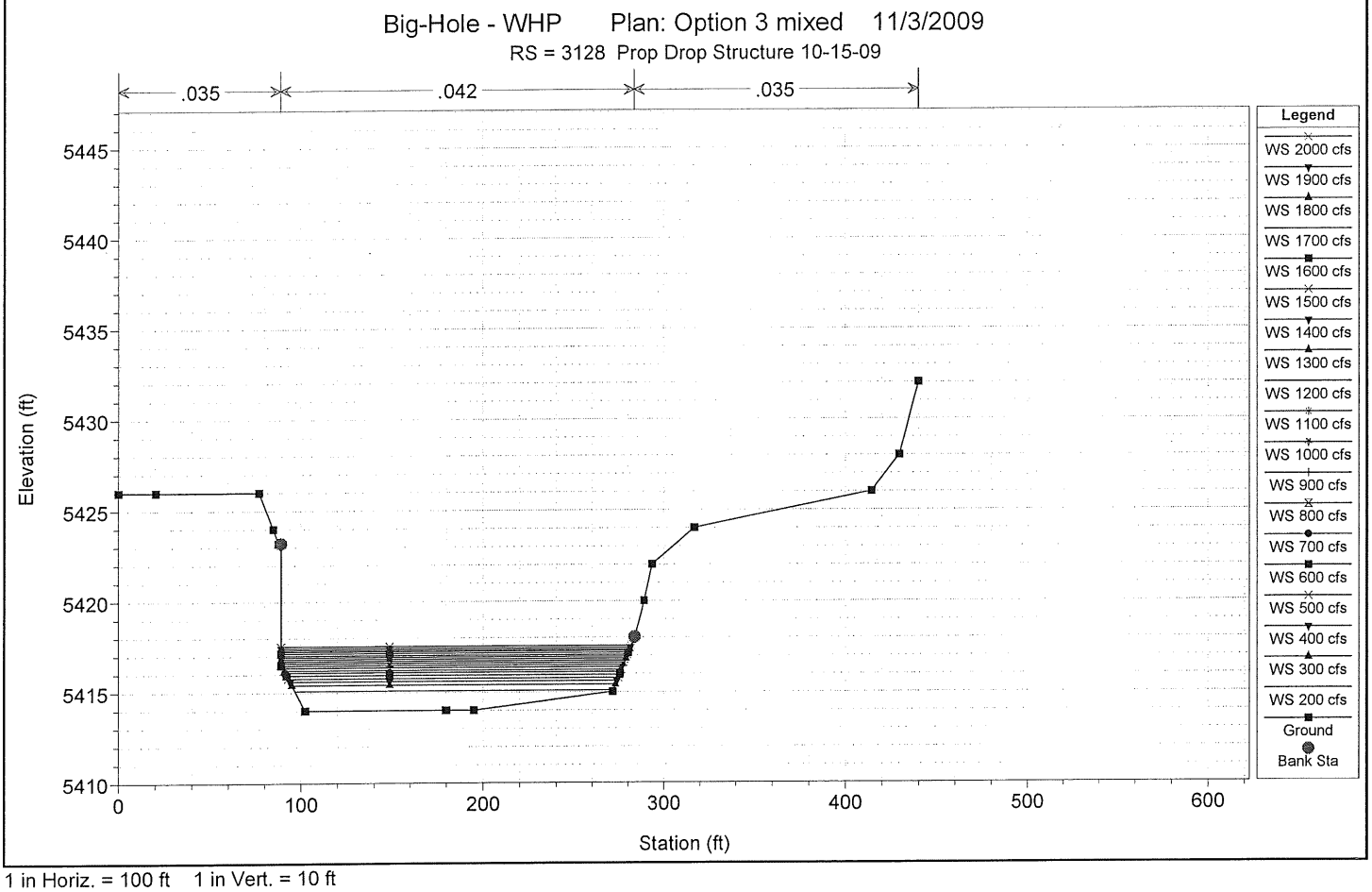

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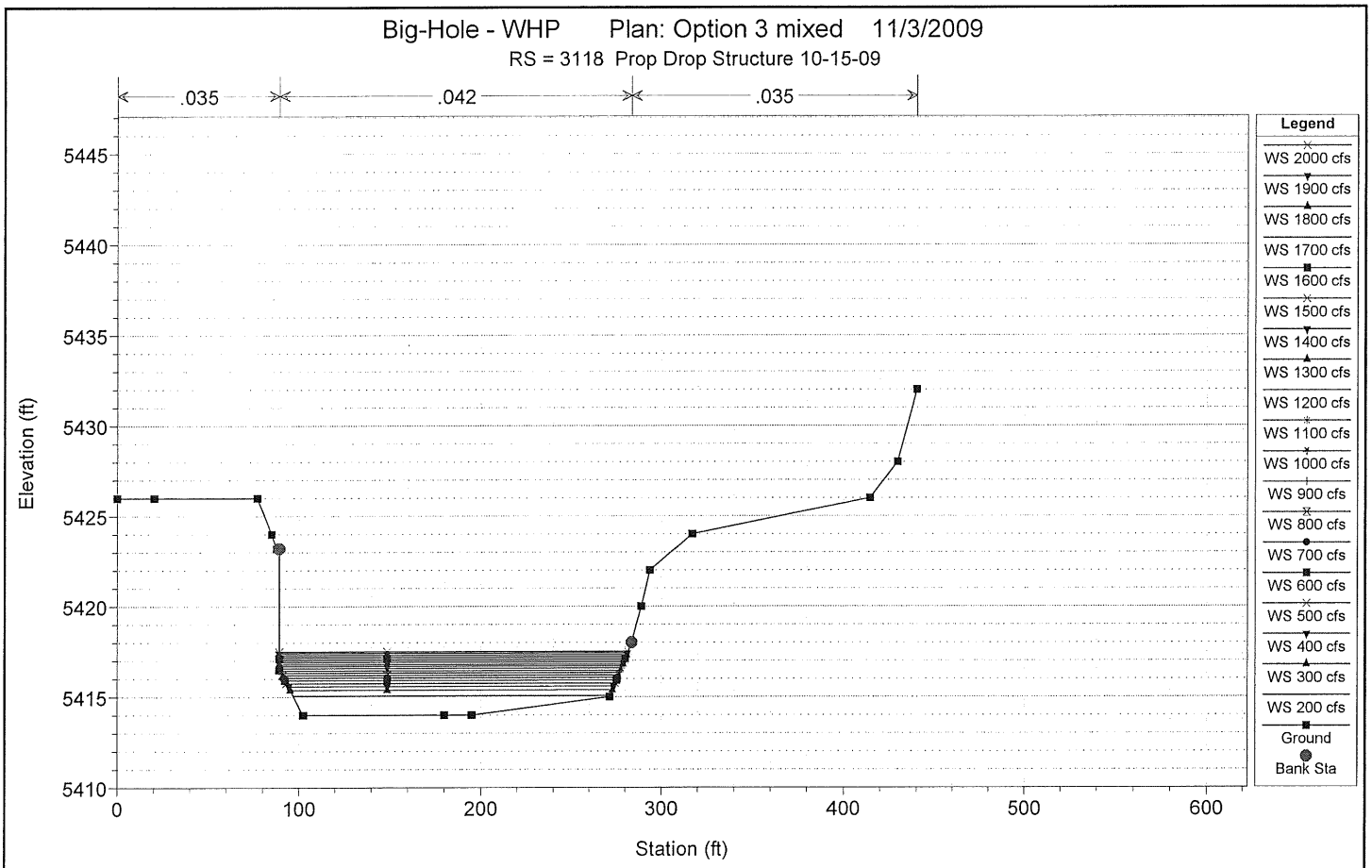

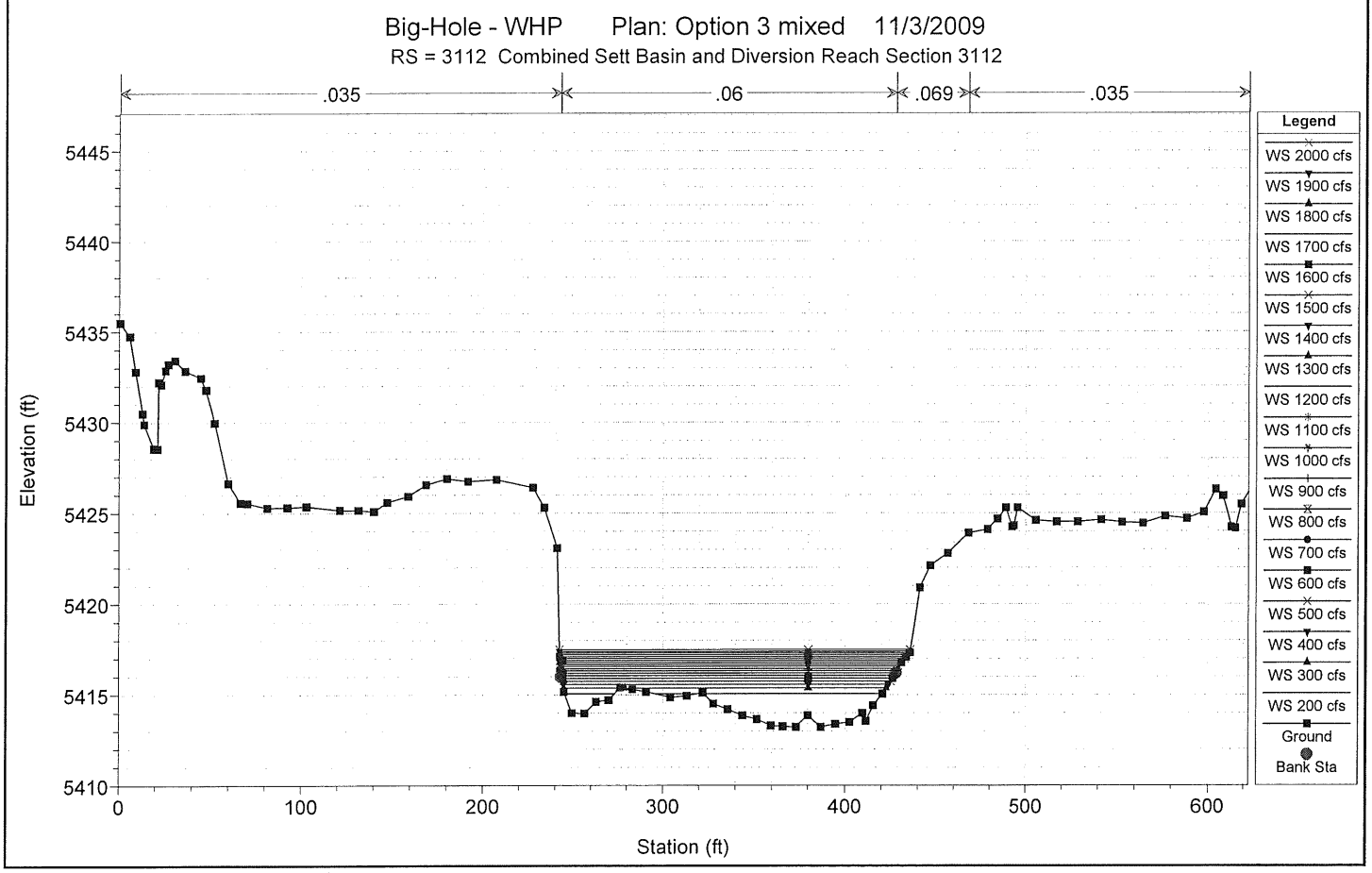

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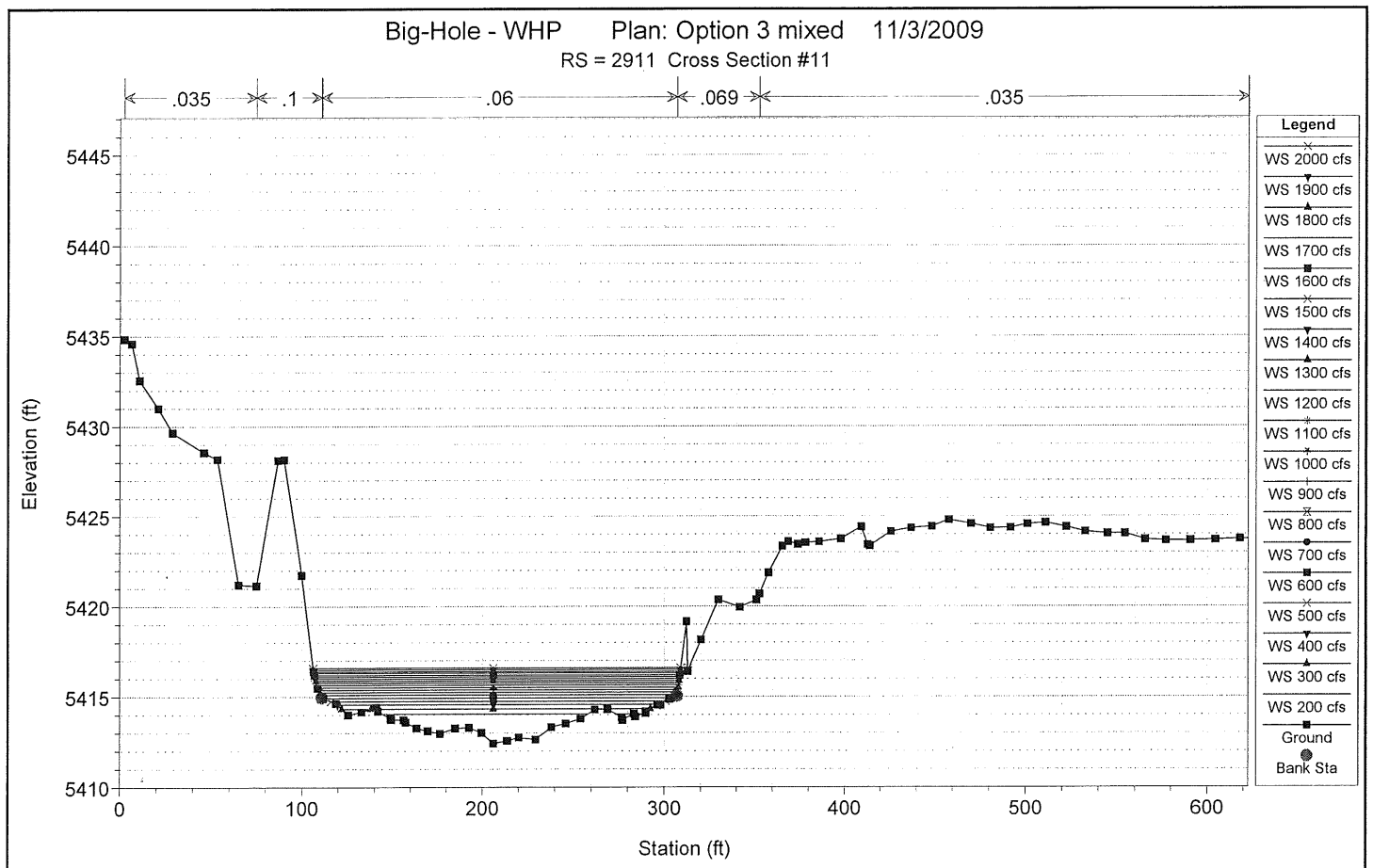

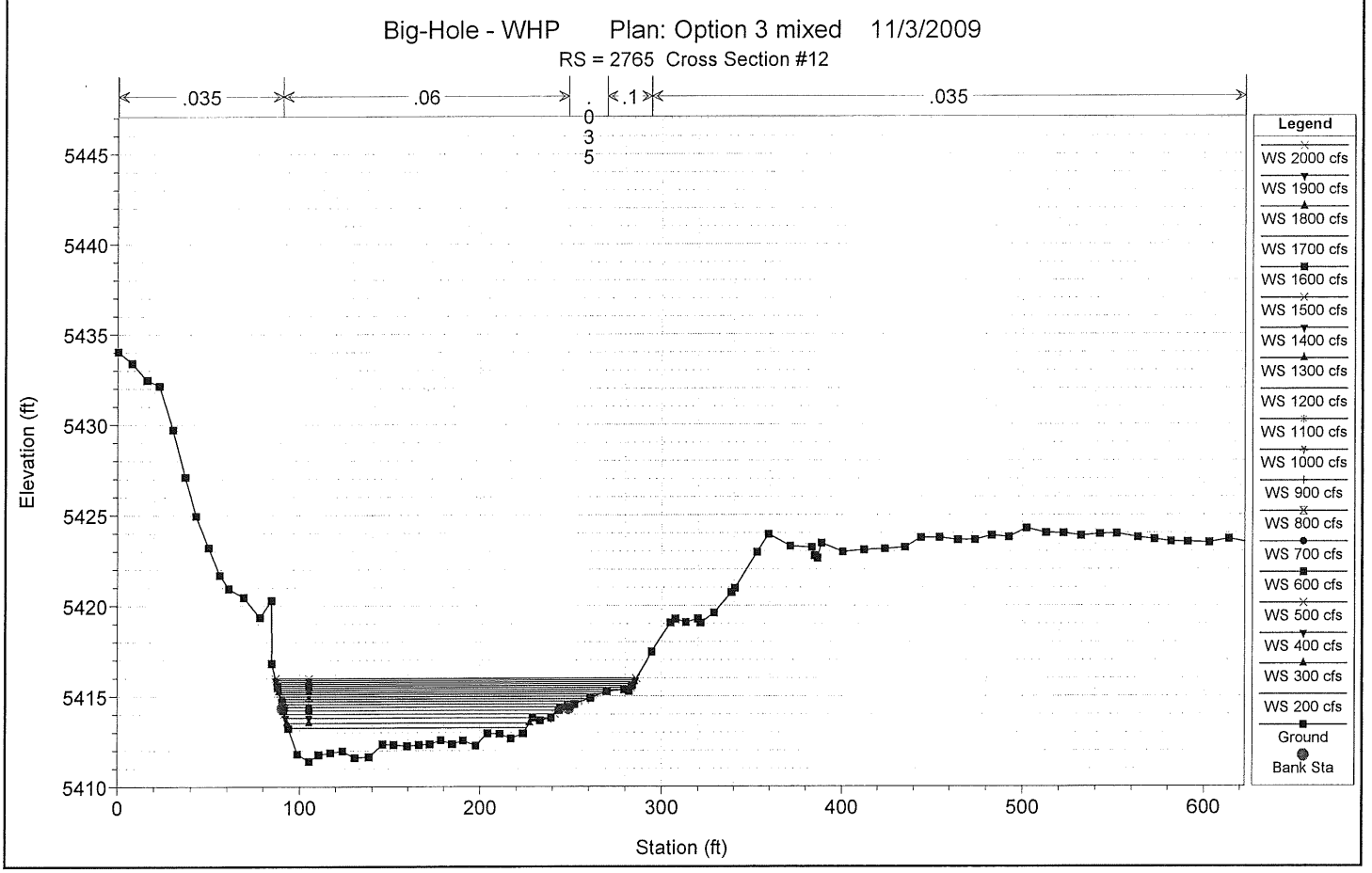

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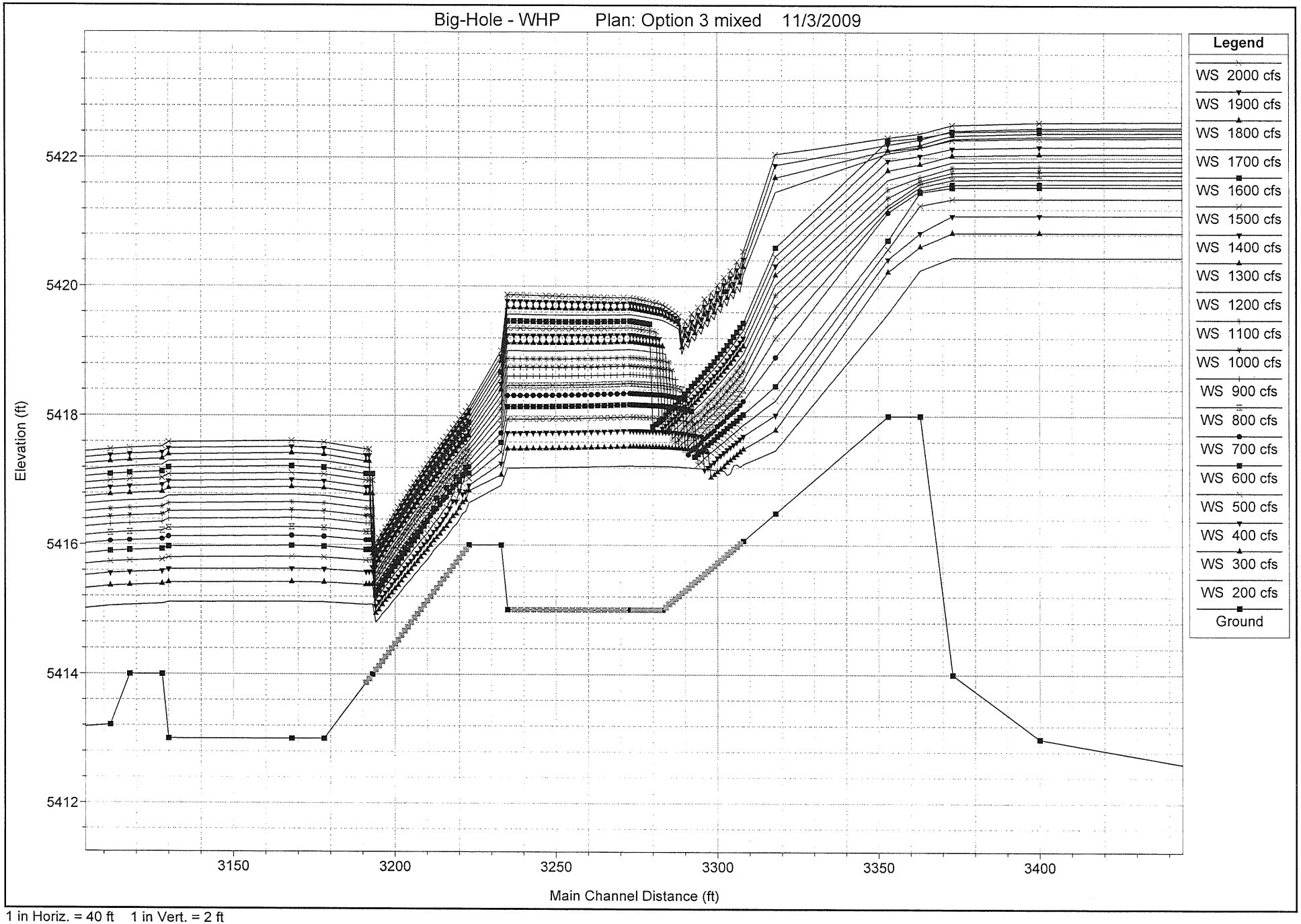
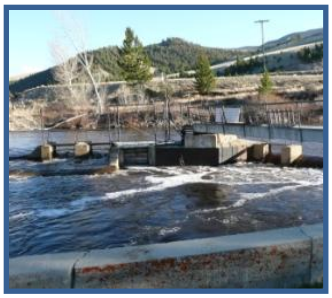


1 in Horiz. = 40 ft 1 in Vert. = 2 ft

23/23



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX E

PRELIMINARY GEOTECHNICAL DATA REPORT

PRELIMINARY GEOTECHNICAL DATA REPORT

BIG HOLE DIVERSION

PREPARED FOR

BUTTE – SILVER BOW COUNTY

PREPARED BY

DOWL HKM

920 Technology Blvd., Suite A
Bozeman, MT 59718
406.586.8834

September, 2009

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PRELIMINARY GEOTECHNICAL DATA REPORT

BIG HOLE DIVERSION

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Bozeman, MT 59718
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Principal Author

Christopher Leibli, P.G.

Reviewed By

Greg Underhill, P.E.

September, 2009

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LIST OF ACRONYMS

BGS ..... Below Ground Surface
ISB ..... Intermountain Seismic Belt
KSF ..... Thousand Pounds per Square Foot
PCF ..... Pounds per Cubic Foot
SPT ..... Standard Penetration Test
USBR ..... U.S. Bureau of Reclamation

1.0 INTRODUCTION

This report presents the results of the preliminary geotechnical investigation at the existing Big Hole Diversion approximately 3 miles west of Divide, Montana in Butte-Silver Bow County. Butte-Silver Bow County proposes to replace the antiquated Big Hole River Diversion Dam and intake facility due to the poor condition of the existing structures. The dam and intake are used to divert water from the Big Hole River to an adjacent pump station located on the north bank of the river. Geologic and geotechnical information compiled in this report will be utilized for evaluation of preliminary designs and corresponding construction cost estimates for the proposed site in question. A final geotechnical investigation will be conducted after preferred options for design are chosen. The project site is located in Section 12, Township 1 South, Range 10 West. A project location map is presented in Figure 1.

This report presents the results from field investigations conducted at the site during July of 2009. Initial site visits were conducted as a preliminary phase to plan the field exploration program. The field investigation drilling program was completed from July 21st to July 31st, 2009. The field investigation included site reconaissance, geotechnical borings, and geophysical surveys.

The following report summarizes the field techniques and presents the results of the investigation.

2.0 INVESTIGATION

Field investigations were completed during July of 2009 to study surface and subsurface conditions at the Big Hole Diversion. The field investigation included site reconaissance, geotechnical borings, and geophysical surveys. Locations of borings are shown on Figure 2.

2.1 Drilling Program

The subsurface drilling exploration was conducted between July 21st and July 31st, 2009. A total of 5 borings were completed to depths ranging from 8 to 55 feet for this investigation at locations shown on Figure 2. Borings B-1, B-3, and B-4 were proposed but not drilled due to difficult drilling conditions and time constraints. Borings were located in the field by DOWL HKM personnel. The borings were advanced using a Boart Longyear BK-81 drill rig operated by Haz-Tech Drilling of Billings, MT. A DOWL HKM geologist monitored the drilling and logged the drill holes. Drilling was initially attempted using 8 inch hollow stem augers in borings B-8 and B-7. Due the existence of large boulders and heaving sands this method was not successful so drilling was completed using tri cone rock bit, rock coring, and casing advancer methods (4-in. nominal diameter). Bedrock and some alluvium was sampled continuously by HQ-size core barrel (4-in. nominal diameter) and diamond-drilling methods (ASTM D 2113).

Standard penetration test (SPT) sampling was performed at each boring location using a 2-inch outside diameter split-spoon sampler in general accordance with ASTM D 1586. Samples were obtained by driving the sampler 18-inches into the soil with a 140-pound, automatic hammer and recording the number of blows required for each 6 inches of penetration. The standard penetration resistance (N_{field}) of the soil was recorded as the number of blows required for the final 12-inches of penetration for the initial 18-inches driven. If 50 blows were recorded within a single 6-inch interval, the test was terminated and the blow count was recorded as 50 blows for the number of inches of penetration. The resistance, or N-value, provides a measure of the relative density of granular soils and an estimation of consistency of cohesive soils.

Disturbed split spoon and core samples were obtained from the borings. Samples were returned to Bozeman, Montana for further examination. In addition, pertinent information including soil sample depths, stratigraphy, soil engineering characteristics and groundwater occurrence were recorded. This information is summarized on the borehole logs in Appendix A. Soil classification legends are also included in Appendix A.

Soils and bedrock were field-classified in general accordance with ASTM D 2488. The stratigraphic contacts shown on the individual borehole logs represent the approximate boundaries between soil types. The actual transitions may be more gradual or abrupt. The soil and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times.

Rock-core parameters were logged and included: rock type, weathering and alteration, strength, recovery (or loss) of core, Rock Quality Designation (RQD), and photo documentation. RQD defines the fraction of solid core recovered greater than 4-inches in length as a percentage of the entire run length. Photographs of rock cores and alluvium cores are included in Appendix C.

2.2 Geophysical Investigation

A geophysical survey was completed for this site to aid in delineating bedrock depth. This survey consisted of seismic refraction and shear wave velocity surveys on land along the north and south sides of the Big Hole River and sub-bottom profile surveys in the water within the Big Hole River. The geophysical surveys and data analysis were completed by Sage Earth Sciences out of Idaho Falls, ID. A copy of their report is presented in Appendix D. Locations of the geophsyical survey transects and a dicussion of the methodology and results are presented in this report. Results of this report are also discussed in section 5.

3.0 SITE CONDITIONS

3.1 Topography

Topography of this site is characterized by a deeply incised V shaped valley sloping up steeply to the north and south of the Big Hole River. A broad relatively flat alluvial terrace is present along the south side of the river about 30 to 35 feet above the river surface elevation. Surrounding topography is generally mountainous to the East, North, and South opening up into a broader floored river valley towards the east. A site topographic map is provided in Figure 2 and a smaller scale USGS topographic map is presented as Figure 3.

3.2 Existing Structures

Structures currently occupying the site consist of the existing pump house, caretakers house, and associated underground utilities on the north side of the river and the existing dam and intake structure. The existing dam and intake structure consists of the following.

- concrete diversion dam approximately 5 feet high and 190 feet long,
- trapezoidal shaped settling area about 80 feet wide by 110 feet long,
- concrete intake pier with gates to control water intake,
- 4 ft x 5ft concrete pipe extending from the intake pier to a wet well on the north bank,
- 20 foot diameter buried concrete wet well adjacent to the pump station building.

3.3 Vegetation

Vegetation in the study area consists primarily of native grasses with scattered brush on the south side of the river and maintained lawn areas, native grasses, brush, and trees on the north side of the river.

3.4 Surface Water

The Big Hole River flows through this site as shown In Figures 2 and 3.

3.5 Groundwater

Groundwater was encountered in every boring completed for this project except for boring B-2, which was abandoned at 8 feet.

Table 1 presents depth to groundwater observed in the borings at the time of the investigation.

Table 1: Groundwater Levels
Big Hole Diversion

Boring Number	Date of Groundwater Measurement	Depth to Groundwater (Feet below ground surface)
B-2	7/31/2009	N.E.
B-5	7/30/2009	9
B-6	7/31/2009	10
B-7	7/21/2009	10
B-8	7/29/2009	13

* N.E. – None Encountered

4.0 GEOLOGY

4.1 Regional

The Big Hole Diversion is located on the eastern edge of the Pioneer Mountain Range. This area is generally comprised of Cretaceous to Mississippian age sedimentary rocks that were folded and thrusted during the Laramide orogeny and subsequently intruded by large granitic batholiths during the Cretaceous. In more recent times Quaternary alluvium has filled river valleys in this area.

4.2 Local

Existing geologic mapping (Ruppel, et. al., 1993) for this area shows that this site consists of Quaternary alluvium overlying Cretaceous to Mississippian age marine sedimentary rocks dipping steeply to the east. Bedrock exposed in road cuts near this site generally consisted of steeply dipping marine sedimentary rocks as mapped. Borings completed for this site were consistent with mapping; generally showing Quaternary alluvial deposits over sedimentary rocks.

Following is a description of the geologic units shown to exist at or near the Big Hole Diversion. Descriptions are derived from the USGS Geologic Map of the Dillon 1x2 Quadrangle, Idaho and Montana (Ruppel, et. al., 1993). A geologic map showing the extents of these units is presented in Figure 4:

Qa Alluvium – Silt, sand, and gravel in channels and flood plains of major rivers and streams. Locally this deposit contained large angular to subrounded cobbles and boulders up to 4 feet in diameter.

Kgtd Granodiorite, tonalite, and quartz diorite – Generally light-gray medium-grained intrusive igneous rocks of Cretaceous age.

Ks Cretaceous Sedimentary Rocks (Undivided) – Lithology highly variable; mostly marine sedimentary rocks including sandstone, mudstone, and limestone of cretaceous age with few conglomerate beds.

Kk Kootenai Formation – Mudstone, siltstone, limestone, and sandstone. Color is highly variable.

Tru Triassic Rocks (Undivided) – Variable Lithology; primarily light-gray to reddish-brown limestone, sandstone, siltstone and calcareous mudstone.

Pp Phosphoria Formation – Primarily glauconitic chert, cherty fine-grained sandstone, and quartzitic sandstone with some mudstone. Color varies from yellowish-brown to brownish-gray to dark-gray.

PMq Quadrant Formation – Light-gray to pale-yellowish-brown fine to medium-grained quartzitic sandstone and vitreous quartzite.

5.0 SUBSURFACE CONDITIONS

5.1 General Subsurface Conditions Encountered in Borings

The subsurface conditions encountered in the five borings completed for this investigation varied somewhat throughout the site. The four borings (B-5, B-6, B-7, and B-8) completed on the north side of the river all consisted of a layer of topsoil and fill overlying alluvium. The one boring (B-2) completed on the south side of the river did not encounter the fill seen on the north side. The alluvium encountered in borings B-5, B-6, and B-7 consisted of loose sand overlying very dense gravel with sand, cobbles, and boulders. The loose sand was not encountered in borings B-2 and B-8. Quartzitic fine-grained sandstone bedrock was also encountered in boring B-8 beneath the alluvium. It is expected that similar bedrock would be encountered at depths greater than drilled in the other borings. Topsoil thickness ranged from 0.5 to 1.6 feet and depth of fill ranged from 7 to 15 feet below ground surface in the four borings north of the river. Loose sand was present to depths of 11 to 12 feet in borings B-5, B-6, and B-7. Bedrock was encountered at 44 feet below ground surface in boring B-8. No other borings were completed deep enough to encounter bedrock; borings were advanced to depths ranging from 8 to 55 feet. A previous investigation in which test wells were drilled was also completed at this site by Ranney Method Western Corporation. Two of these wells were located approximately 400 feet downstream of the existing pump house on the north side of the river (TH-2 and TH-3) and both showed alluvium similar to that encountered in this investigation to their depths of completion (26.5 and 30.8 feet, respectively). Well logs and a well location map from this previous investigation are presented in Appendix F for reference.

Following is a description of the materials encountered in the borings completed for this investigation. Detailed logs are available in Appendix B.

<u>Topsoil and organic matter:</u>

Topsoil and organic material was present above either the fill or alluvium in all borings completed for this investigation. This material was generally light to dark brown with common organics.

<u>Fill:</u>

Fill was encountered beneath the topsoil in borings B-5, B-6, B-7, and B-8. This material was variable throughout the site depending on location. In boring B-5 the fill consisted of large boulders with voids and some poorly graded gravel with sand to a depth of 7.0

feet. In borings B-6 and B-7 the fill consisted of loose dark brown to medium brown poorly graded sand with scattered angular gravel. In boring B-8 the fill was a mixture of poorly graded sand with gravel, clayey sand with gravel, poorly graded gravel with sand, and clayey gravel with sand. Large boulders and pieces of concrete were also present in the fill from boring B-8.

Poorly graded sand (alluvium):

Native alluvium consisting of poorly graded sand was present beneath the fill in borings B-5, B-6, and B-7. This sand was generally loose to medium dense and medium brown. Blow counts ranged from 3 to 17 blows per foot. Based on the loose nature of this material and its location on the inside of a river bend, it is interpreted as sand that built up on the river bank before the river was modified by the construction of the existing dam. The presence of scattered organics in the upper portion of this deposit also supports the interpretation that this was an existing vegetated river bank surface before fill was placed.

Poorly graded gravel with sand, cobbles, and boulders (alluvium):

Poorly graded gravel with sand, cobbles, and boulders was present in all of the borings completed for this investigation. This material was generally very dense with large boulders up to 4 feet in diameter. Cobbles and boulders were generally very hard, subangular to subrounded and of variable composition and color. Blow counts varied from 29 to greater than 92 with split spoon refusal in many cases on the large boulders and cobbles. Drilling was slow and very difficult in this material due to the large boulders and cobbles. It was evident from materials exposed in the river bed and the side of the terrace on the south side that some of these boulders can be up to 8 feet in diameter.

Sandstone Bedrock:

Only one boring (B-8) was completed deep enough to encounter bedrock during this investigation. Bedrock was encountered in this boring at a depth of approximately 44 feet below ground surface (elevation of 5389 feet). Bedrock encountered in boring B-8 consisted of very strong and hard quartzitic fine-grained sandstone. Color was generally dark gray and conjugate fractures were common in the upper 5 feet. Based on similar S-wave velocities for the bedrock contact determined in the seismic refraction survey for this site (generally around 10,000 to 12,000 fps); it is likely that bedrock throughout the site has a similar hardness and strength properties. Based on existing geologic mapping

and bedrock outcrops near the site it appears that bedrock generally consists of marine sedimentary rocks in this area. A discussion of interpreted bed rock depth based on borings and the geophysical survey is presented in Section 5.2.

5.2 Interpreted Depth to Bedrock and Bedrock Elevations from Geophysical Survey and Borehole Logs

Based on the data generated by the geophysical survey a bedrock elevation contour map of a section of the river was generated. This map is presented as Figure 5 in appendix A. Refraction lines were not included in this map due to their distance from the sub-bottom profiler lines. Refer to the geophysical report in Appendix D for refraction line profiles. The geophysical survey determined bedrock elevations to vary from approximately 5,332 feet to 5,405 feet above MSL. These depths were based on calculations using a sediment velocity of 3,000 fps. Sediment velocity was initially estimated lower at approximately 2,000 fps but the estimate was increased to better match depth to bedrock encountered in boring B-8 and to better match characteristics of the denser than anticipated alluvium that was encountered in the borings. Depth to bedrock below ground surface varied from approximately 20 to 80 feet below ground surface on the refraction lines and approximately 20 to 70 feet below river bottom surface on the sub-bottom profiler lines. The bedrock surface elevation was generally lower towards the middle and southern portions of the river becoming higher near the north bank as shown in Figure 5 and the sub-bottom profiler graphs in the geophysical report in Appendix D. The bedrock contour generated from the sub-bottom profiler survey also shows a deep scour hole in the bedrock that extends to approximately 70 feet below the river bottom surface in the upstream portion north of the centerline of the river (directly south of boring B-7). The highest bedrock elevations (up to 5,405 feet) encountered on the refraction lines tended to be near the western part of the seismic refraction line on the north side of the Big Hole River south and west of boring B-8: The lowest depth to bedrock also occurred in this area (approximately 20 feet below ground surface). The highest bedrock elevations (up to 5,400 feet) encountered on the sub-bottom profiler lines were generally near the north bank and on a relatively shallow dipping bench on the downstream portion of the river towards the north bank.

6.0 SEISMICITY

6.1 General

The Gillam Property Dam site is located near the western edge of the Intermountain Seismic Belt (ISB). The ISB is a concentrated zone of seismicity that is defined by the location of over 14,000 earthquake epicenters in Montana, Wyoming, and Idaho. The ISB essentially follows the spine of the Rocky Mountains. East of the ISB, the recorded occurrence of earthquakes drops off dramatically.

6.2 Site Specific Ground Motion Parameters

Peak ground acceleration at the Big Hole Diversion was obtained from MBMG Special Publication 117 "Probabilistic Earthquake Hazard Maps of the State of Montana". The site response units map (Figure E-4) shows the site to be situated on soft bedrock with areas of Quaternary alluvium very close to the site. Borings completed for this project indicate that the site is located on Quaternary alluvium so the PGA values were derived from the areas close to the site showing Quaternary alluvium on the site response units map and from the location of the Big Hole diversion mapped as soft bedrock. Based on a Quaternary alluvium subgrade, the 1% probability of exceedance in 50 years PGA for the site is 0.2 to 0.3g (Figure E-1), the 2% probability of exceedance in 50 years PGA is 0.1 to 0.2g (Figure E-2), and the 10% probability of exceedance in 50 years PGA is 0.1 to 0.2g (Figure E-3). Based on a soft bedrock subgrade, the 1% probability of exceedance in 50 years PGA for the site is 0.1 to 0.2g (Figure E-1), the 2% probability of exceedance in 50 years PGA is 0.1 to 0.2g (Figure E-2), and the 10% probability of exceedance in 50 years PGA is less than 0.1g (Figure E-3).

Modal magnitude and modal distance of earthquakes for this site were also determined from MBMG Special Publication 117 as listed in the table below and shown on Figures E-6 through E-11.

Table 2: PGA, Modal Magnitude, and Modal Distance
Big Hole Diversion

Percent Probability of Exceedance in 50 Years	PGA on Soft Bedrock	PGA on Alluvium	Modal Magnitude on Rock	Modal Distance on Rock (km)
1%	0.1 to 0.2g	0.2 to 0.3g	6.0 to 6.4	11 to 22
2%	0.1 to 0.2g	0.1 to 0.2g	5.5 to 5.9	11 to 22
10%	Less than 0.1g	0.1 to 0.2g	5.5 to 5.9	31 to 40

7.0 LIMITATIONS

The conclusions presented in this report assume that site conditions are not substantially different than those exposed by the explorations. If during construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present, DOWL should be advised at once to review those conditions.

If there is a substantial lapse of time between submission of this report and the start of work at the site, and if conditions have changed due to natural causes or construction operations at or near the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions.

This report was prepared for the use of the project Owner and his consultants for this project. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions.

Any conclusions by a construction contractor or bidder relating to construction means, methods, techniques, sequences or costs based upon the information provided in this report are not the responsibility of the Owner or DOWL HKM.

8.0 REFERENCES

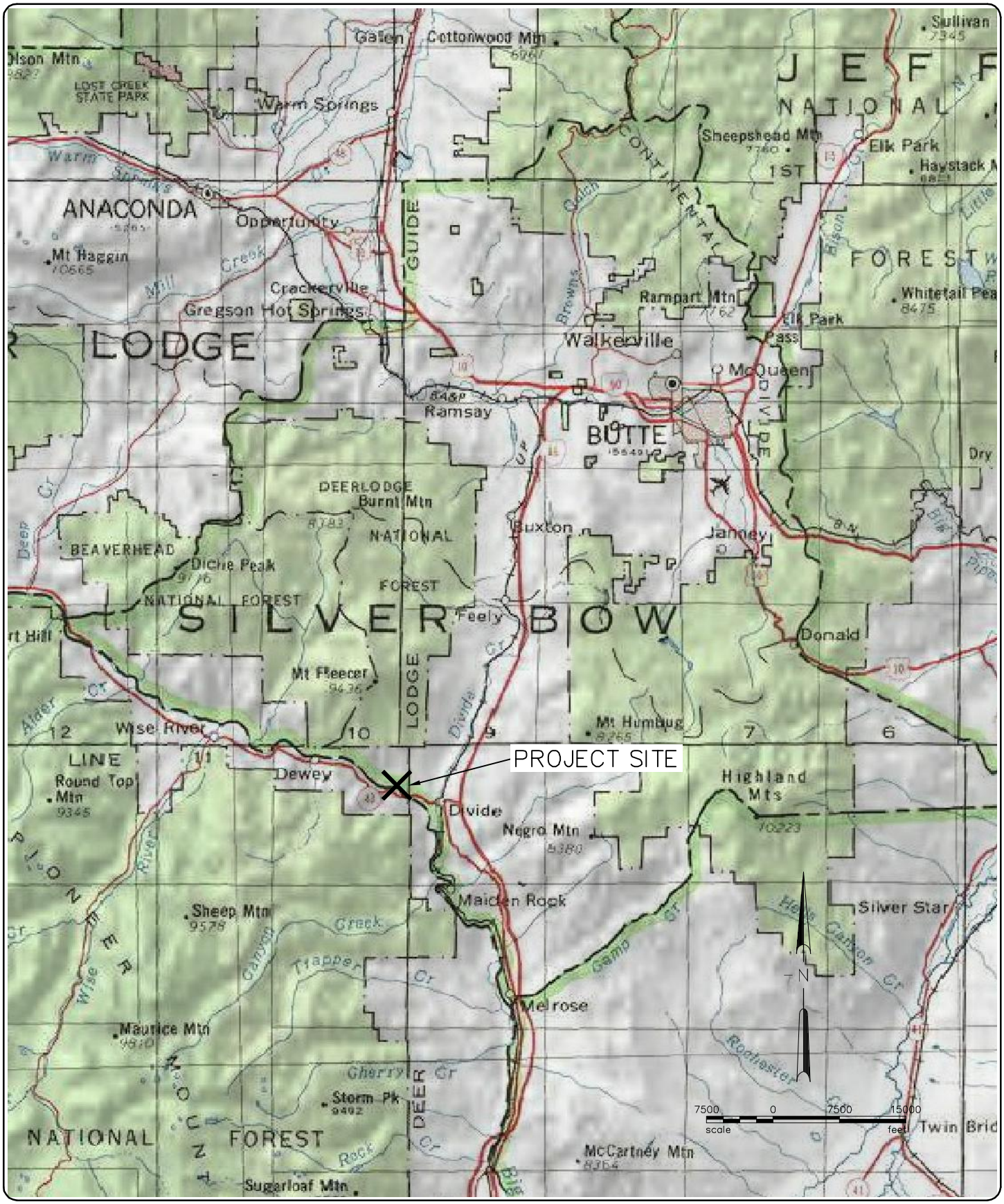
Alt, D., and D.W. Hyndman. 1986. Roadside Geology of Montana. Mountain Press Publishing Company, Missoula, Montana.

Ruppel, E.T., O'Neil, J.M., and Lopez, D.A., 1993. Geologic Map of the Dillon 1° x 2° Quadrangle, Idaho and Montana. United States Geological Survey: Miscellaneous Investigations Series Map I-1803-H.

Wong, I., Olig, S., Dober, M., Wright, D., Nemser, E., Lageson, D., Silva, W., Stickney, M.S., Lemieux, M., Anderson, L., 2005, Probabilistic earthquake hazard maps for the state of Montana, Montana Bureau of Mines and Geology: Special Publication 117, 72 p.

APPENDIX A

FIGURES



BIG HOLE DIVERSION

VICINITY MAP

FIGURE 1

DOWL HKM

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FIGURE 2

DOWL HKM

4428.10198.01 AUGUST 2009

BIG HOLE DIVERSION

BOREHOLE LOCATION AND SITE TOPOGRAPHY

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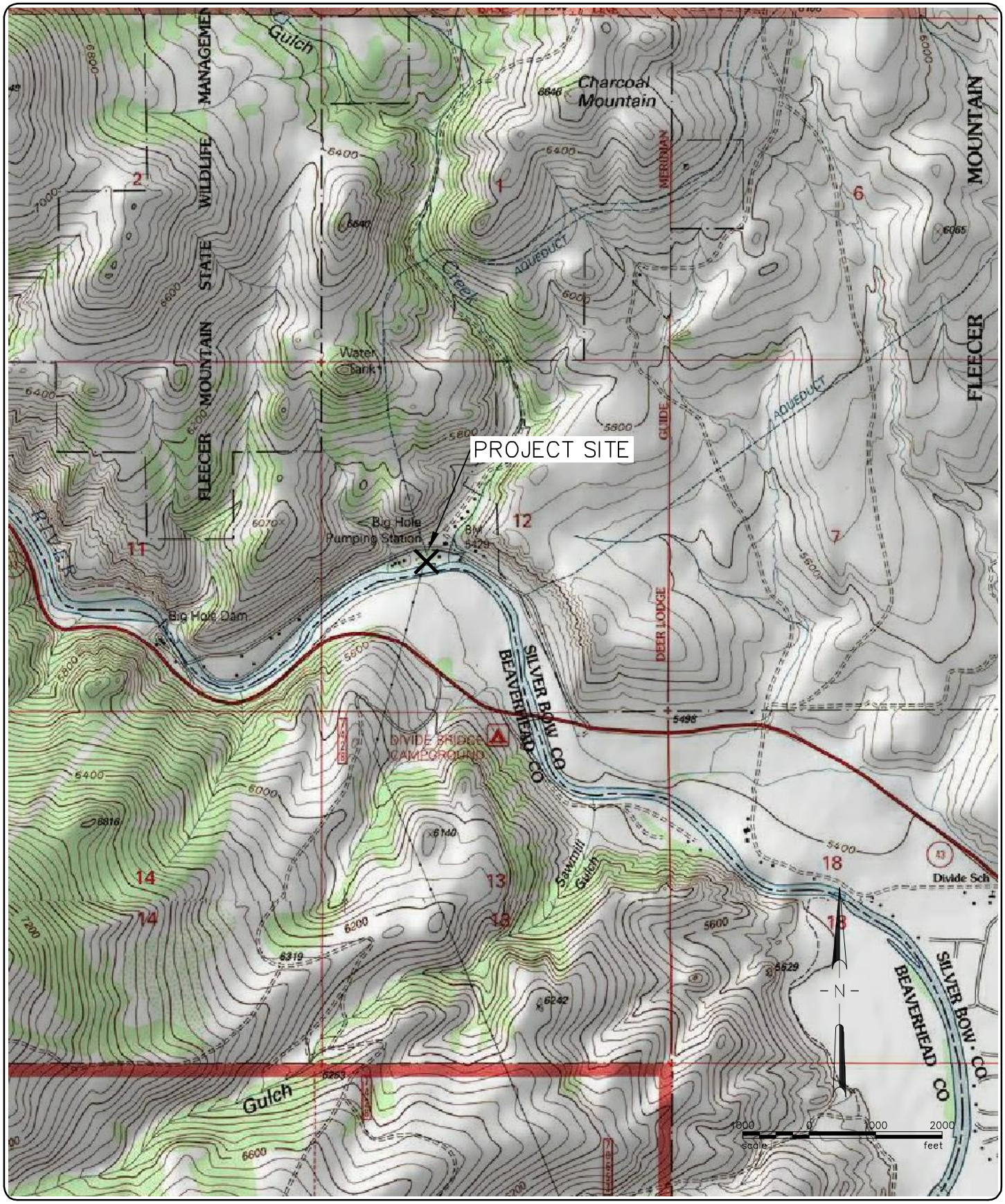

BIG HOLE DIVERSION

USGS TOPOGRAPHIC MAP

FIGURE 3

DOWL HKM

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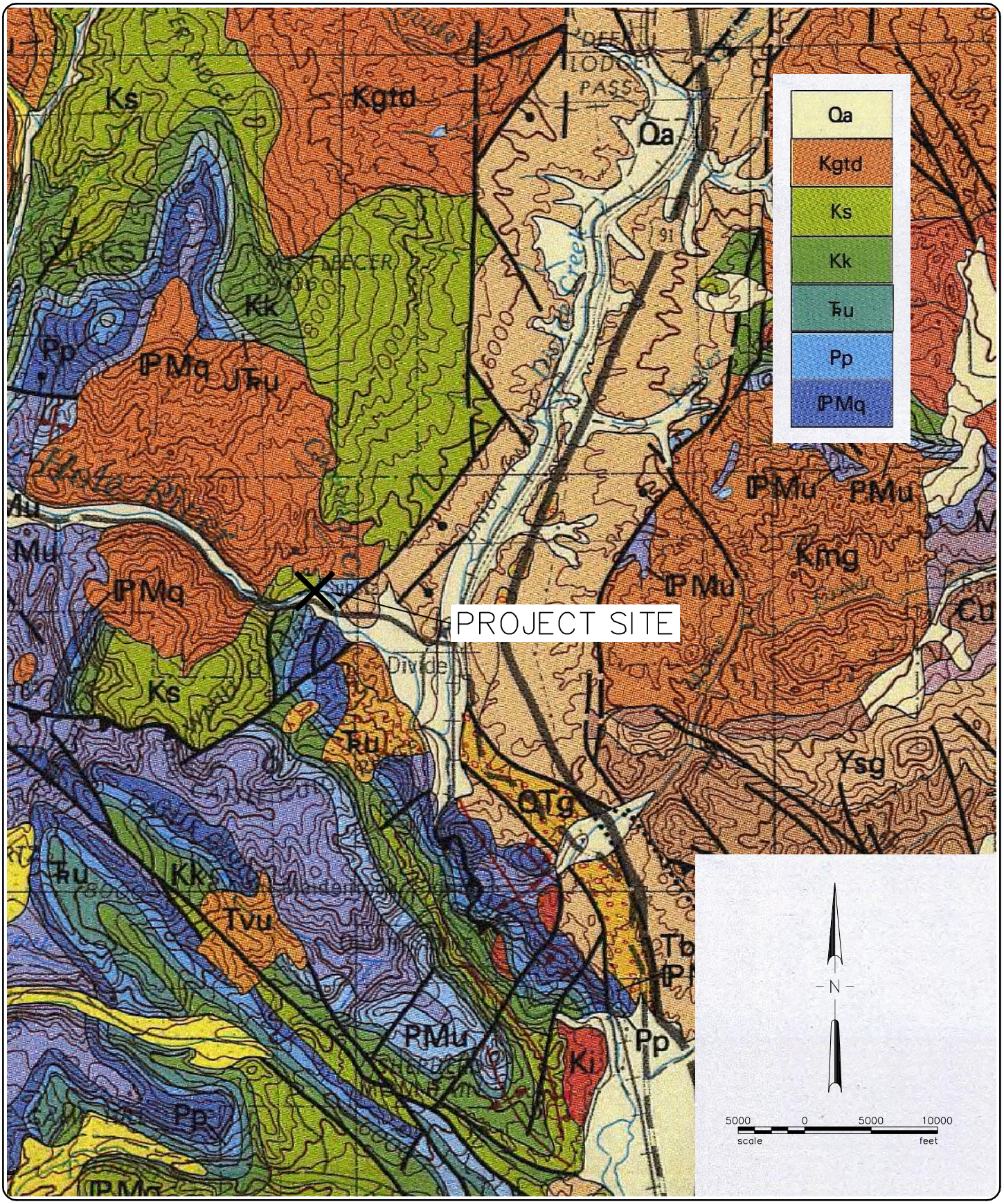

BIG HOLE DIVERSION
GEOLOGIC MAP
USGS MAP I-1803-H

FIGURE 4

DOWL HKM

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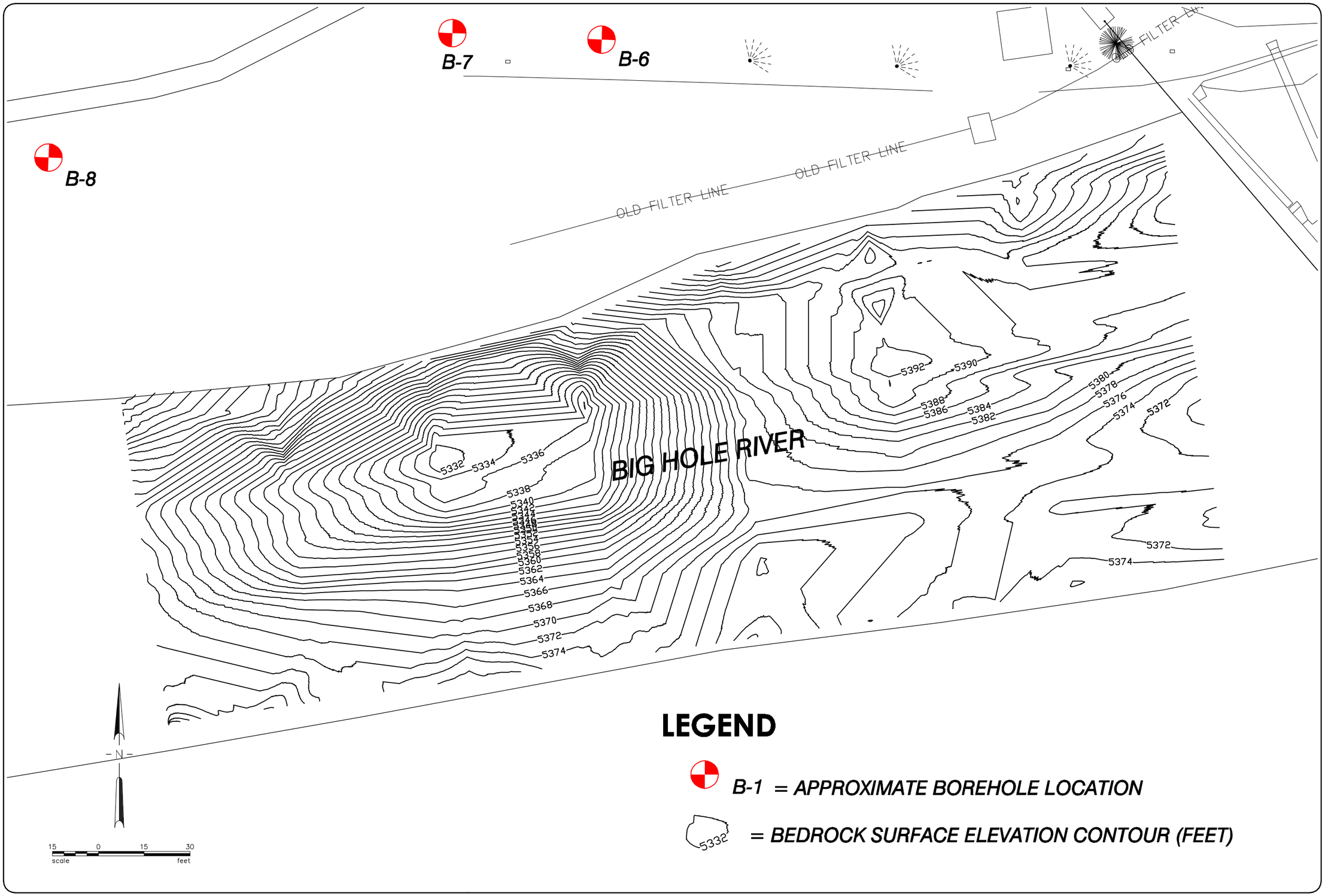

FIGURE 5

DOWL HKM

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BIG HOLE DIVERSION

BEDROCK ELEVATION MAP

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APPENDIX B

EXPLORATION BORING LOGS

DOWL HKM

SOIL CLASSIFICATION/LEGEND

Unified Soil Classification System

Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions	
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded gravels
			GP	Poorly-graded gravels
		GRAVELS w/ FINES More than 12% fines	GM	Gravel and silt mixtures
			GC	Gravel & clay mixtures
	SANDS 50% or more of coarse faction passes No. 4 sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded sands
			SP	Poorly-graded sands
		SANDS with FINES More than 12% fines	SM	Sand and silt mixtures
			SC	Sand and clay mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS & CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity clays
			ML	Non-plastic and low-plasticity silts
		ORGANIC	OL	Non-plastic and low plasticity organic clays Non-plastic and low-plasticity organic silts
	SILTS & CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity clays
			MH	High-plasticity silts
		ORGANIC	OH	High-plasticity organic clays High-plasticity organic soils
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color and has an organic odor		PT	peat

Component Definitions By Gradation

Component	Size Range
Boulders	Greater than 12-in.
Cobbles	3-in. to 12-in.
Gravel	3-in. to No. 4 (4.75 mm)
Coarse gravel	3-in. to ¾-in.
Fine gravel	¾-in. to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (.075 mm)
Coarse sand	No. 4 (4.75 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.425 mm)
Fine sand	No. 40 (0.425 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay, Lean Clay	CL
Clay, Fat Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Relative Density or Consistency Utilizing Standard Penetration Test Values

Cohesionless Soils[a]			Cohesive Soils[b]		
Density[c]	N blows/ft[c]	Relative Density (%)	Consistency	N blows/ft[c]	Undrained Shear Strength[d] (psf)
Very loose	0 to 3	0 - 15	Very soft	0 to 2	<250
Loose	4 to 9	15 - 35	Soft	3 to 4	250 - 500
Med. Dense	10 to 29	35 - 65	Firm	5 to 8	500 - 1000
Dense	30 to 49	65 - 85	Stiff	9 to 15	1000 - 2000
Very Dense	Over 50	>85	Very Stiff	16 to 29	2000 - 4000
			Hard	Over 30	>4000

(a) Soils consisting of gravel, sand and silt, either separately or in combination, possessing no characteristics of plasticity and exhibiting drained behavior.

(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.

(c) Undrained shear strength = ½ unconfined compressive strength.

(d) Qp - Denotes pocket penetrometer field measurement (tons per square foot) approximation to unconfined compressive strength.

Descriptive Terminology Denoting Components Proportions

Descriptive Terms	Range of Proportion
Trace or Scattered	0 - 5%
Few	5 - 10%
Some or Adjective[a]	15 - 30%
And	30 - 50%

(a)Use gravelly, sandy or silty as appropriate.

Groundwater Elevation

Water Elevation Noted During Drilling

Water Elevation Recorded After Drilling Complete

Soil Moisture

Dry	No sign of water dry to the touch
Slightly Moist	Dry of the optimum moisture content.
Moist	Approximately at optimum moisture.
Wet	Wet of optimum to saturated.

Samples

Split Spoon Sampler (2.0" OD)

Ring Sampler (3.0" OD)*

*Indicates increased blow counts due to sampler size.

Shelby Tube Sampler (3.0" OD)

Bulk Sample (auger cuttings)

Unless otherwise noted, drive samples advanced with 140-lb. hammer and 30-in. drop.

DOWL HKM

ROCK CLASSIFICATION DESCRIPTIONS

ROCK STRENGTH			
Class	**Strength**	**Field Test**	**Approximate Range of Uniaxial Compressive Strength kg/cm^2 (tons/ft^2)**
I	Extremely Strong	Many blows with geologic hammer required to break intact specimen.	>2000
II	Very Strong	Hand held specimen breaks with hammer end of pick under more than one blow.	2000-1000
III	Strong	Cannot be scraped or peeled with knife, hand held specimen can be broken with single moderate blow with pick.	1000-500
IV	Moderately Strong	Can just be scraped or peeled with knife. Indentations 1mm to 3mm show in specimen with moderate blow with pick.	500-125
V	Moderately Weak to Weak	Material crumbles under moderate blow with sharp end of pick and can be peeled with a knife, but is too hard to hand trim for triaxial test specimen.	125-12

WEATHERING		
Grade	**Symbol**	**Diagnostic Features**
Fresh	F	No visible sign of decomposition or discoloration. Rings when struck by hammer.
Slightly Weathered	WS	Slight discoloration inwards from open fractures, otherwise similar to F.
Moderately Weathered	WM	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped by knife. Texture preserved.
Highly Weathered	WH	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.
Completely Weathered	WC	Minerals decomposed to soil but fabric and structure preserved (Saprolite). Specimens easily crumbled or penetrated.
Residual Soil	RS	Advanced state of decomposition resulting in plastic soils. Rock fabric and structure completely destroyed. Large volume change.

STRUCTURAL PARAMETERS		
Description for Structural Features: Bedding, Foliation, or Flow Banding	**Spacing**	**Description for Joints, Faults or Other Fractures**
Very Thickly (bedded, foliated, or banded)	More than 6 feet	Very Widely (fractured or jointed)
Thickly	2 - 6 feet	Widely
Medium	8 - 24 inches	Medium
Thinly	2½ - 8 inches	Closely
Very Thinly	¾ - 2½ inches	Very Closely
Description for Microstructural Features: Lamination, Foliation, or Cleavage		**Description for Joints, Faults or Other Fractures**
Intensely (laminated, foliated or cleaved)	¼ - ¾ inch	Extremely Close
Very Intensely	Less than ¼ inch	

RQD	
RQD (Rock Quality Designation)	**Description of Rock Quality**
0 - 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Very Good

Project No.: 4428.10198.01

LOG OF BOREHOLE B-2

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
South side of Bighole River on gravel terrace.	Big Hole Diversion, Montana

Surface Elevation: 5451.3 feet

DEPTH (FT.)	MATERIAL DESCRIPTION	GRAPHIC LOG	ELEVATION (FT.)
0	Topsoil and organic material.		
0.5			5450.8
	Poorly graded gravel with sand, cobbles, and boulders (GP); very dense, light brown matrix with variable colored and composition gravel, cobbles, and boulders; boulders are subrounded to subangular up to 4 feet, alluvium.		5448
6			
8.0			5443.3
	Boring abandoned at 8.0 feet.		
	Large boulders were making drilling very difficult.		
12			
	Drilling was progressing at approximately 2 feet per hour.		
	Evident from looking at the side of the terrace that large boulders exist in this material to the river elevation or deeper (approximately 30 feet lower than borehole elevation).		
18			
24			
30			
36			
42			

SAMPLES: BULK; DRIVEN/PUSH; BLOWS PER 6"; N BLOWS/FT; NUMBER; IN. RECOVERED IN. DRIVEN

TESTS: POCKET PENETROMETER, TSF; M.C. PL — LL; N VALUE □ BLOWS/FT 10 20 30 40; ADDITIONAL DATA/ REMARKS

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Fax: (406) 586-1730

STARTED	7/31/09	FINISHED	7/31/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# Auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

Project No.: 4428.10198.01

LOG OF BOREHOLE B-5

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
North side of the Bighole River south of the pumphouse.	Big Hole Diversion, Montana

Surface Elevation: 5426.1 feet

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)
0	Topsoil and organic material.	
1.5	5424.6	5424
	Fill, poorly graded gravel with sand, cobbles, and boulders (GP); very dense, light brown, primarily large boulders with voids in between them as indicated by loss of drilling fluid circulation.	
6		
7.0	5419.1	5418
	Native poorly graded sand (SP), very loose, medium brown, few organics, this appears to be the previous river bank surface, alluvium. - Groundwater encountered at 9 feet below ground surface.	
11.0	5415.1	
12	Poorly graded gravel with sand, cobbles, and boulders (GP); very dense, light brown matrix with variable colored and composition gravel, cobbles, and boulders; boulders are subrounded to subangular up to 2 feet in diameter, grades to poorly graded gravel with clay, sand, cobbles, and boulders (GP-GC) in some places; alluvium.	5412
18		5406
24		5400
30	- Core run completed from 30 to 35 feet through alluvium.	5394
35.0	5391.1	
36	End of boring.	
	Groundwater encountered at 9 feet below ground surface.	
42		

SAMPLES

BULK DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED IN. DRIVEN
	50/ 1"	50		0/1 0%
	3 2 1	3		16/18 89%
	21 50/ 1"	71		2/7 29%
	23 21 50/ 5"	71		11/17 65%
	25 39 50/ 2"	89		8/14 57%
	33 50/ 3"	83		7/9 78%

TESTS

POCKET PENE-TROMETER, TSF

M.C. PL LL

N VALUE BLOWS/FT 10 20 30 40

71 71 89 83

ADDITIONAL DATA/ REMARKS

DOWL HKM
920 Technology Blvd., Suite A
Bozeman, Montana 59718
Telephone: (406) 586-8834
Fax: (406) 586-1730

STARTED	7/29/09	FINISHED	7/30/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

Project No.: 4428.10198.01

LOG OF BOREHOLE B-6

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
North side of the Bighole River south of caretaker's house.	Big Hole Diversion, Montana

Surface Elevation: 5428.6 feet

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)
0	Topsoil and organic material.	
1.5	5427.1	
	Fill, poorly graded sand (SP), loose, dark brown, scattered angular gravel.	5424
6		
7.0	5421.6	
	Native poorly graded sand (SP), very loose, medium brown, few organics, this appears to be the previous river bank surface, alluvium. - Groundwater encountered at 10 feet below ground surface.	5418
12	12.0 5416.6	
	Poorly graded gravel with sand, cobbles, and boulders (GP); very dense, light brown matrix with variable colored and composition gravel, cobbles, and boulders; boulders are subrounded to subangular up to 3 feet in diameter, grades to poorly graded gravel with clay, sand, cobbles, and boulders (GP-GC) in some places; alluvium.	5412
18		
		5406
24		
		5400
30		
		5394
36	- Core run completed from 35 to 39 feet through alluvium.	
40.0	5388.6	
	End of boring.	
42	Groundwater encountered at 10 feet below ground surface.	

SAMPLES

BULK DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED IN. DRIVEN
	2 3 1	4		14/18 78%
	2 2 1	3		1/18 6%
	50/ 1"	50		0/1 0%
	50/ 1"	50		0/1 0%
	46 45 42	87		12/18 67%
	50/ 1"	50		0/1 0%

TESTS

POCKET PENE-TROMETER, TSF

M.C. PL LL

N VALUE BLOWS/FT 10 20 30 40

87

ADDITIONAL DATA/ REMARKS

DOWL HKM
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Bozeman, Montana 59718
Telephone: (406) 586-8834
Fax: (406) 586-1730

STARTED	7/29/09	FINISHED	7/30/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

Project No.: 4428.10198.01

LOG OF BOREHOLE B-7

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
North side of the Bighole River south of caretaker's house.	Big Hole Diversion, Montana

Surface Elevation: 5429.8 feet

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)
0	Topsoil and organic material.	
1.6	5428.2	
	Fill, poorly graded sand (SP), loose, dark brown, scattered angular gravel.	5424
6		
7.0	5422.8	
	Native poorly graded sand (SP), medium dense, medium brown, few organics, this appears to be the previous river bank surface, alluvium. - Groundwater encountered at 10 feet below ground surface.	5418
12		
12.0	5417.8	
	Poorly graded gravel with sand, cobbles, and boulders (GP); very dense, light brown matrix with variable colored and composition gravel, cobbles, and boulders; boulders are subrounded to subangular up to 3 feet in diameter, grades to poorly graded gravel with clay, sand, cobbles, and boulders (GP-GC) in some places; alluvium.	5412
18		
		5406
24		
25.8	5404	
	End of boring.	
	Auger refusal on large boulder.	
30	Could not core due to hole going crooked from augering through very coarse material and did not have casing advancer setup at the time this boring was drilled.	
	Drilled B-6 east of this hole with a casing advancer.	
36	Groundwater encountered at 10 feet below ground surface.	
42		

SAMPLES

BULK DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED IN. DRIVEN
	1 2 4	6		8/18 44%
	5 10 7	17		8/18 44%
	22 28 50	78		10/18 56%
	22 14 15	29		12/18 67%
	39 50/ 4"	89		10/10 100%

TESTS

POCKET PENE-TROMETER, TSF

M.C. PL LL

N VALUE BLOWS/FT 10 20 30 40

ADDITIONAL DATA/ REMARKS

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Telephone: (406) 586-8834
Fax: (406) 586-1730

STARTED	7/21/09	FINISHED	7/21/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

Project No.: 4428.10198.01

LOG OF BOREHOLE B-8

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
North side of the Bighole River on berm.	Big Hole Diversion, Montana

Surface Elevation: 5433.4 feet

DEPTH (FT.)	MATERIAL DESCRIPTION	ELEVATION (FT.)
0	Topsoil and organic material.	
0.5		5432.9
	Fill, variable composition, zones of poorly graded sand with gravel (SP), clayey sand with gravel (SC), poorly graded gravel with sand (GP), and clayey gravel with sand (GC), large cobbles and boulders are common up to 2 feet in diameter, scattered boulder sized concrete pieces, loose to very dense, moist to saturated, variable color mostly medium to dark brown.	5430
6		5424
12	- Groundwater encountered at 13 feet below ground surface.	
15.0		5418.4
	Poorly graded gravel with clay, sand, cobbles, and boulders (GP-GC); very dense, light to medium brown matrix with variable colored and composition gravel, cobbles, and boulders; boulders are subrounded to subangular up to 3 feet in diameter, grades to poorly graded gravel with sand, cobbles, and boulders (GP) in some places; alluvium.	5418
18		5412
24		5406
30		5400
36		5394
42		
44.0		5389.4

GRAPHIC LOG

SAMPLES

BULK DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED IN. DRIVEN
	2 3 5	8		3/18 17%
	16 50/ 4"	66		2/10 20%
	24 23 39	62		6/18 33%
	15 35 39	74		8/18 44%
	21 33 36	69		12/18 67%
	42 50/ 1"	92		6/7 86%
	50/ 3"	50		2/3 67%

TESTS

POCKET PENE-TROMETER, TSF

M.C. PL LL

N VALUE BLOWS/FT 10 20 30 40

N VALUE	ADDITIONAL DATA/ REMARKS
66	
62	
74	
69	
92	Auger refusal at 35 feet on 7/21/09. Not able to core due to crooked hole from augering through very coarse material. Pulled off hole and came back on 7/27/09 to finish with a casing advancer.

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Fax: (406) 586-1730

STARTED	7/20/09	FINISHED	7/29/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

Project No.: 4428.10198.01	LOG OF BOREHOLE B-8	Sheet 2 of 2

CLIENT	PROJECT
Butte-Silver Bow County	Big Hole Diversion
BORING LOCATION	**SITE**
North side of the Bighole River on berm.	Big Hole Diversion, Montana

DEPTH (FT.)	MATERIAL DESCRIPTION Surface Elevation: 5433.4 feet	GRAPHIC LOG	ELEVATION (FT.)	SAMPLES: BULK / DRIVEN/PUSH	BLOWS PER 6"	N BLOWS/FT	NUMBER	IN. RECOVERED / IN. DRIVEN	TESTS: POCKET PENE-TROMETER, TSF	M.C. PL — LL / N VALUE □ BLOWS/FT (10 20 30 40)	ADDITIONAL DATA/ REMARKS
	Quartzitic fine grained sandstone, dark gray, very strong and hard, closely conjugate fractured with clay and oxidation infilling fractures, highly weathered in fractures, unweathered outside of fractures, weathering in fractures decreases with depth.		5388		50/ 1"	50		0/1 0%			Core Run 45-50 feet: - Recovery = 60%. - RQD = 0%.
48											
			5382								Core Run 50-52 feet: - Recovery = 100%. - RQD = 0%. Core Run 52-55 feet: - Recovery = 93%. - RQD = 25%.
54											
	55.0 — 5378.4 End of boring. Groundwater encountered at 13 feet below ground surface.										
60											
66											
72											
78											
84											

DOWL HKM

DOWL HKM
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Bozeman, Montana 59718
Telephone: (406) 586-8834
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STARTED	7/20/09	FINISHED	7/29/09
DRILL CO.	Haz-Tech	DRILL RIG	BK-81
DRILLER	P. Bray	HAMMER	140# auto
LOGGED BY	C. Leibli	APPROVED BY	G. Underhill

APPENDIX C

CORE PHOTOS

Big Hole Diversion
Core Photo Log

30
35
Big Hole Diversion
B-5
30-35 feet

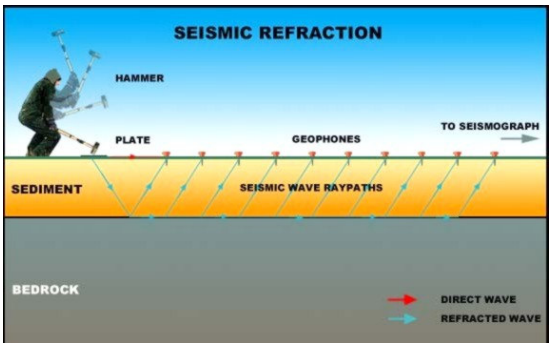
34
39
Big Hole Diversion
B-6
35-39 feet

APPENDIX D

GEOPHYSICAL INVESTIGATION REPORT

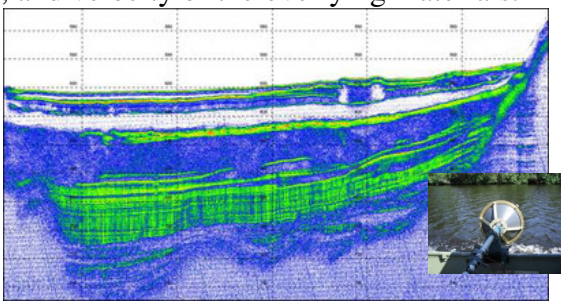
August 31, 2009

RE: SEISMIC REFRACTION, SHEAR WAVE VELOCITY & SUB-BOTTOM PROFILE SURVEYS, BIGHOLE DIRVERSION



Based on the project objective and site conditions, SES conducted a land seismic refraction, shear wave velocity, and sub-bottom profile survey at the Southwestern Montana project site. The field work was performed on July 29th and 30th, 2009

Seismic Refraction - land
Given a physical setting of increasing density with depth, and by measuring acoustic travel time between known points, the seismic refraction method can be used to determine the depth to a refracting horizon, the seismic velocity of the horizon, and velocity of the overlying materials. The objective of the refraction survey is to map the depth below existing grade to the buried rock surface and determine the seismic velocity of the rock and overlying materials along 750 feet of profile.



Sub-Bottom Profiler – Stream Channel
At the proposed diversion dam alignment area, along a series of profiles crossing the stream channel, a sub-bottom profiler was used to map the thickness of sediments overlying rock. Sub bottom profilers use reflected acoustic energy to map the depth of water and thickness of water bottom sediments.

Technical Approach – Surface Refraction

750 feet of seismic refraction profile were acquired distributed across the site as shown. Refraction data were acquired in accordance with ASTM standard, **ASTM D 5777-00** *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation.* Depth calculations along profile were made a 16.4 foot spacing. Sage Earth Science will used a 24-channel engineering seismograph and 600 pound weight drop to perform the acoustic travel time measurements. The survey was designed for an estimated maximum depth of investigation of 100 feet depending of the subsurface setting. At each location, a fully reversed profile to account for dipping/sloping surfaces was performed.

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telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

Table 1 Survey parameters

recording instrument	Bison 9024 s/n 6-93913
geophone	Mark products – 4 hz. vertical
Geophone/station spacing	16.4 feet (5 meters)
number of channels	24
sample rate	1.0 millisecond
number of samples	2000
record length	2 seconds
low pass filter	120 hz
low cut filter	4 hz
seismic source	600 weight drop
source locations	Channels 1,24 and offset as appropriate
data reduction method	Generalized reciprocal method (GRM)

Technical Approach – Shear Wave Velocity Sounding

Using surface wave analysis methods, the seismic data were analyzed to determine the *s-wave* velocity in the shallow subsurface (0-200 feet). Multi-channel Analysis of Surface

Waves (MASW) uses the dispersive characteristics of surface waves to determine the variation of shear wave velocity with depth. Shear wave velocities are acquired by analyzing seismic surface waves generated by an impulsive source and received by an array of geophones. A dispersion curve is calculated from the data that shows the phase velocity of the surface waves as a function of frequency (wavelength-depth). A shear wave velocity sounding (1-D profile of velocity as a function of depth) is then modeled from the dispersion curve.

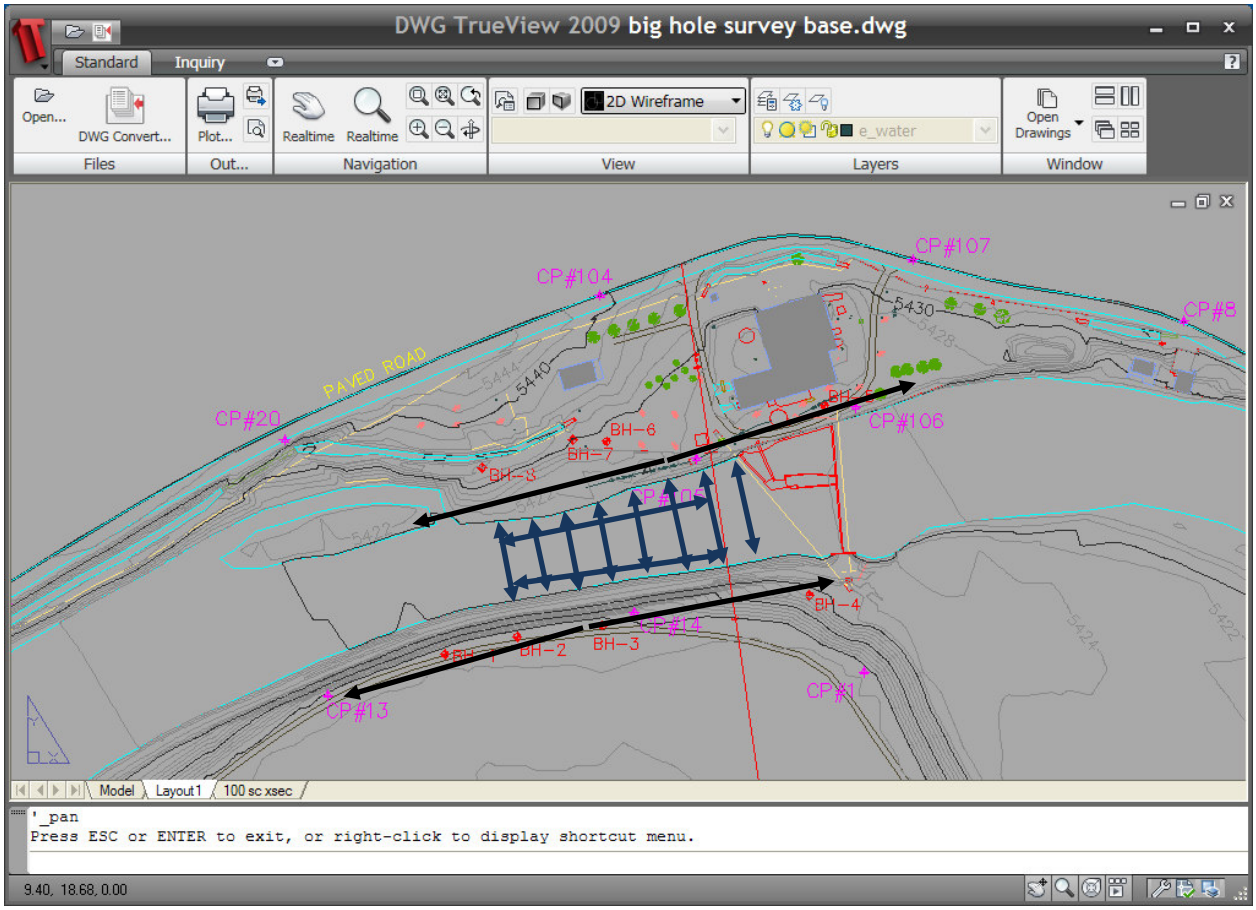
Data were acquired using a 24-channel engineering seismograph, 4 Hz. natural period geophones at 16.4 foot spacing, and 600 lb weight drop.

Table 1 Survey parameters

recording instrument	Bison 9024 s/n 6-93913
geophone	Mark products – 4 hz. vertical
Geophone/station spacing	16.4 feet (5 meters)
number of channels	24
sample rate	1.0 millisecond
number of samples	2000
record length	2 seconds
low pass filter	120 hz
low cut filter	4 hz
seismic source	600 weight drop
source locations	Channels 1,24 and offset as appropriate
MASW shear wave velocities	Multichannel Analysis of Surface Wave

Technical Approach – Sub-bottom Profile

Continuous profile data were acquired using a Syquest StrataBox sub-bottom profiler. The Stratabox is a portable high-resolution marine sediment imaging instrument utilizing digital signal processing based technology. It is designed for inshore and coastal geophysical marine surveys to meet a wide variety of mission requirements including sub-bottom profiling and bottom classification. The instrument is capable of delivering 6 cm sediment strata resolution with bottom penetration of up to 130 feet depending on site conditions. The system is deployed from a boat or buoy and is traversed across the stream channel.



Profile Location Map

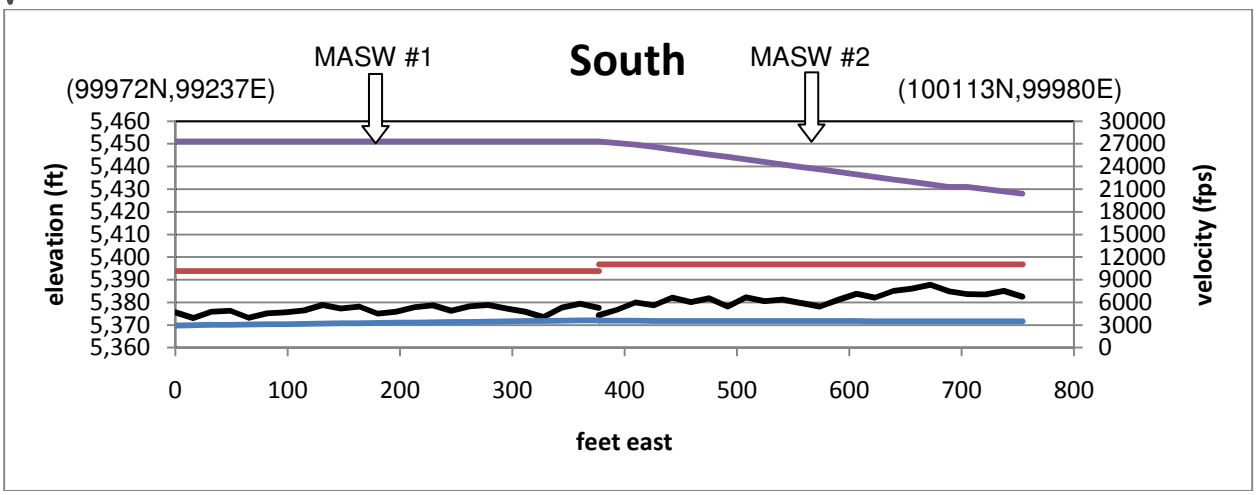
Sub bottom profiles locations referenced to CP#105

Perpendicular to banks beginning 50 downstream conducted at 50 foot intervals

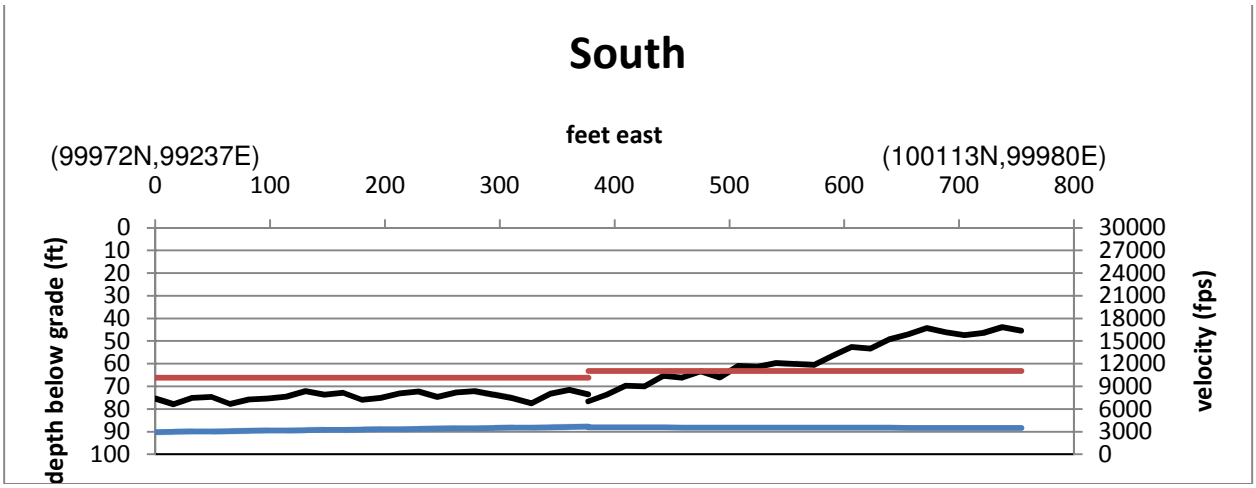
(-50, 0, 50, 100, 150, 200, 250, 300)

Two long profiles conducted from 0 to 300 ft up stream.

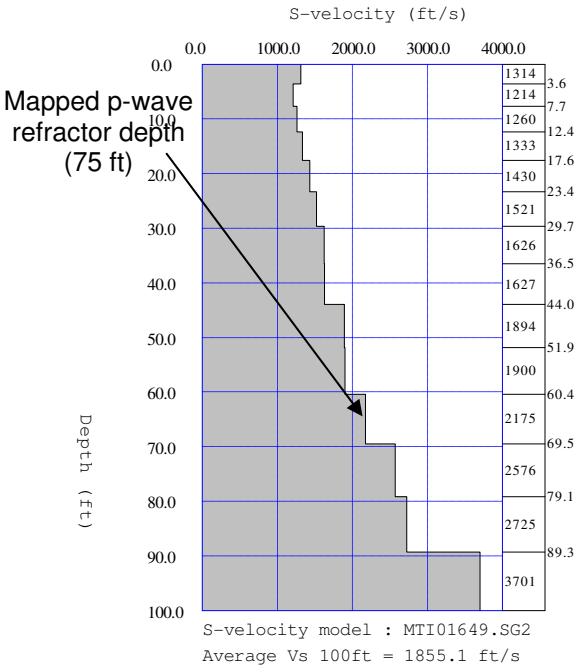
Profile distribution to the west was limited by shallow stream depth.



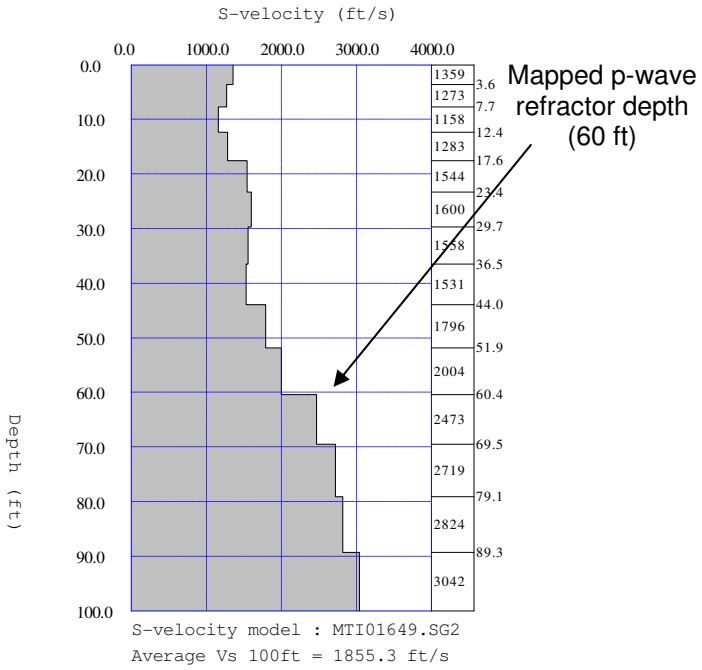
South Bank – Seismic Refraction Elevation Profile
purple – surface elevation
black - rock elevation
red – refractor velocity
blue - sediment velocity



South Bank – Seismic Refraction Depth Below Grade Profile
black - rock depth below grade
red – refractor velocity
blue - sediment velocity

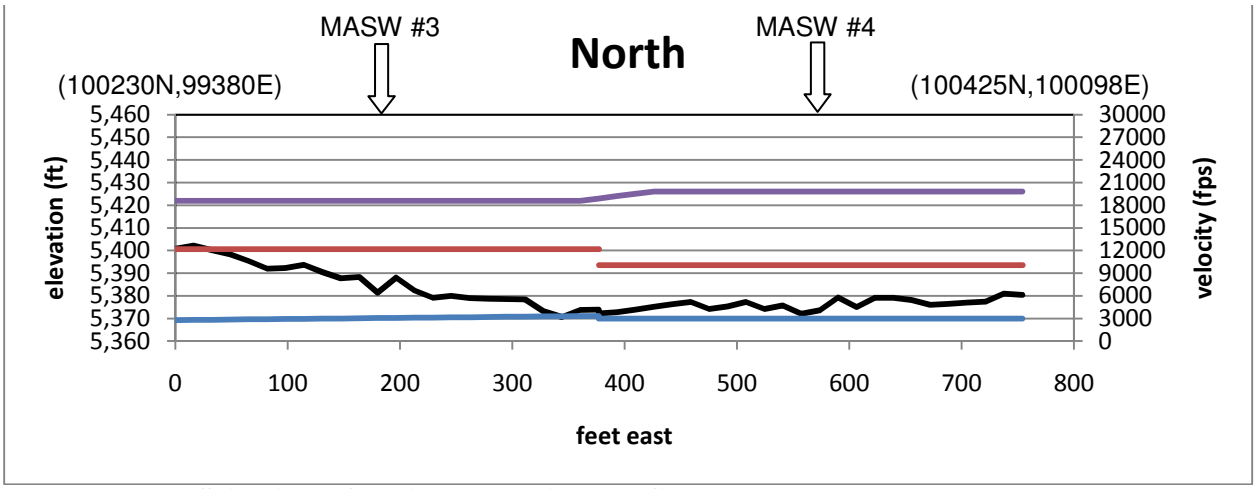


MASW #1
(100094N,99816E)

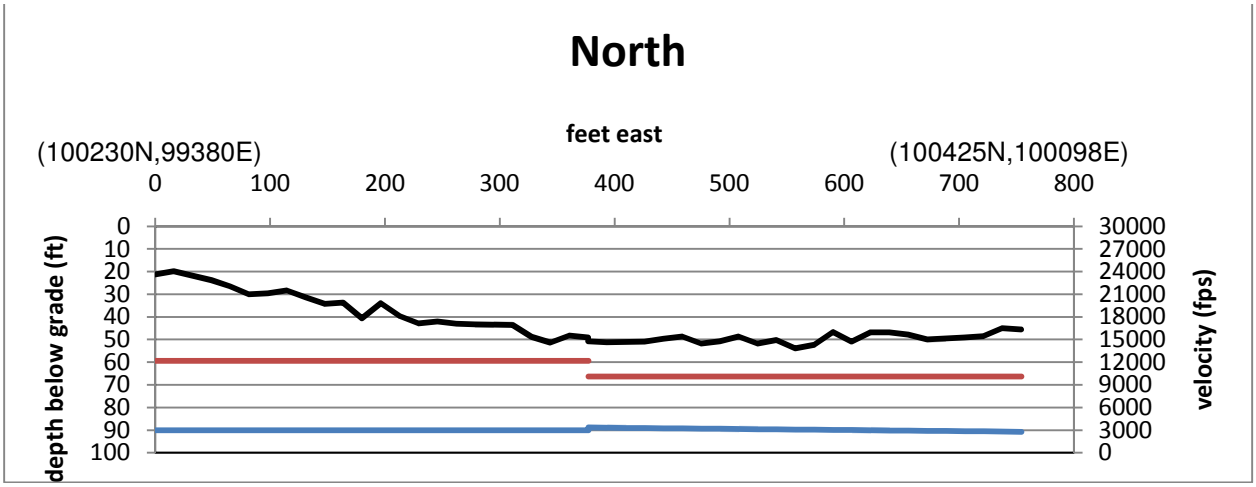


MASW #2
(100022N,99428E)

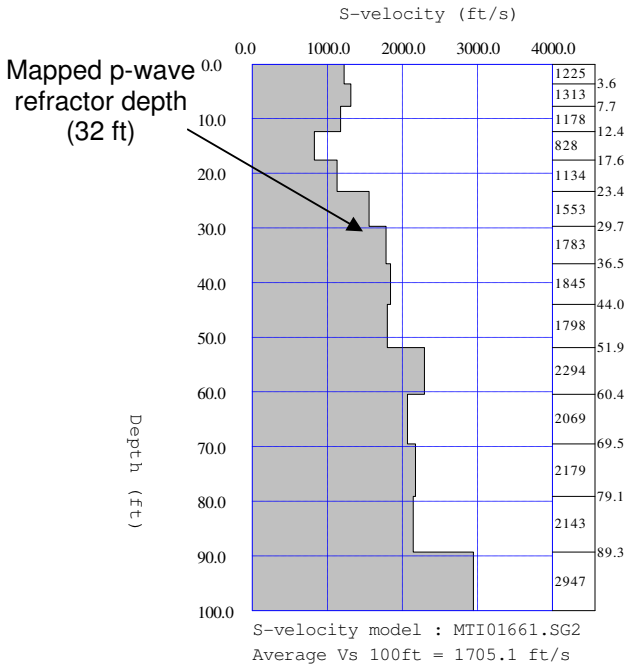
South Bank MASW Seismic shear wave soundings



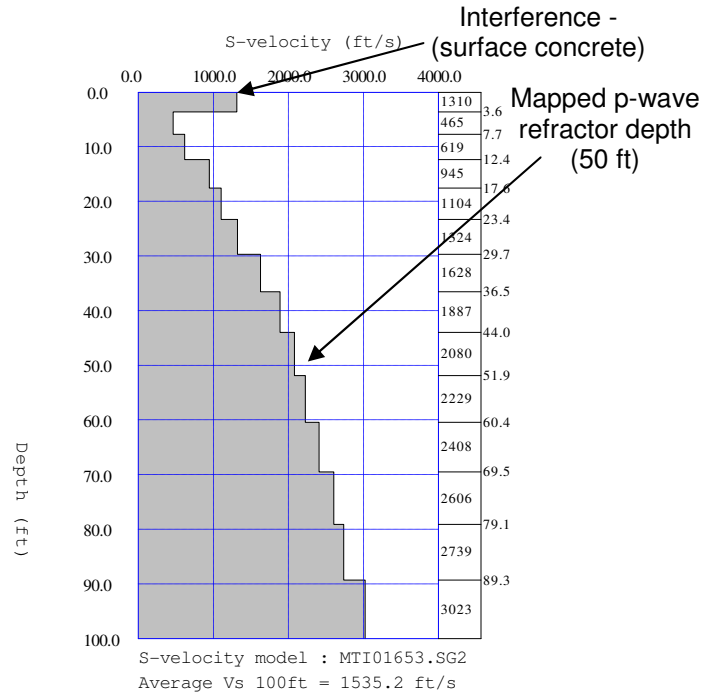
North Bank – Seismic Refraction Elevation Profile
purple – surface elevation
black - rock elevation
red – refractor velocity
blue - sediment velocity



North Bank – Seismic refraction depth below grade profile
black - rock depth below grade
red – refractor velocity
blue - sediment velocity



MASW #3
(100411N,99918E)



MASW #4
(100317N,99558E)

North Bank MASW Seismic shear wave soundings

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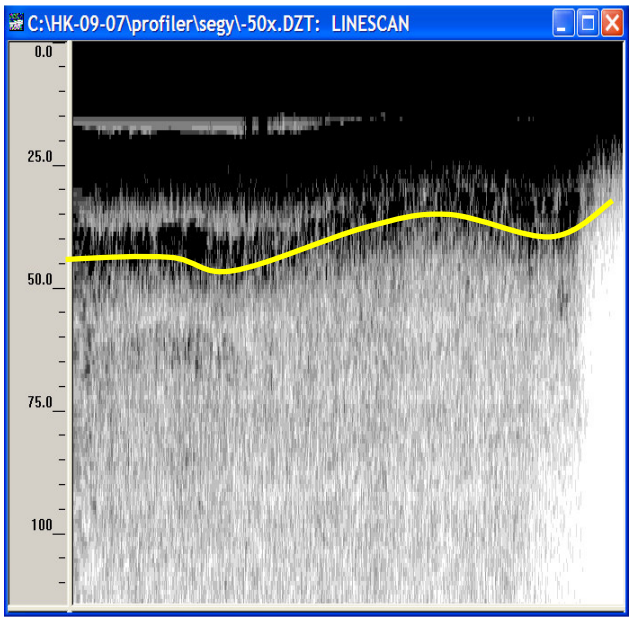
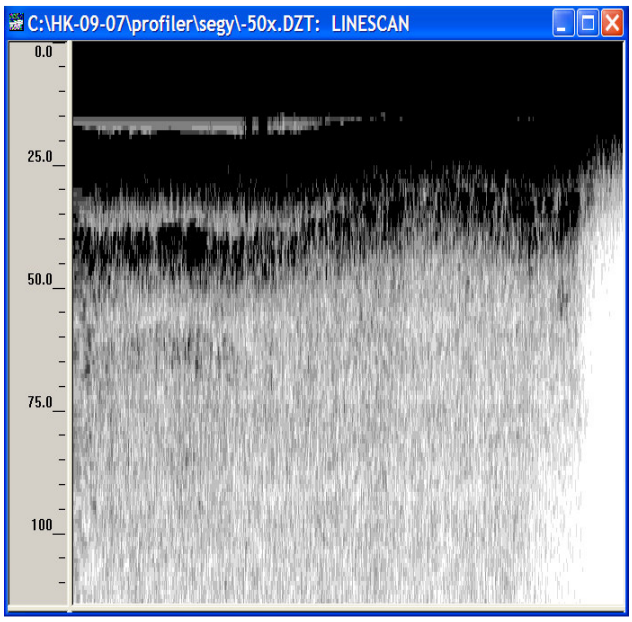
http://www.sageearthscience.com

50 feet down stream of CP5

S N
0 153 ft





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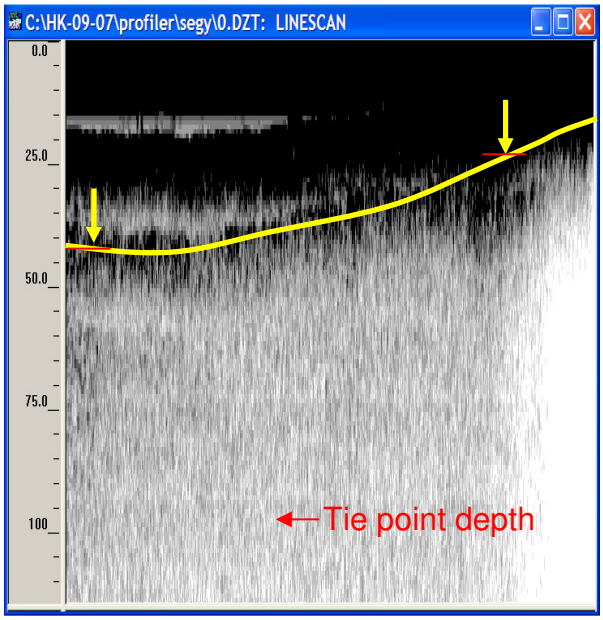
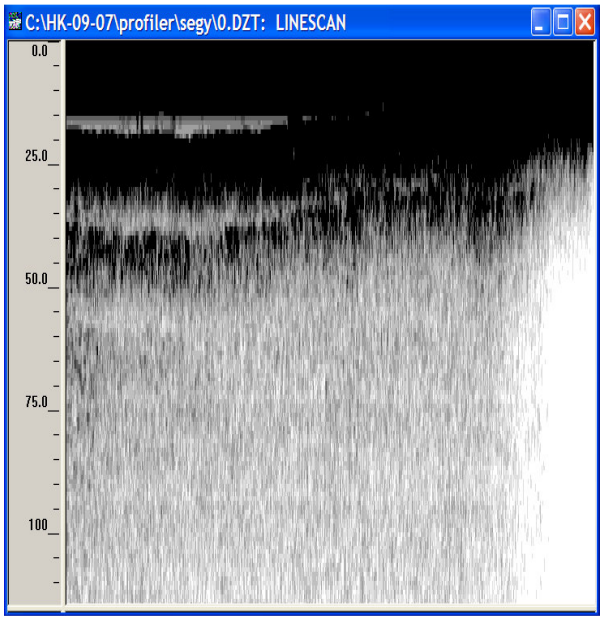
0 feet down stream of CP5

S N

0 144 ft





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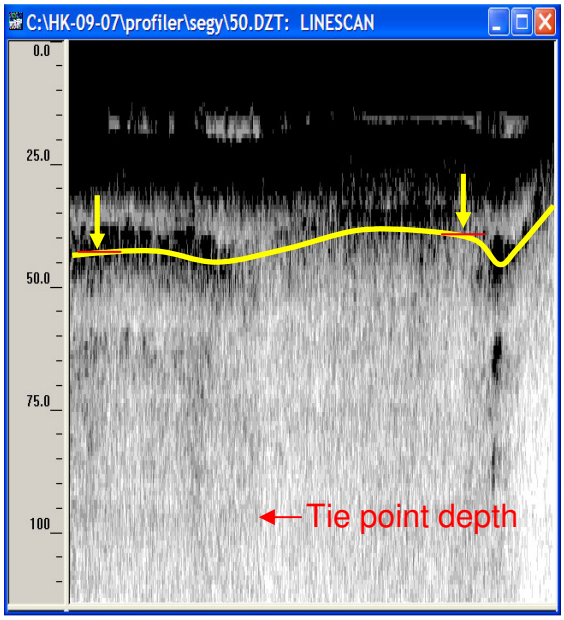
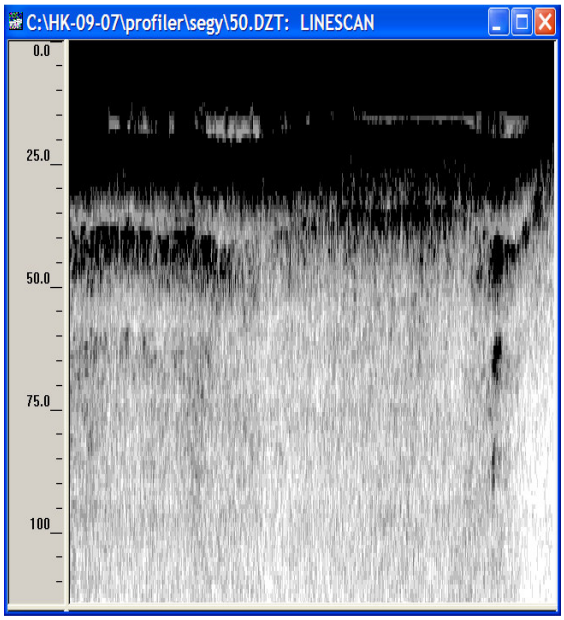
50 feet up stream of CP5

S N

0 135 ft





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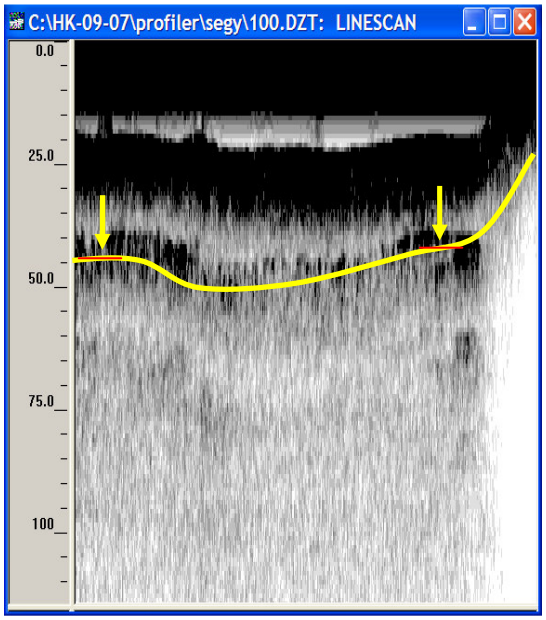
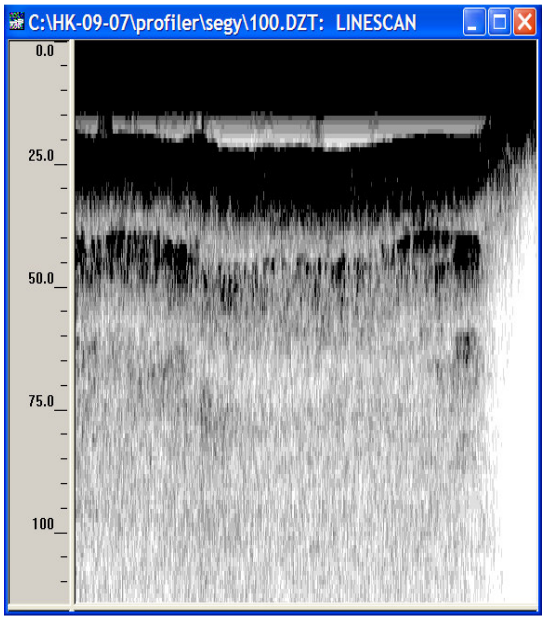
100 feet up stream of CP5

S N

0 129 ft





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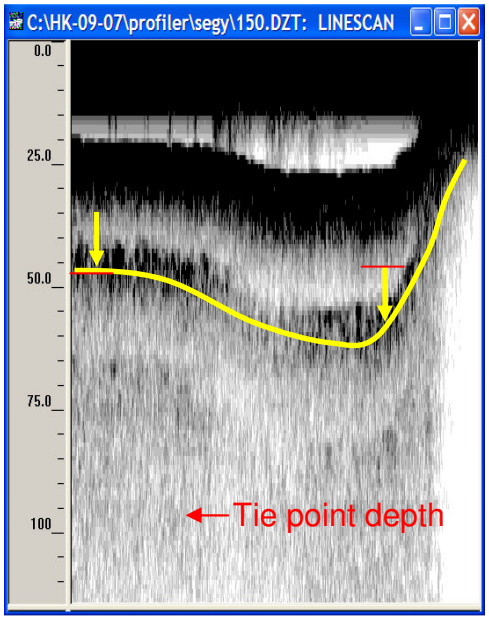
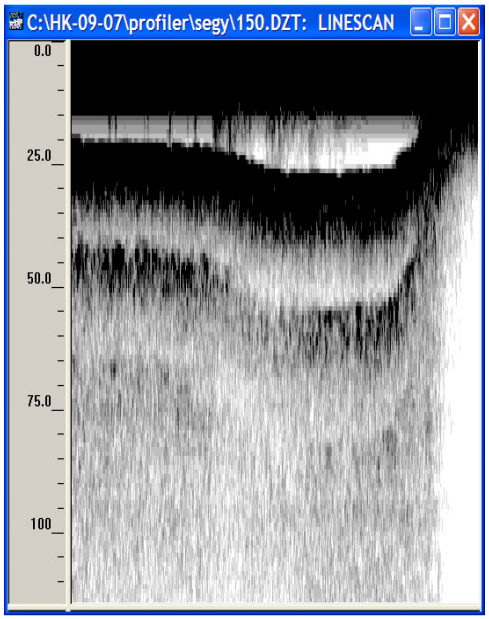
http://www.sageearthscience.com

150 feet up stream of CP5

S S
0 117 ft



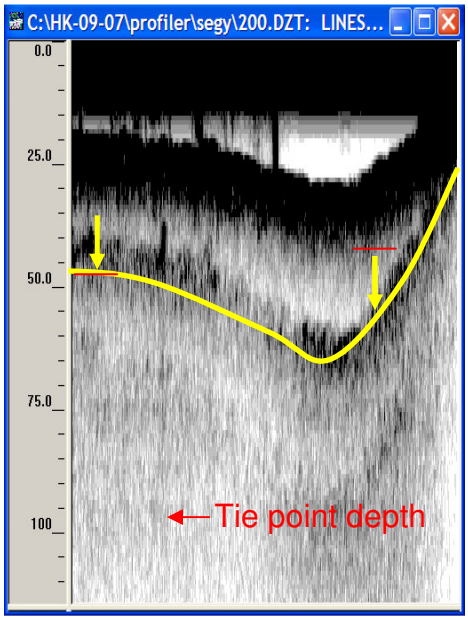


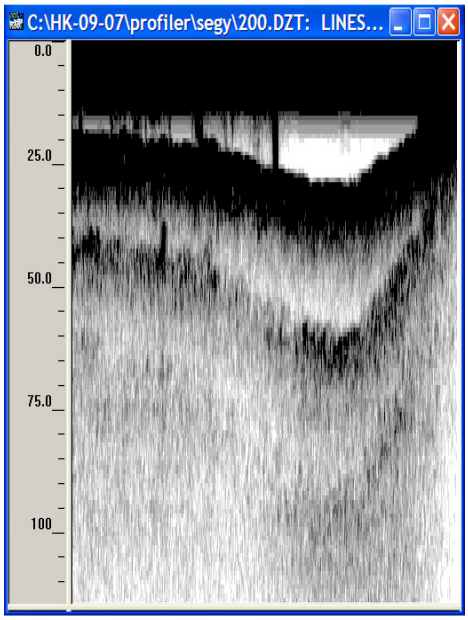
2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

200 feet up stream of CP5

S N

0 111 ft



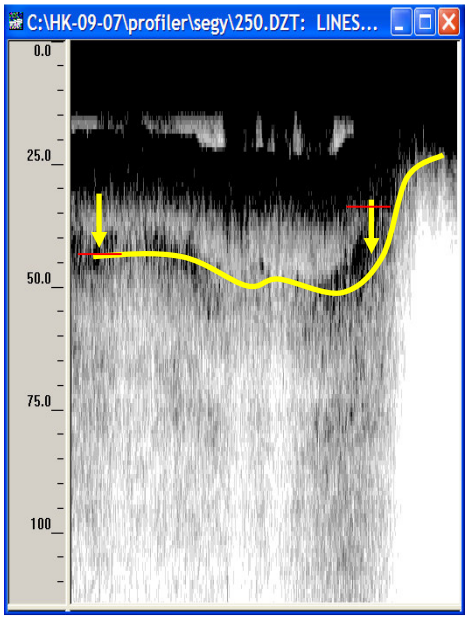


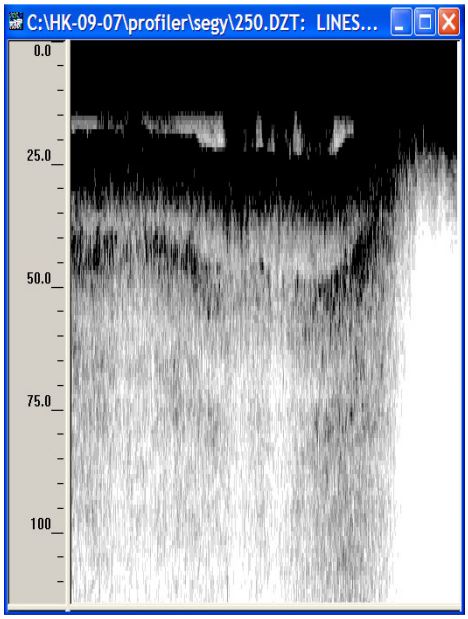
2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

250 feet up stream of CP5

S N

0 111 ft



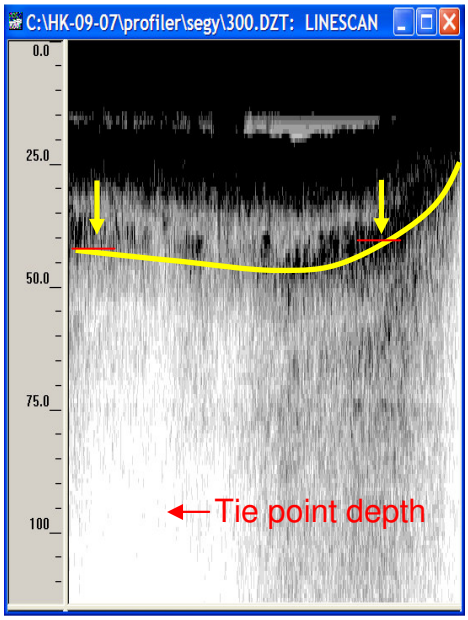


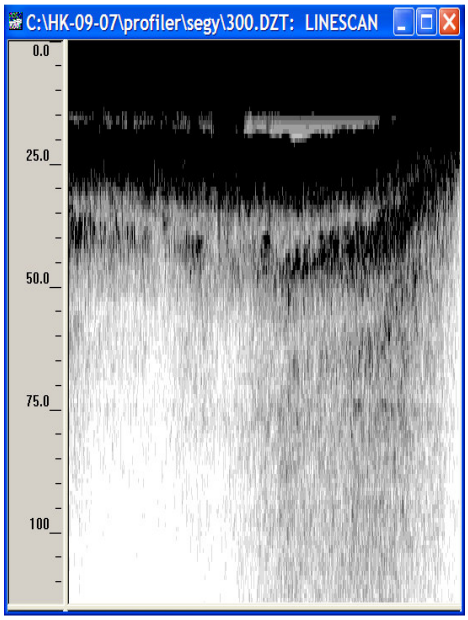
2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

300 feet up stream of CP5

S N

0 114 ft



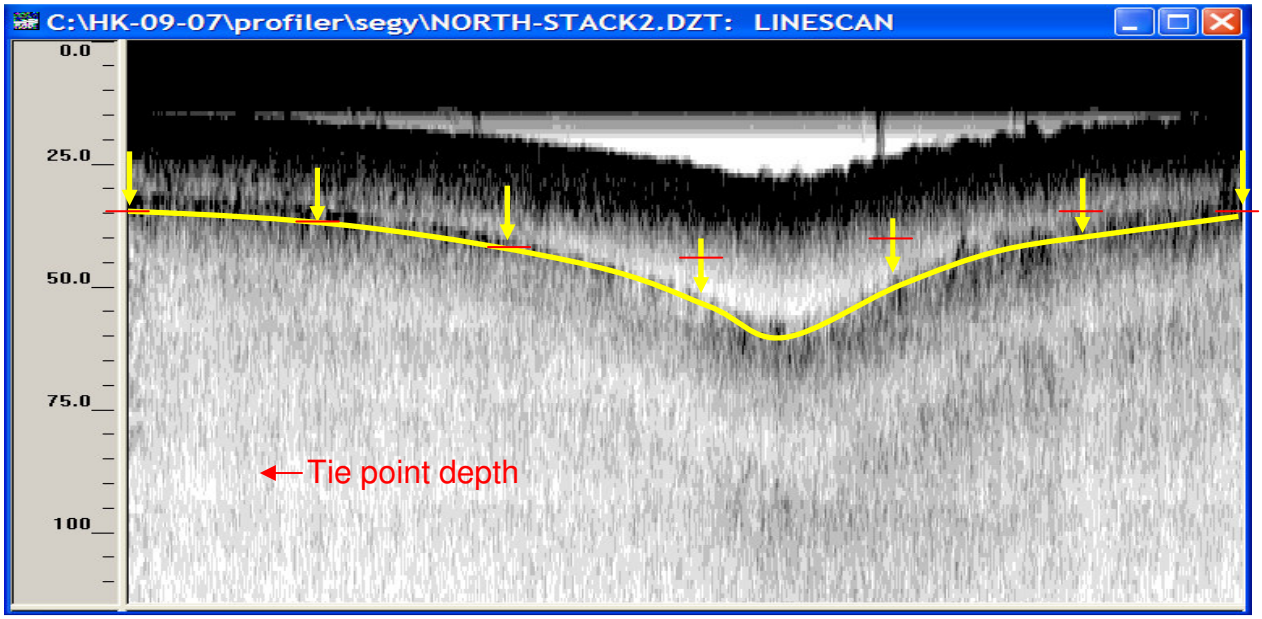


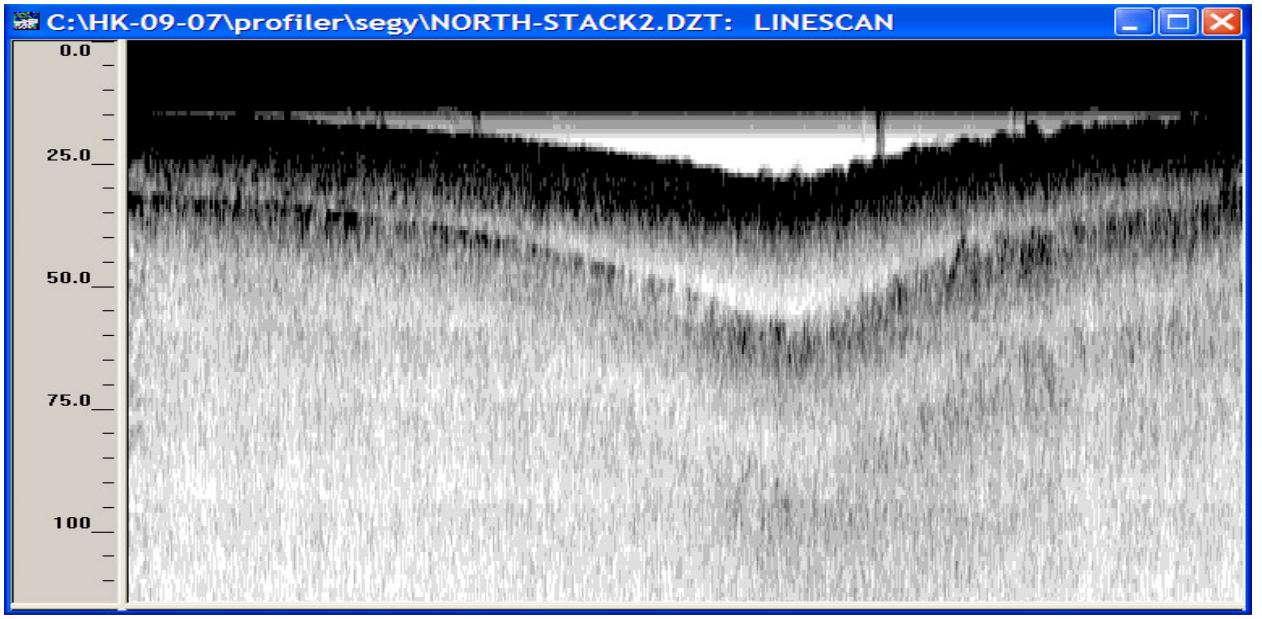
2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

North profile

0 E

300 W



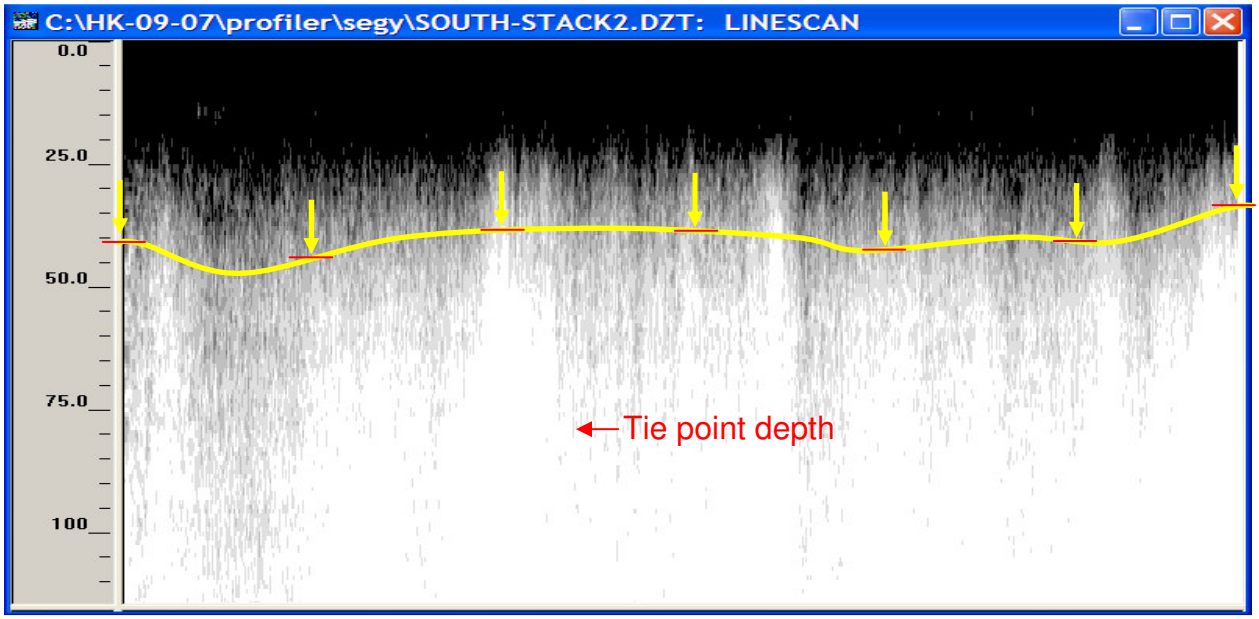


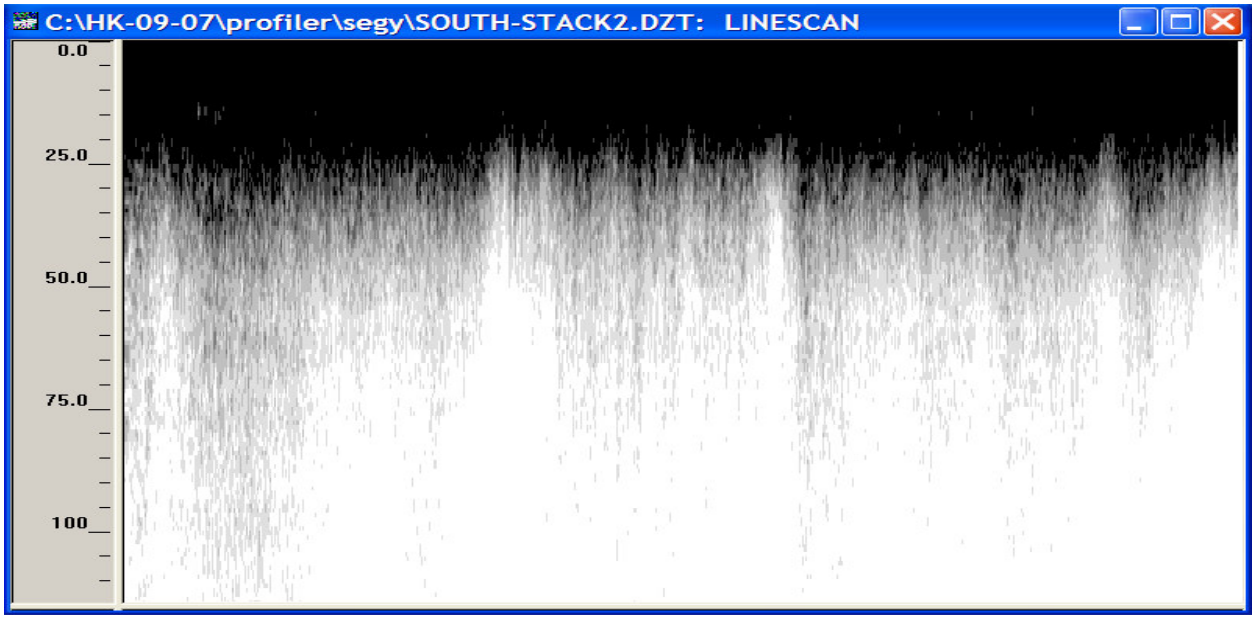
2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

South profile

0 E

300 W



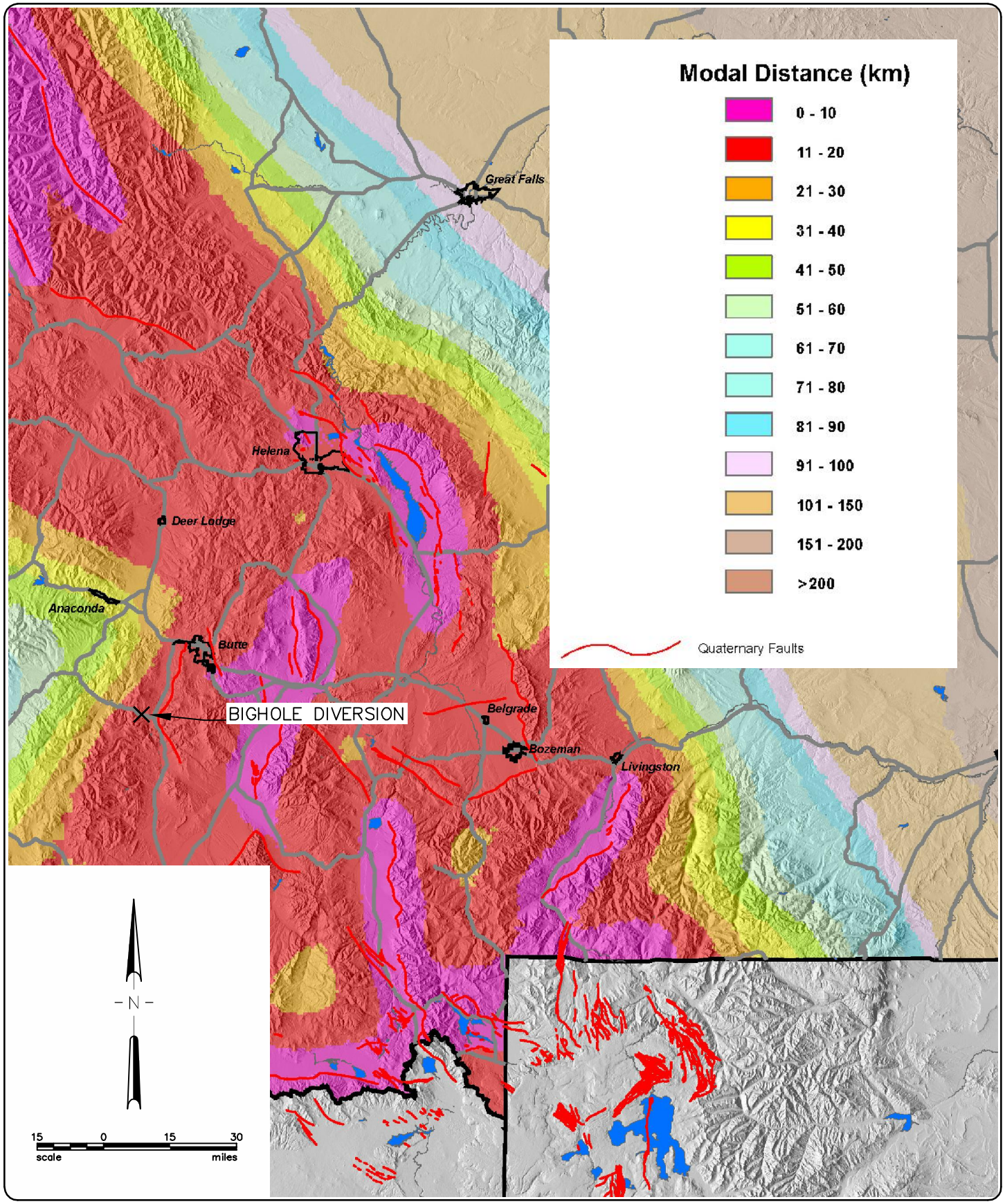


Glen Carpenter / geophysicist - principal

2184 Channing Way, Suite 110, Idaho Falls, ID 83404
telephone: (208)522-5049, Fax: (208)528-6200, email: sageearthscience@yahoo.com
http://www.sageearthscience.com

APPENDIX E

PEAK GROUND ACCELERATION, MODAL MAGNITUDE, AND MODAL DISTANCE MAPS



Big Hole Diversion

Modal Distance on Rock for 2% in 50 yr Exceedance

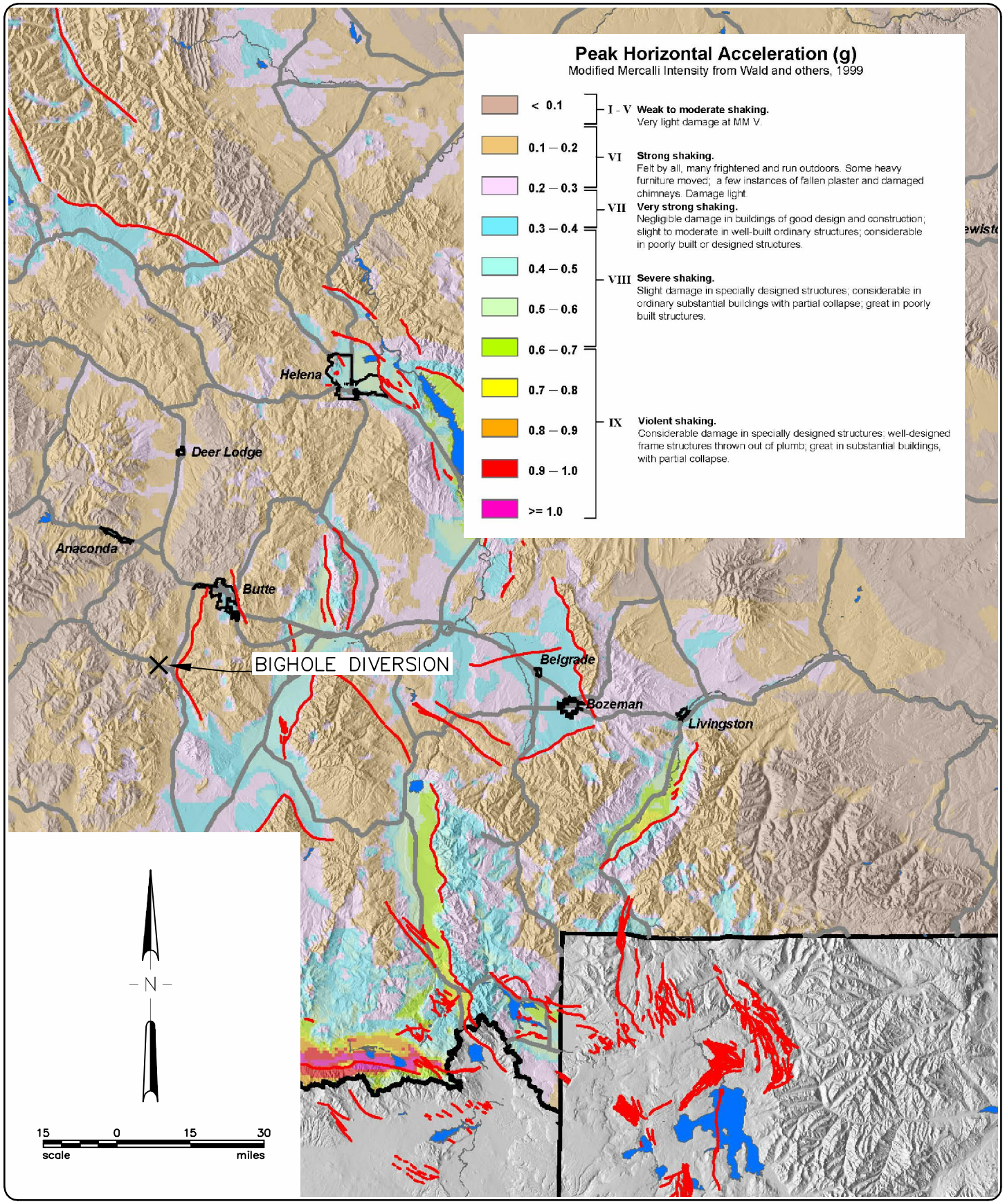
Source: Plate 27, MBMG Special Publication 117

FIGURE E-10

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28110198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:40:30 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

PGA at Ground Surface for 1% in 50 yr Exceedance

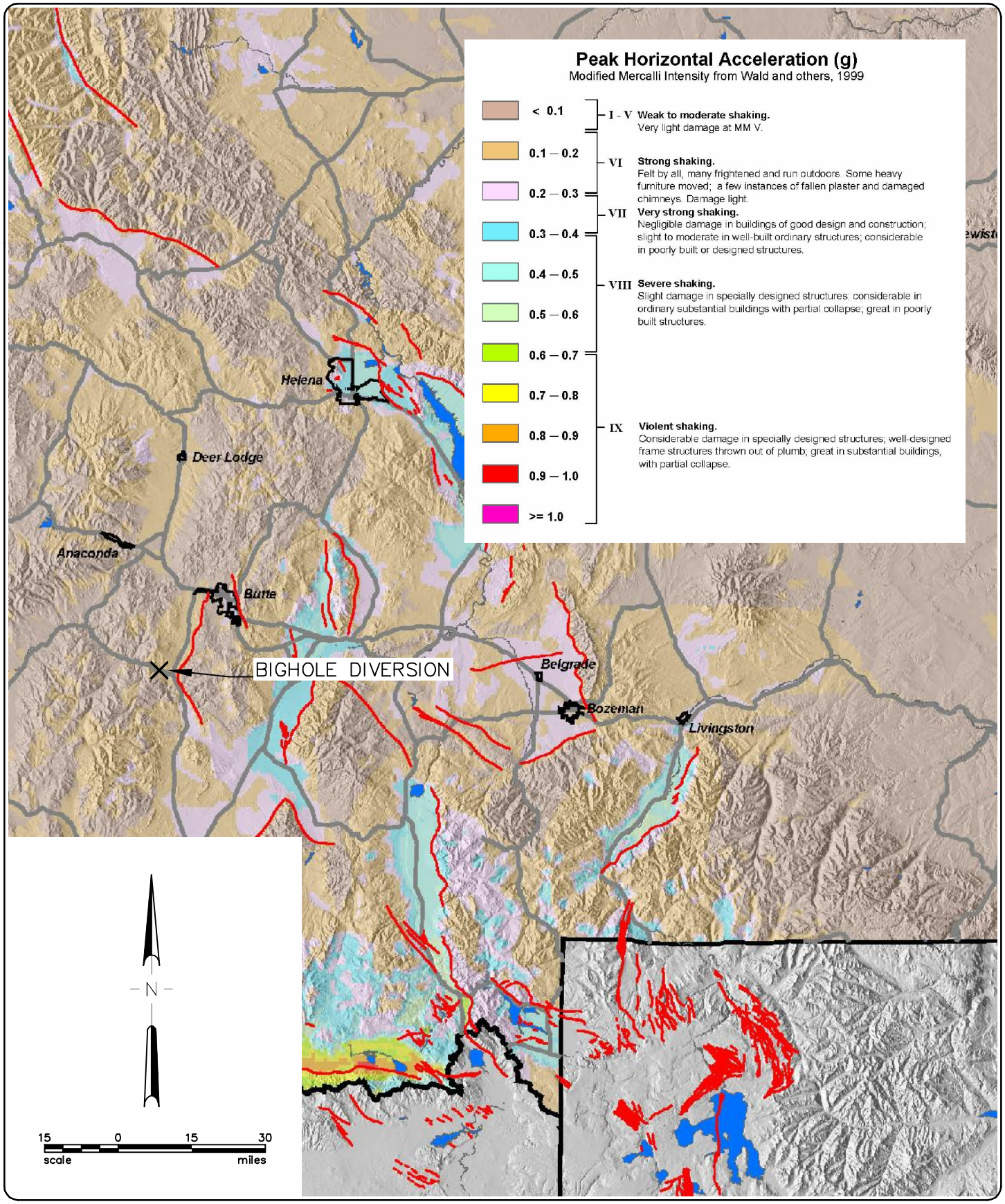
Source: Plate 20, MBMG Special Publication 117

FIGURE E-1

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28\10198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:33:24 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

PGA at Ground Surface for 2% in 50 yr Exceedance

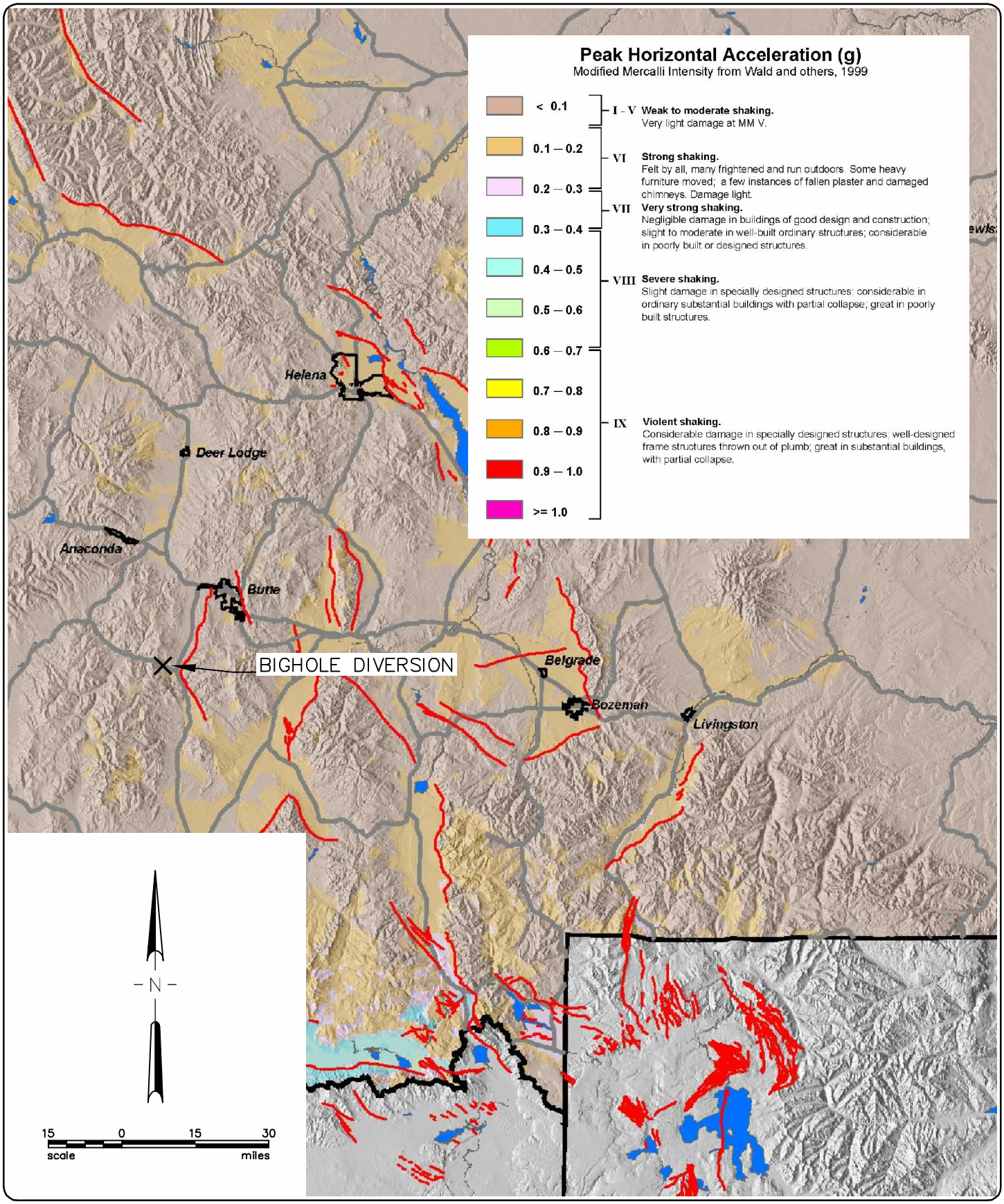
Source: Plate 17, MBMG Special Publication 117

FIGURE F-2

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28\10198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:34:24 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

PGA at Ground Surface for 10% in 50 yr Exceedance

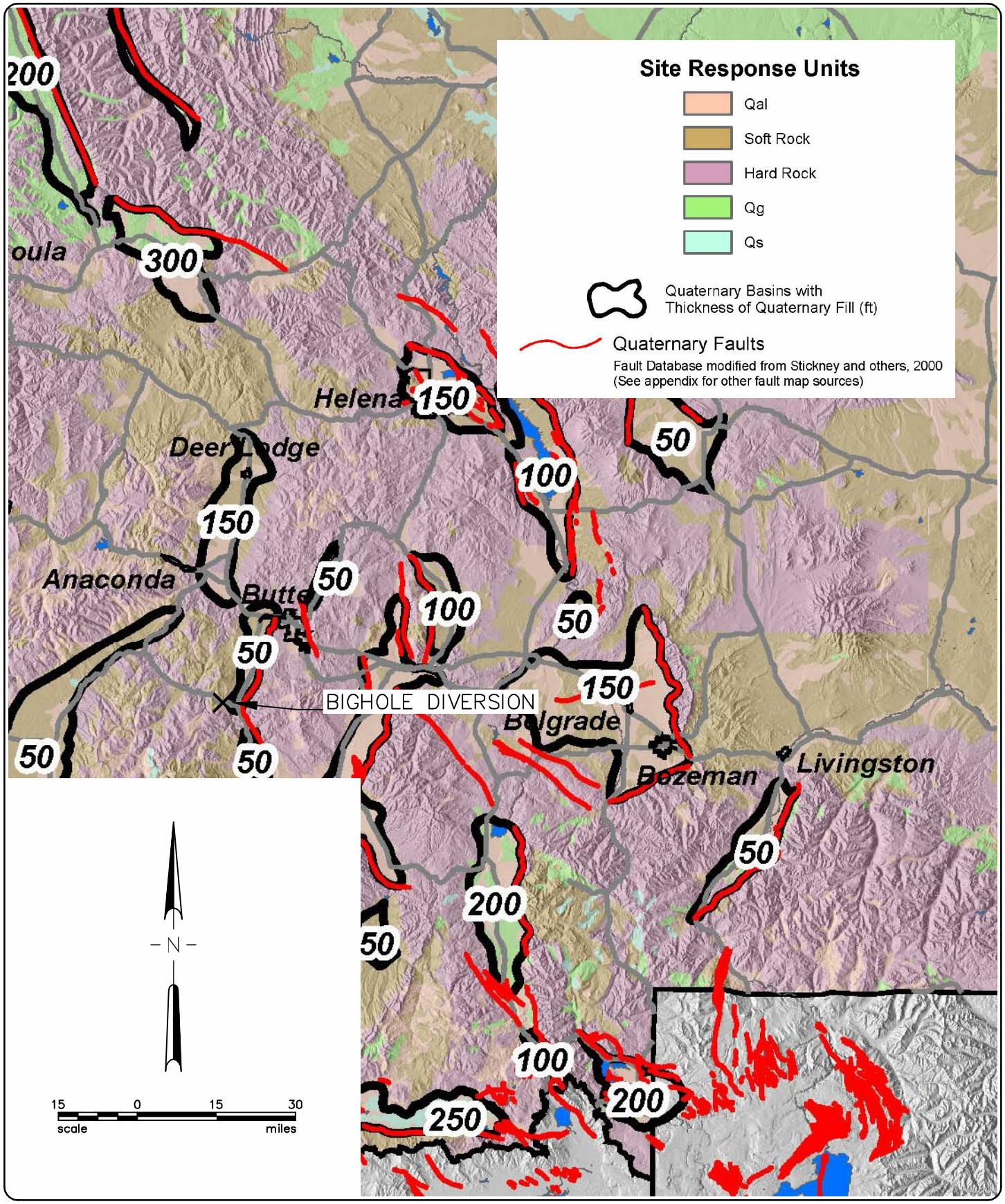
Source: Plate 14, MBMG Special Publication 117

FIGURE E-3

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\2810198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:35:01 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Regional Geologic Map

Source: Plate 3, MBMG Special Publication 117

FIGURE E-4

DOWL HKM

4428.10198.01 | AUGUST 2009

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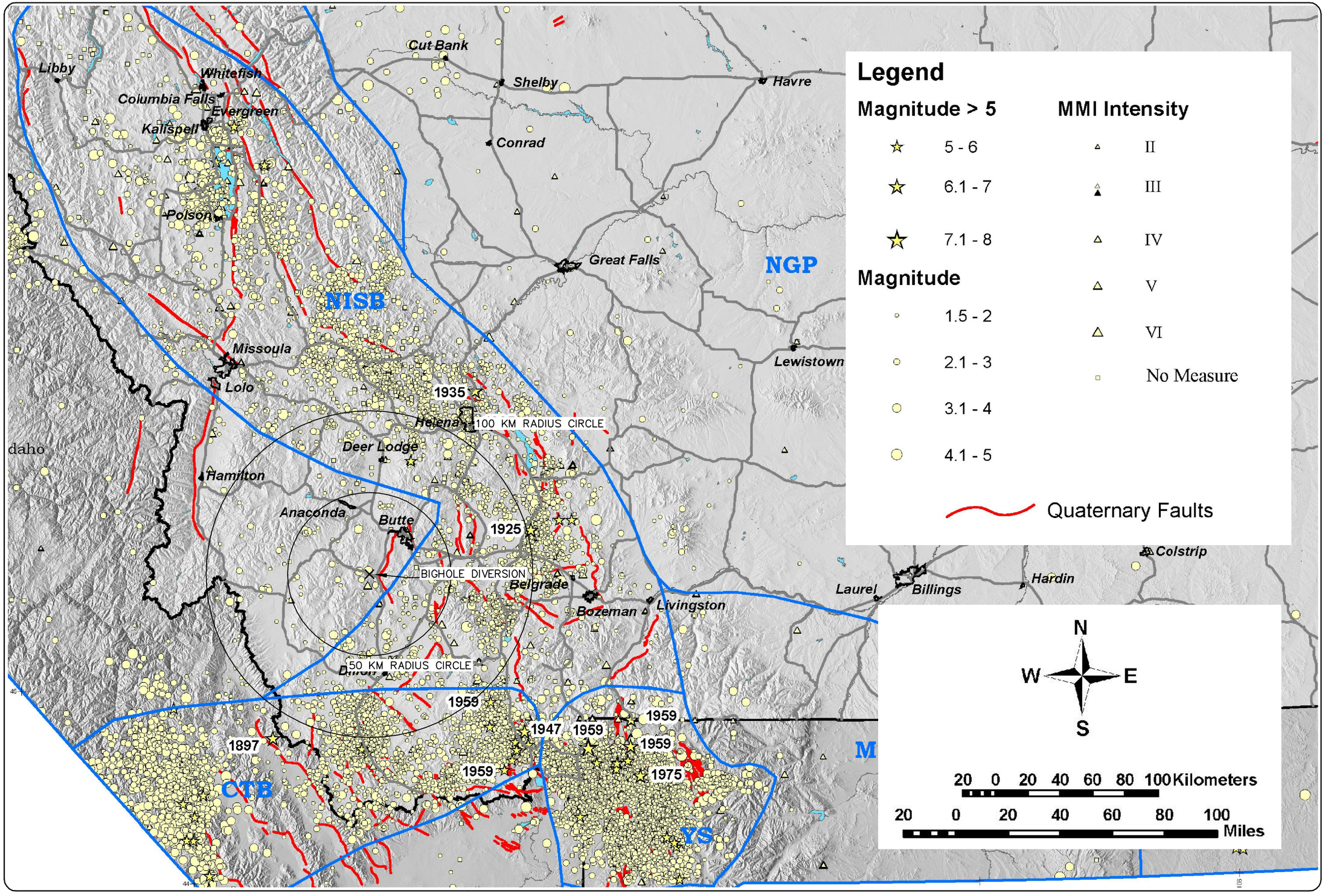


FIGURE E-5

DOWL HKM

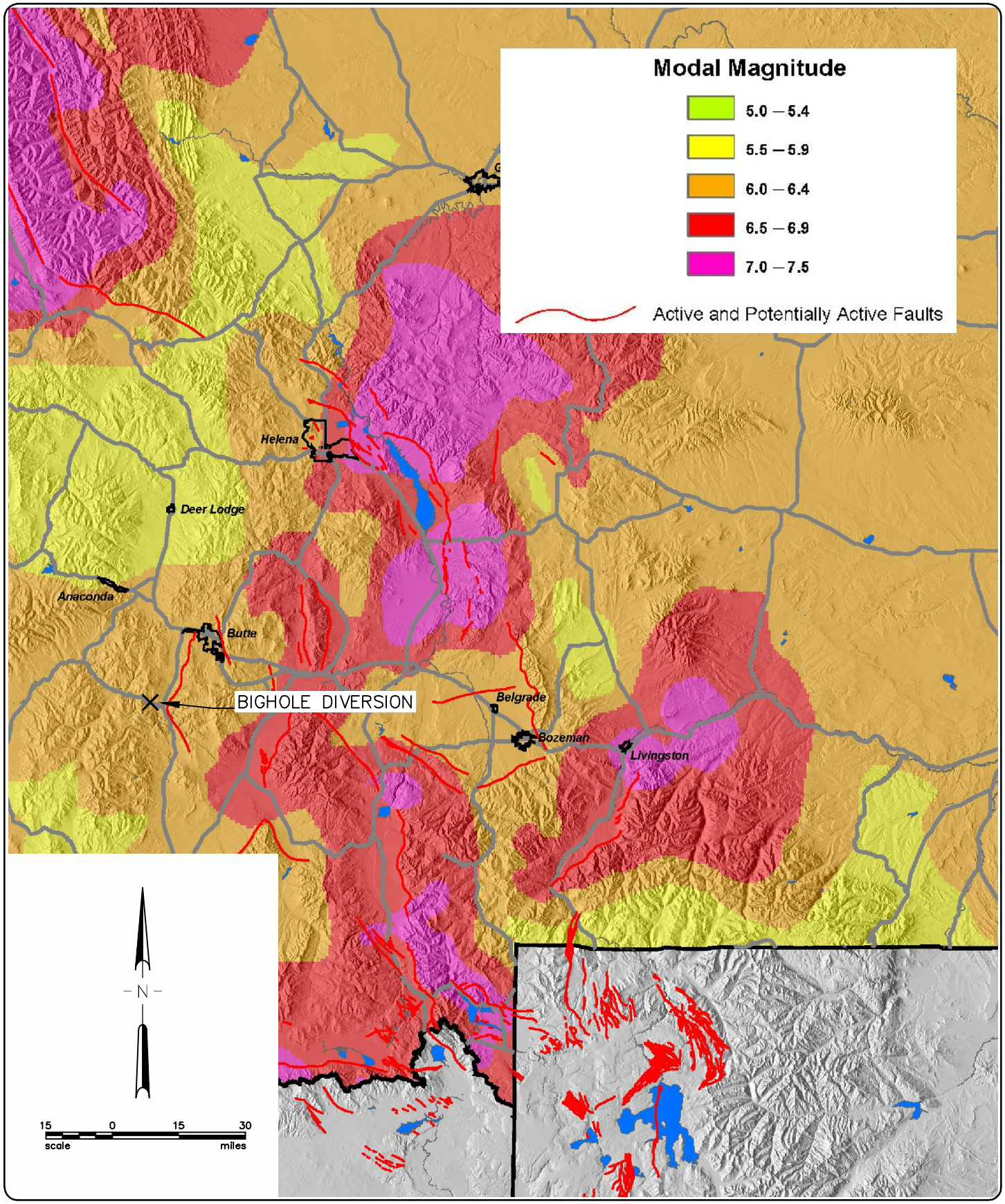
4428.10198.01 AUGUST 2009

Big Hole Diversion

Historic Seismicity in Montana

Source: Plate 1, MBMG Special Publication 117

H:\28\10198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:36:25 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Modal Magnitude on Rock for 1% in 50 yr Exceedance

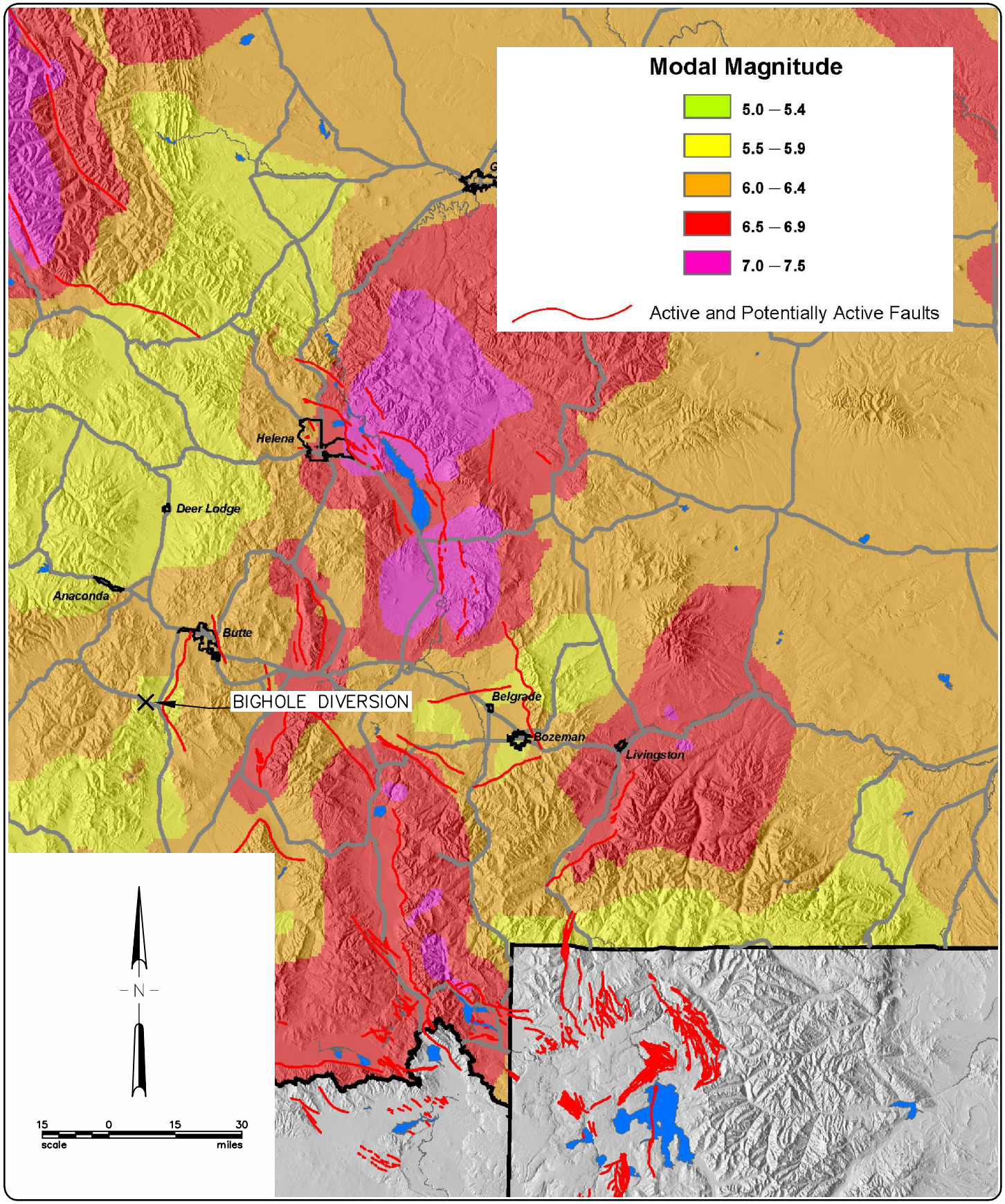
Source: Plate 25, MBMG Special Publication 117

FIGURE E-6

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28110198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:37:28 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Modal Magnitude on Rock for 2% in 50 yr Exceedance

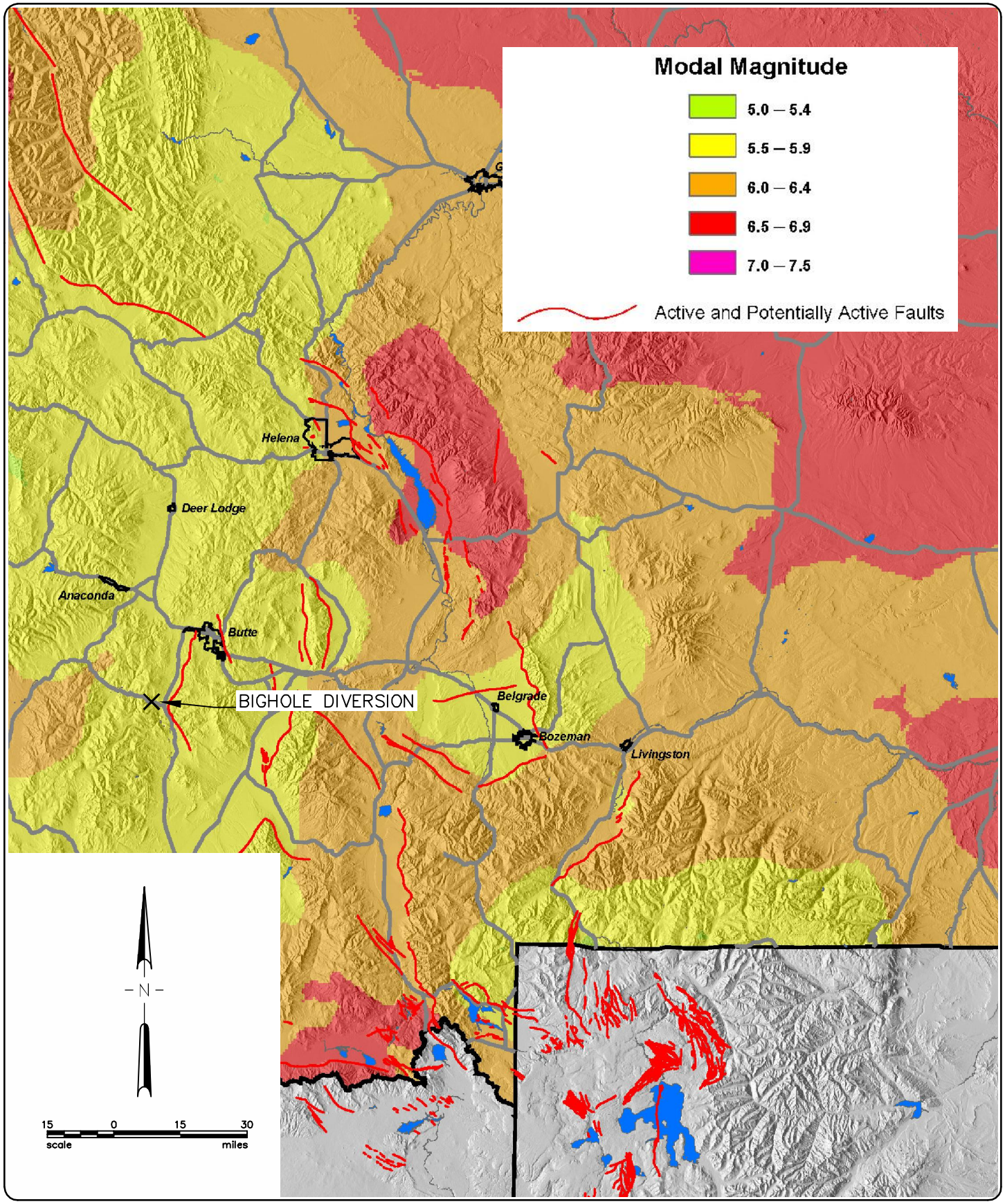
Source: Plate 24, MBMG Special Publication 117

FIGURE E-7

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28110198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:38:13 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Modal Magnitude on Rock for 10% in 50 yr Exceedance

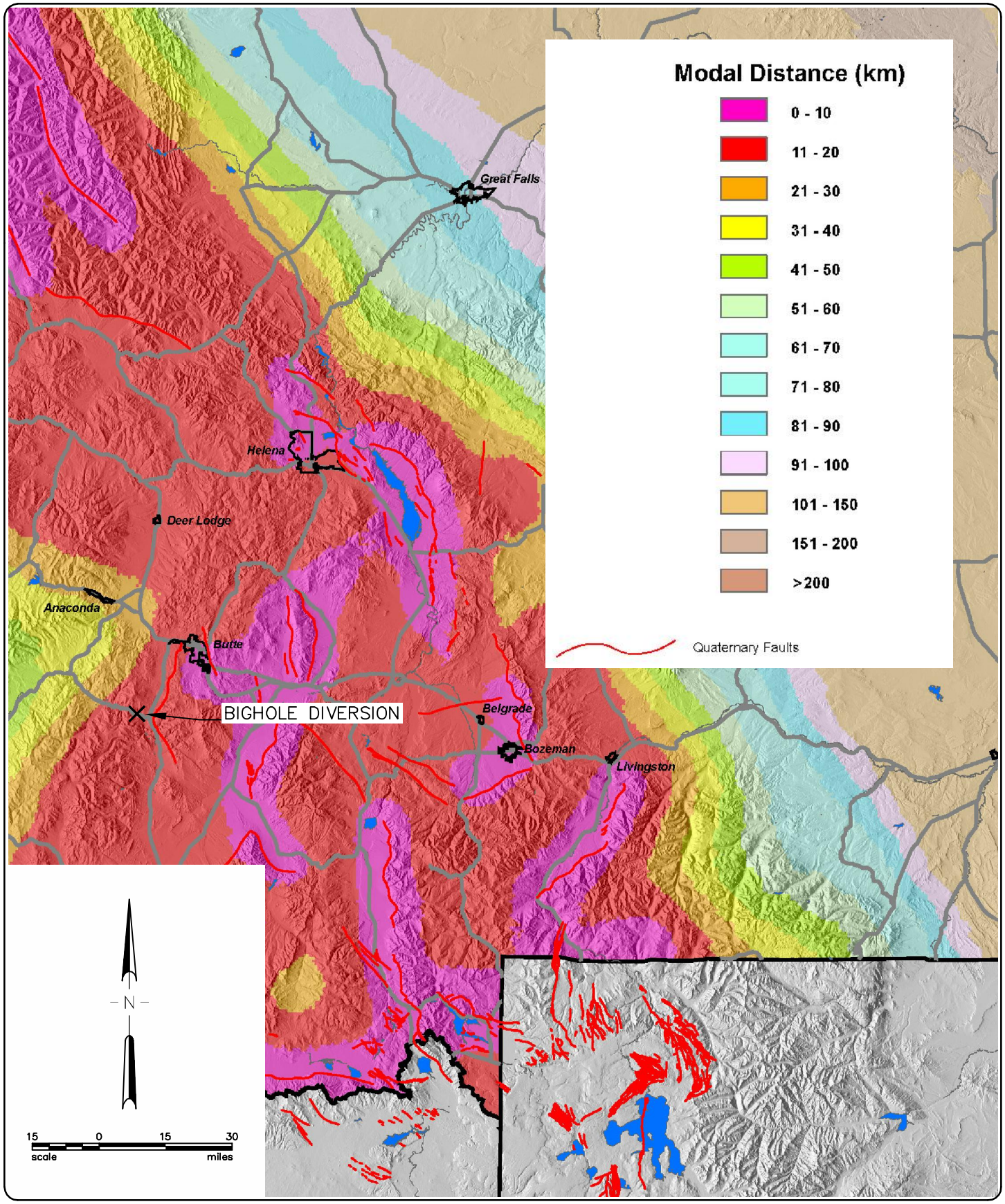
Source: Plate 23, MBMG Special Publication 117

FIGURE E-8

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28110198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:38:47 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Modal Distance on Rock for 1% in 50 yr Exceedance

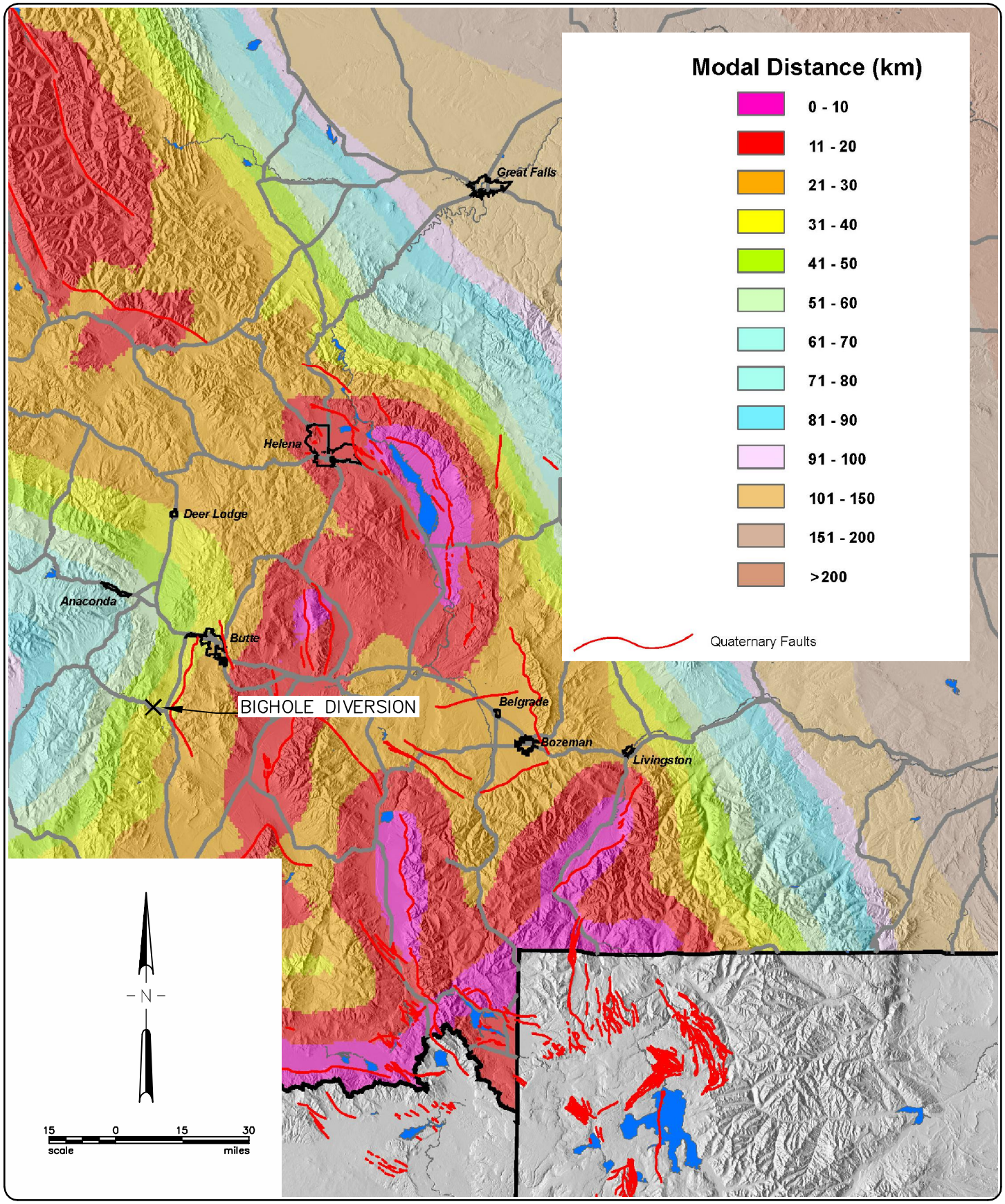
Source: Plate 28, MBMG Special Publication 117

FIGURE E-9

DOWL HKM

4428.10198.01 | AUGUST 2009

I:\28110198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:39:34 AM, PDF-XChange for AcroPlot Pro



Big Hole Diversion

Modal Distance on Rock for 10% in 50 yr Exceedance

Source: Plate 26, MBMG Special Publication 117

FIGURE E-11

DOWL HKM

4428.10198.01 | AUGUST 2009

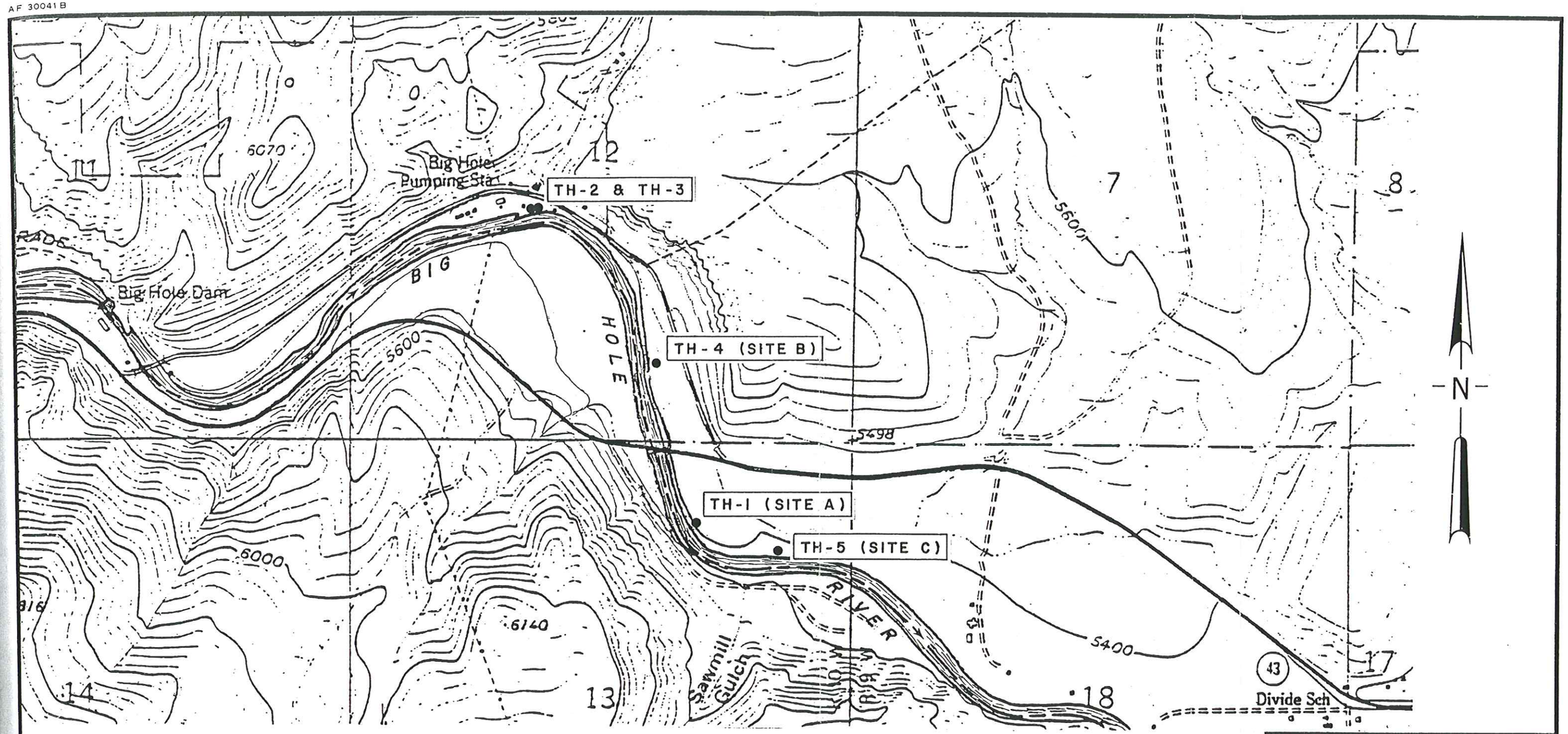
I:\28\10198\Geotechnical\Seismic\Bighole Diversion PGA Determination.dwg, 8/26/2009 11:41:04 AM, PDF-XChange for AcroPlot Pro

APPENDIX F

RANNEY METHOD WESTERN CORPORATION WELL LOGS

AND LOCATION MAP

AF 30041 B



1000 0 1000 2000
scale feet

1" = 1000'

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

LOCATION MAP

DRAWN: MSM	APPROVED: FCM
DATE: 2-8-91	FIG.: SW-116-01

Abadan 890-290 7/93

RANNEY COLLECTOR WELLS

Transmittal Sheet

Please Deliver To: Dick Palley Company: Dowl HKM

Address: 130 North Main St. Suite 100

City / State: Butte, Montana 59701 Date: 30 June 2009

Total Number of Pages: 21 including this cover sheet.

We Provide Services for:

- Collector Well Construction
- Surface Water Intake Construction
- Hydrogeological Surveys & Studies
- Outfall Diffusers & Infiltration Galleries
- Design/Build Services
- Complete Turnkey Construction
- Aquifer Recharge /ASR
- Exploratory Test Drilling
- Riverbank Filtration Evaluations
- Large Diameter Caissons
- Well Head Protection / Modeling

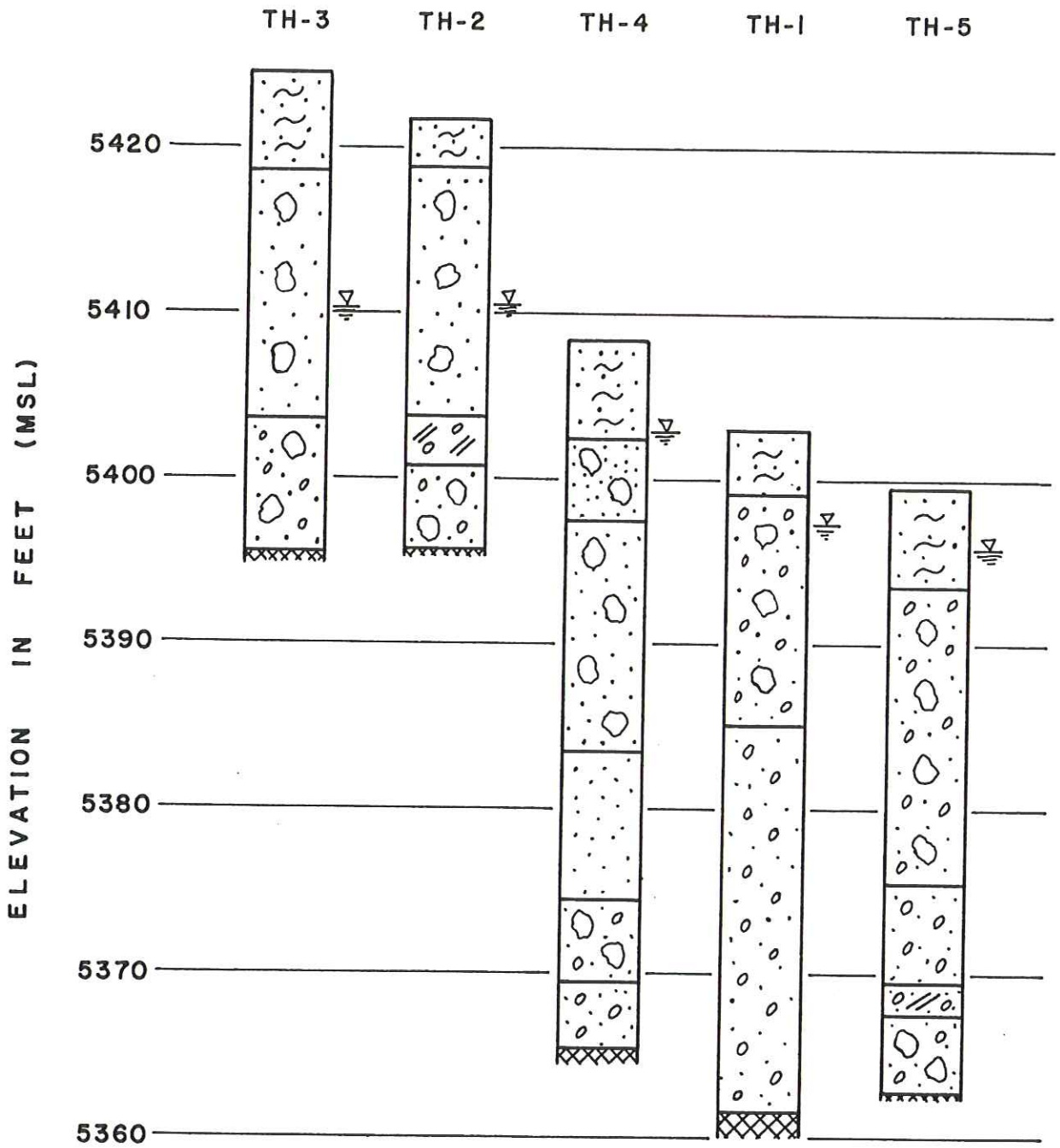
From: Matt Reed

Ranney Collector Wells
6360 Huntley Road
Columbus, Ohio 43229
(614) 888-6263 / Fax (614) 888-9208
email:
www.ranneymethod.com

Notes:

Dick:

Good luck with your project. Please let us know if there is anything we can assist with.



LEGEND

SAND
GRAVEL
SILT
COBBLES
CLAY
BEDROCK

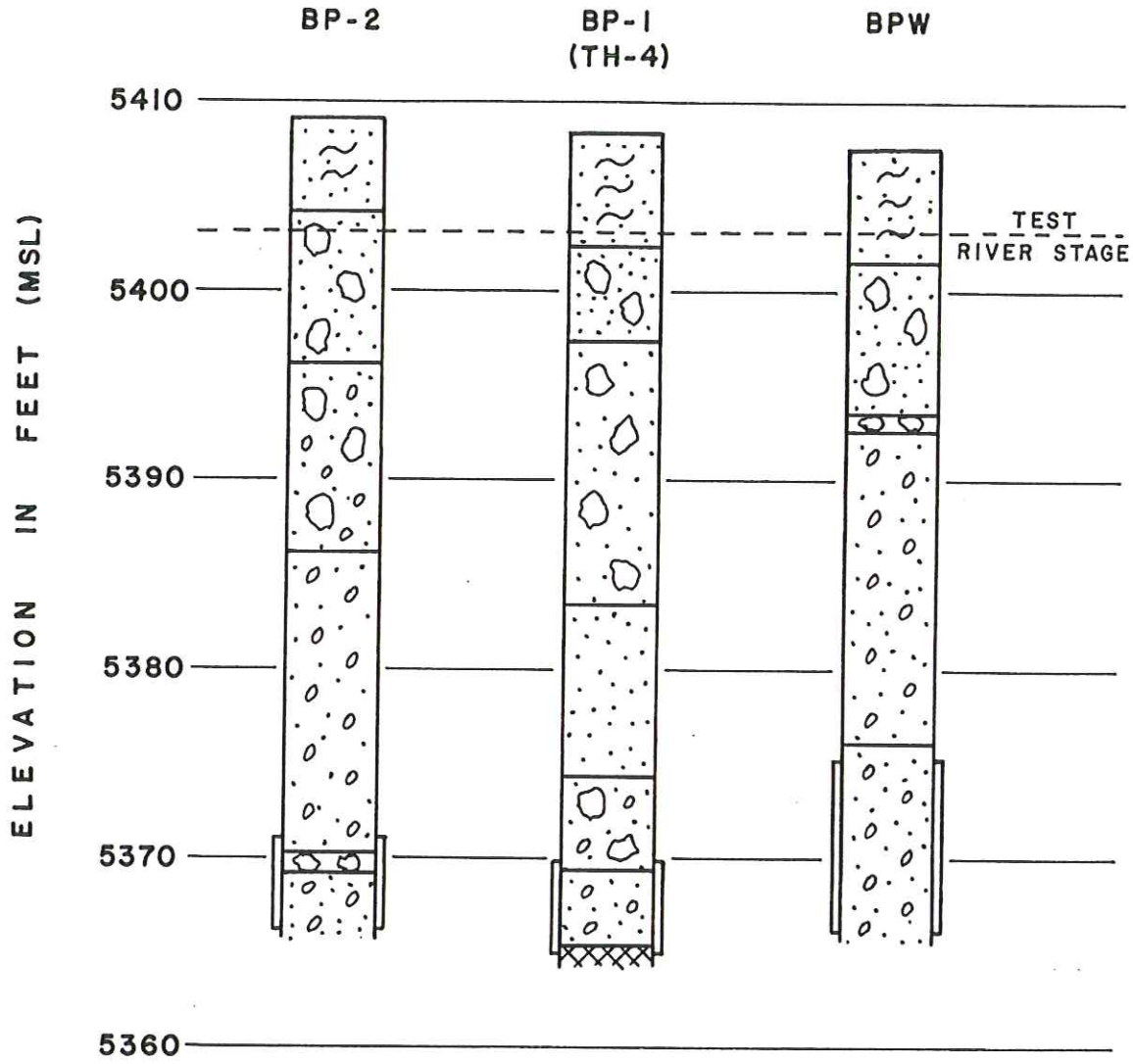
RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

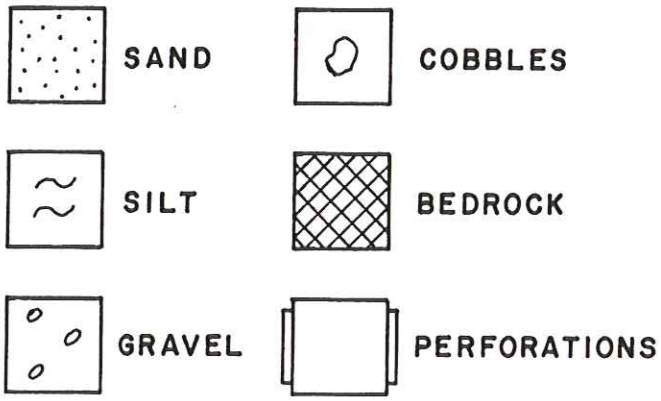
LOGS OF TEST HOLES

DRAWN: MSM	APPROVED: FCM
DATE: 3-11-91	FIG.: SW-116-02

Abadon 880-280 7/83



LEGEND



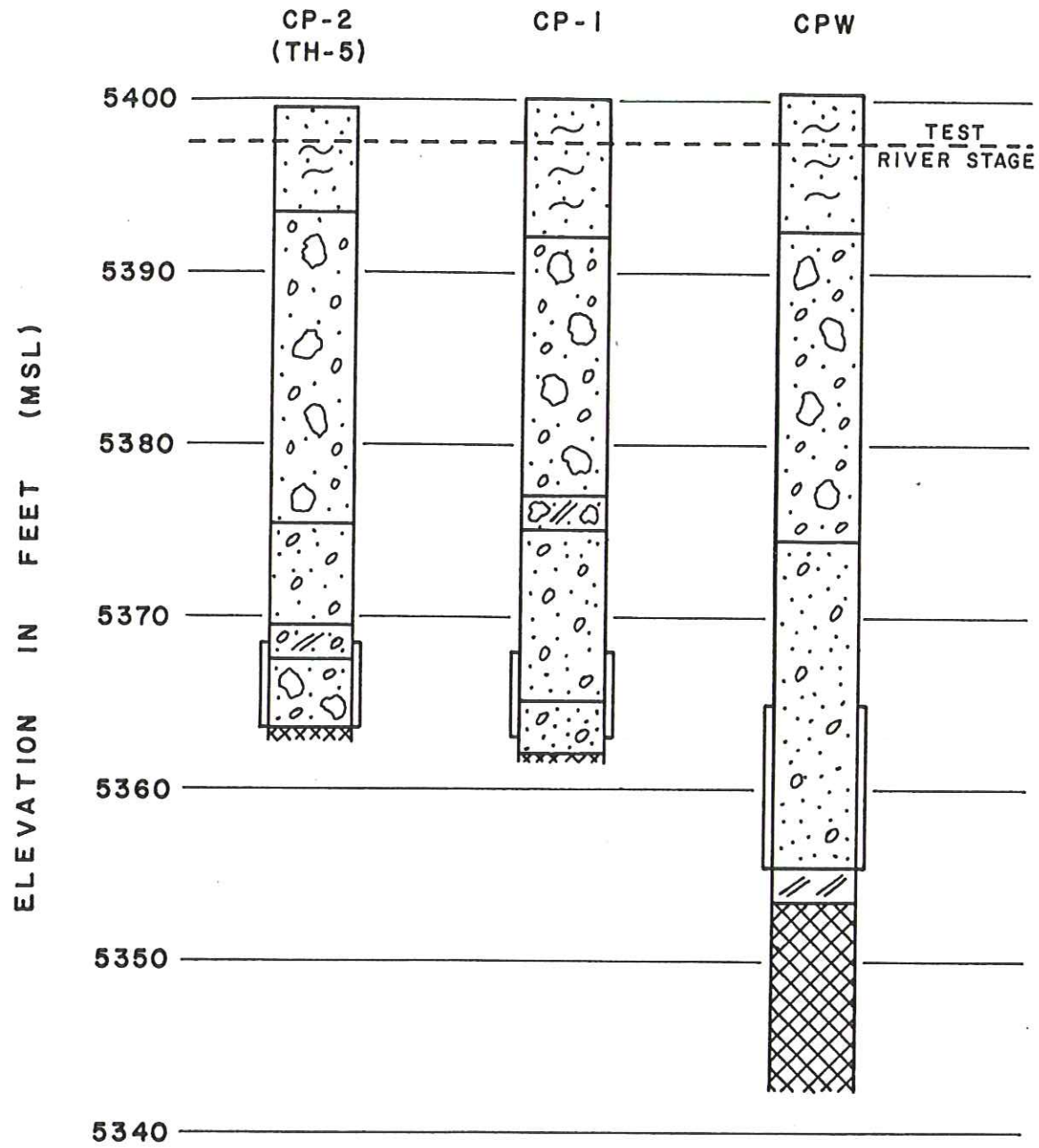
RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

LOGS OF WELLS
SITE B

DRAWN: MSM	APPROVED: FCM
DATE: 3-11-91	FIG.: SW-116-04

Abadon 880-280 7/83



LEGEND

SAND
GRAVEL
SILT
COBBLES
CLAY
BEDROCK

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

LOGS OF WELLS
SITE C

DRAWN: MSM	APPROVED: TCM
DATE: 3-11-91	FIG.: SW-116-08

Abadan 880-280 7/83

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

ell No. T.H.-2 Survey No. SW-116

wner BUTTE WATER Co. Location Big Hole River near Divide, MT. 50' from river edge 40' from top of bank

ell Location ≈325' downstream of dam

ameter 8" Depth 26' 6"

otal Casing 31'-6" (8 5/8" O.A.) Perforations: Top 21' Bottom 26'

evations: Top of Casing 5' above ground (5426.76) Ground 5421.76

atic Water Level -16.25' from top of casing 12/12/90 3:30 PM (11.25' below ground surface.)

FROM	TO	DESCRIPTION OF MATERIAL
0	3'	top soil
3'	18'	coarse sand, rock chips (large boulders)
18'	21'	cemented gravel
21'	26'	clean coarse angular sand, rock chips
26'	26' 6"	pulverized boulder (stopped drilling, could not advance casing)
		10/10/91 STATIC WATER LEVEL 5412.48
		RIVER LEVEL 5413.03

Driller Lee Lock of O'Keefe Drilling Date Started 12-10-90

Report by P. Helusa Date Completed 12-11-90

INNEY
ETHOD

Ranney Method Western Corporation

Kennewick, Washington

No. T.H.-3 Survey No. 116

r BUTTE Water Co. Location Big Hole River near Divide, MT.
50' from river edge, 40' from top of bank

Location ≈275' DOWNSTREAM OF DAM

ater 8" Depth 30'-9"

Casing 33' (8 5/8" O.D.) Perforations: Top 25' Bottom 30'

6.82

tions: Top of Casing 2'3" above ground Ground 5424.57

Water Level -16.50 from top of casing 3:35 PM 12/12/90 (14.25' below ground surface.)

ROM	TO	DESCRIPTION OF MATERIAL
0	6'	top soil
6'	21'	coarse sand, pulverized rock (large boulders)
21'	29'	clean coarse angular sand, rock chips
29'	30'9"	rock chips, pulverized boulder (stopped drilling, damaged casing resulted from hard driving
		11/10/91 STATIC WATER LEVEL 5412.54
		RIVER LEVEL 5413.03

r Lee Lock of O'Keefe Drilling Date Started 12-11-90

rt by P. Heluso Date Completed 12-12-90

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

PUMPING TEST SUMMARY

Survey No. SW-116

Pumping Test Site at Pump Station

Owner BUTTE WATER COMPANY

Location Big Hole River at Divide, MT.

Data Taken by P. Heluso

PUMPING WELL:

Well No. N/A Depth _____ Diameter _____

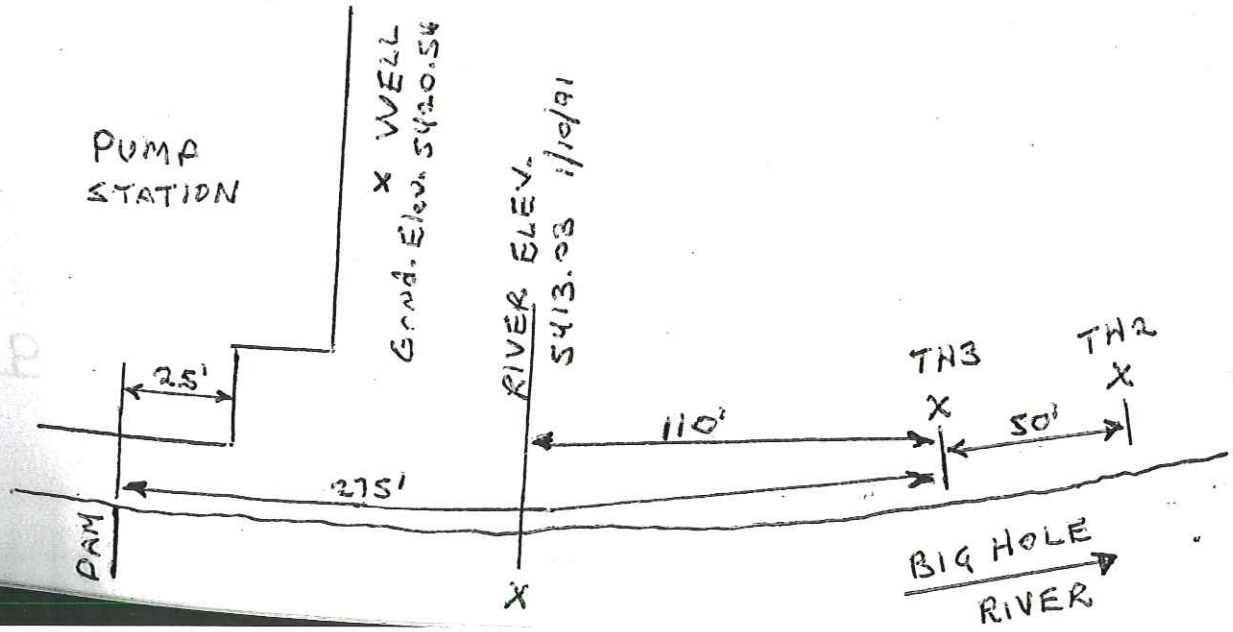
Screen Setting or Perforations: Top _____ Bottom _____ Type and Length _____

Ground Elevation _____ Elevation Top of Casing _____

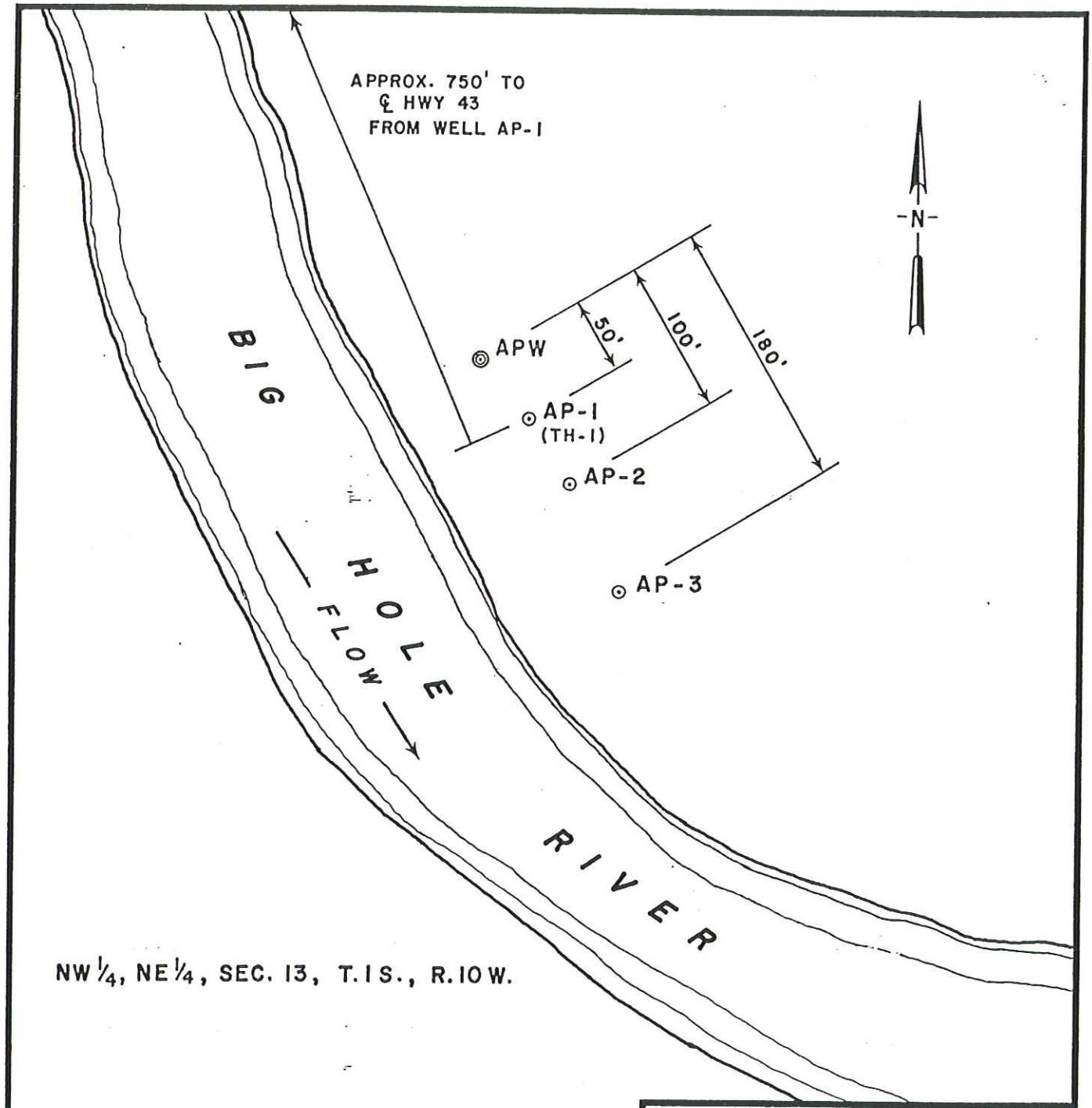
OBSERVATION WELLS:

Well No.	Depth	Perforations	Ground Elevation	Elevation Top of Casing
TH-2	26'-6"	-21 to -26	5421.76	5426.76
TH-3	30'-9"	-25 to -30	5424.57	5426.82

LOCATION MAP: (Show sketch of test pattern noting distances and direction of wells and river)



AF 30041 A



NW 1/4, NE 1/4, SEC. 13, T.1S., R.10W.

SCALE

1" = 100'

MAP IS APPROXIMATE
(NOT SURVEYED)

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
MONTANA

LOCATIONS OF WELLS

DRAWN: MSM	APPROVED: 7cm
DATE: 1-31-90	FIG.: SW-115-02

Abadan 850-280 7/83

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. APW

Survey No. SW-115

Owner BUTTE WATER Co.

Location Big Hole River near Divide, MT.

Well Location 50' NW of AP-1 ; 69' from rivers edge

Diameter 12"

Depth 42'

Total Casing 44'9" then pulled 8'6"

Perforations: Top 34' Bottom 42'

Elevations: Top of Casing 6" above ground

Ground

Static Water Level 6.0' (10:10 AM 12/18/89) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	5'	Top soil, sandy silt
5'	8'	Grey sand, gravel, cobbles (water at 6')
8'	18'	Brown M to C sand, M gravel, loose, clean
18'	28'	Brown C sand, M gravel, loose, clean
28'	34'6"	Brown M to C sand, M to L gravel, loose, clean
34'6"	40'	Brown fine sand, L gravel, loose, clean
40'	42'	Brown C sand, L gravel, some clay, loose, clean

Driller O'Keefe Drilling (Lee Lock)

Date Started 12/14/89

Report by P. Melusso

Date Completed 12/21/89

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. T.H.1 (AP-1) Survey No. SW-115

Owner Butte Water Co. (Robert Peccia & Assocs) Location Big Hole River near Divide, MT

Well Location 750' downstream from State Highway 43 Bridge; 80' from river's edge 50' from top of bank

Diameter 8" Depth 41'

Total Casing 43'-5" (8 5/8" O.D.) Perforations: Top 35' Bottom 40'

Elevations: Top of Casing 2.2' above ground Ground

Static Water Level 5.8' (11:20 am 12/9/89) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	4'	Top soil, sandy silt
4'	18'	Grey sand, gravel, cobbles (water at 6' feet)
18'	32.5'	Brown coarse sand, med. to large gravel, loose, clean
32.5'	41.5'	Brown med. to coase sand, fine to med gravel, loose, clean
41.5'	43'	Blue sandy clay

Driller O'Keefe Drilling (Lee Lock-driller) Date Started 12/7/89

Report by Frederick C. Nielsen Date Completed 12/9/89

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. AP-2 Survey No. SW-115

Owner Butte Water Co. Location Big Hole River near Divide, Mt.

Well Location 50' SE of AP-1 80' from river's edge

Diameter 8" Depth 40'

Total Casing 41'-2" (8 5/8" O.D.) Perforations: Top 35' Bottom 40'

Elevations: Top of Casing 5404.24 Ground 5403.00

Static Water Level 5.3' (9:00 AM 12-13-89) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	5'	Top soil, sandy silt
5'	10'	Grey sand, gravel, cobbles (water at 5½')
10'	21'	Brown M to C sand, F to M gravel, loose, clean
21'	29'	Brown M to C sand, M to L gravel, loose, clean
29'	31'	Brown M to C sand, Large gravel, loose, clean
31'	35'6"	Brown M to C sand, M to L gravel, loose, clean
35'6"	37'6"	Brown M to C sand, M to L gravel, tight, clean
37'6"	39'	Brown F to M sand, ~~F~~ M gravel, tight, clean
39'	40'	Brown F to M sand, F to M gravel, tight, clean
40		sandy clay

Driller O'Keefe Drilling (Lee Lock) Date Started 12/12/89

Report by P. Heluso Date Completed 12/12/89

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. AP-3 Survey No. SW-115

Owner BUTTE WATER Co. Location Big HOLE RIVER, NEAR DIVIDE, MT

Well Location 130' SE of AP-1; 74' from River's edge

Diameter 8" Depth 41'-4"

Total Casing 44'-4" (8 5/8" OD.) Perforations: Top 35 Bottom 40

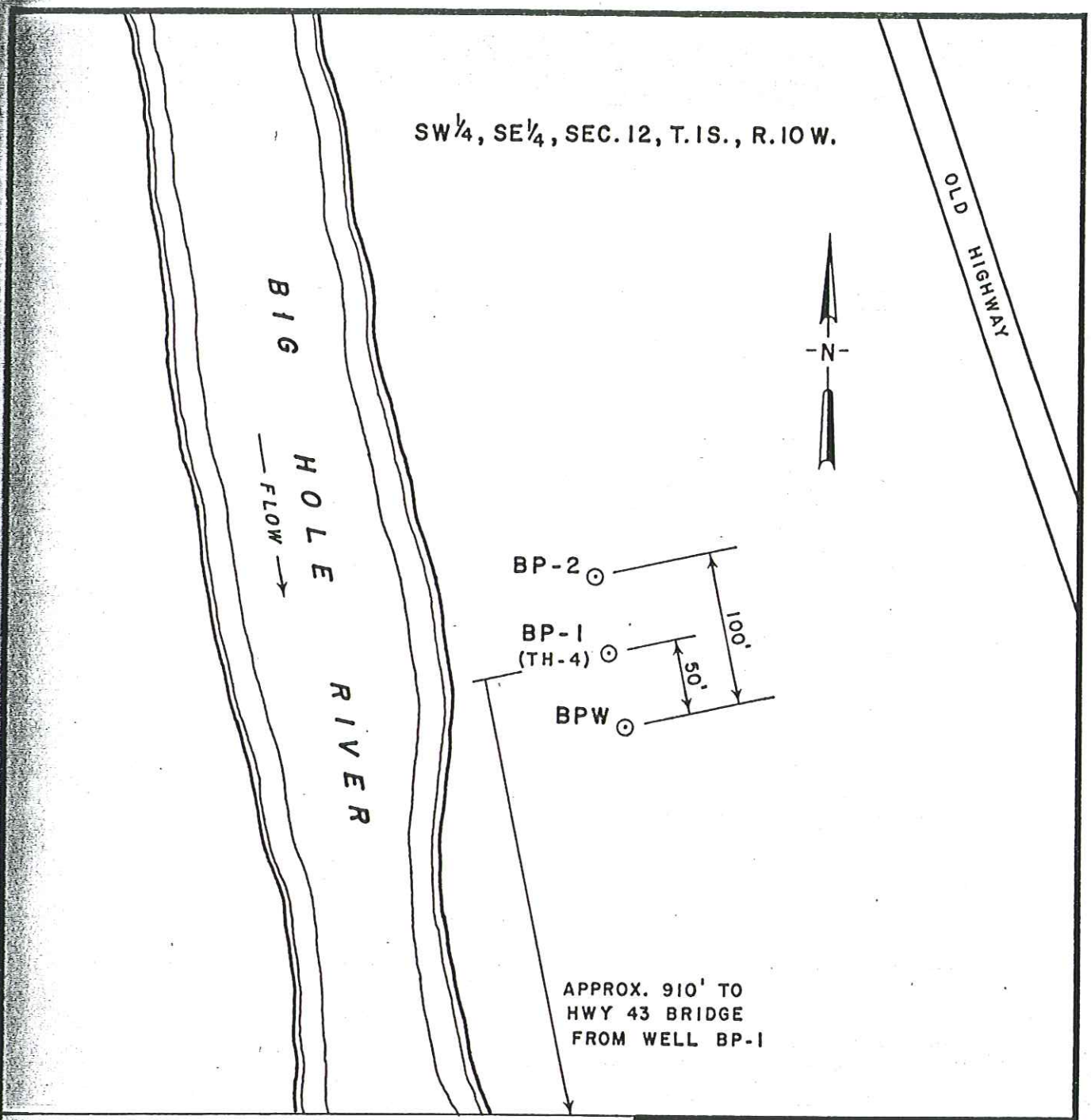
Elevations: Top of Casing 5405.76 Ground 5402.77

Static Water Level 5.7' (8:20 AM 12/15/89) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	4'	Top soil, sandy silt
4'	8'	Grey sand, gravel, cobbles (WATER AT 6 FT)
8'	18'	Brown fine sand, small gravel, loose, clean
18'	28'	Brown f to m sand, small gravel, loose, clean
28'	39' 6"	Brown m to c sand, small gravel, loose, clean
39' 6"	40'	Brown f to m sand, m gravel, tight, clean
40'	41'	Brown fine sand, tight, clean

Driller O'KEEFE DRILLING (LEE LOCK) Date Started 12/12/89

Report by P. Heluso Date Completed 12/14/89



SCALE

1" = 100'

MAP IS APPROXIMATE

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

LOCATIONS OF WELLS
SITE B

DRAWN: MSM	APPROVED: 7cm
DATE: 3-11-91	FIG.: SW-116-03

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. BFW

Survey No. 116

Owner Butte Water Company

Location Big Hole River at Divide, MT

Well Location ≈ 860' upstream from ℄ State Hwy 43 Bridge

Diameter 8"

Depth

Total Casing 41'-6"

Perforations: Top -32'4" Bottom -41'-6"

Elevations: Top of Casing 5408.13

Ground 5407.63

Static Water Level _____ below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	6'	top soil, coarse sand
6	14'	coarse sands, rock
14'	15'	broken rock (hard driving)
15'	26'	coarse sand, fine gravel
26'	31' 6"	coarse sand, small gravel
31' 6"	42'	(fine sand, small gravel as reported by Lee Lock)
		(well sanded in during 24 hour pump test
		bottom depth -36'9" from top of casing)

Driller Lee Lock of O'Keefe Drilling

Date Started 12-18-90

Report by P. Helvas

Date Completed 1-10-91

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. TH-4 (BP-1) Survey No. 116

Owner BUTTE WATER COMPANY Location Big Hole River at Divide, MT.

Well Location ≈ 910' upstream from ℄ State Hwy 43 Bridge

Diameter 8" Depth 44'

Total Casing 47' (8 5/8" O.D.) Perforations: Top 38'-6" Bottom 43'-6"

Elevations: Top of Casing 5411.46' 3' above ground Ground 5408.40

Static Water Level -8.58' from top of casing 2:20 PM 12/15/90 (5.58 below ground surface.)

FROM	TO	DESCRIPTION OF MATERIAL
0	6'	Top soil, coarse sand
6'	11'	coarse sand, 6" rock
11'	22'	broken rock, coarse sand
22'	25'	large rock, coarse sand
25'	34'	fine to med angular sand
34'	39'	med. sand, small gravel, large rock
39'	43'	fine and med. sand, small gravel
44'		clay, bedrock

Driller Lee Lock of O'Keefe Drilling Date Started 12-13-90

Report by P. Heluso Date Completed 12-15-90

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. BP2 ([redacted]) Survey No. 116

Owner BUTTE WATER CO. Location Big Hole River at Divide, MT

Well Location ≈ 960' upstream from ℄ State Hwy 43 Bridge

Diameter 8" Depth 43'6"

Total Casing 47' (8 5/8" O.D.) Perforations: Top 38' Bottom 43'

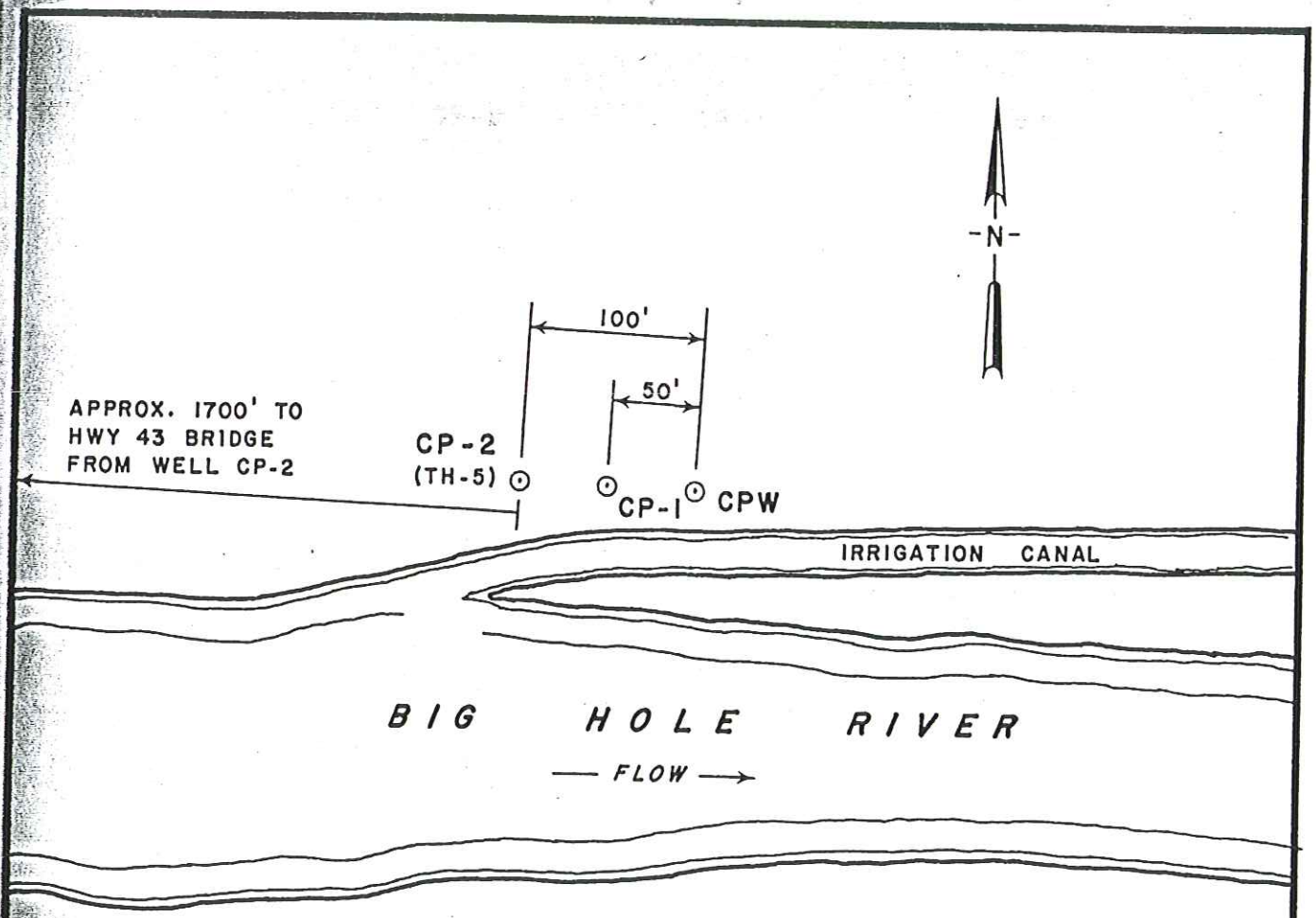
Elevations: Top of Casing 5412.80' 3'-6" above ground Ground 5409.15

Static Water Level 9.37' from top of casing 10:25 AM 12-18-90 (5.87' below ground surface.)

FROM	TO	DESCRIPTION OF MATERIAL
0	5'	top soil, coarse sand
5'	13'	coarse sand, large rocks
13'	23'	coarse sand, gravel, broken rock
23'	32'	coarse sand, small gravel
32'	39'	coarse sand, fine gravel
39'	40'	Rock, extremely hard to drive thru
40'	43'6"	coarse sand, fine gravel

Driller Lee Lock of O'Keefe Drilling Date Started 12/15/90

Report by P. Heluso Date Completed 12/17/90



NE 1/4, NE 1/4, SEC. 13, T.1S., R.10W.

SCALE

1" = 100'

MAP IS APPROXIMATE

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

ROBERT PECCIA & ASSOCIATES
CONSULTING ENGINEERS
BUTTE WATER COMPANY
BUTTE, MT

LOCATIONS OF WELLS
SITE C

DRAWN: MSM	APPROVED: FCM
DATE: 3-11-91	FIG.: SW-116-07

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. CPW

Survey No. SW-116

Owner BUTTE WATER COMPANY

Location Big Hole River at Divide, MT

Well Location ≈ 1800' downstream from E State Hwy 43 Bridge; 70' from river edge

Diameter 8"

Depth 45'

Total Casing 35'6" + 10' screen

Perforations: Top - 35'6" Bottom - 45'

Elevations: Top of Casing 5401.12

Ground 5400.45

Static Water Level _____ below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	8'	Top soil, silty sand
8	16'	coarse sand, gravel, cobbles
16'	26'	sand, gravel, rocks
26	31'	coarse sand, gravel
31'	45'	coarse angular sand (tight); gravels
45'	47'	clay > open hole backfilled w/gravel
47'	58'	consolidated sand

Driller Lee Lock of O'Keefe Drilling

Date Started 1-15-91

Report by P. Heluso

Date Completed 1-16-91

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. CP-1 Survey No. SW-116

Owner BUTTE WATER COMPANY Location Big Hole River at Divide, MT.

Well Location ≈1750' downstream from ℄ State Hwy 43 Bridge; 70' from river edge

Diameter 8" Depth 38'

Total Casing 41'-1½" Perforations: Top -32' Bottom -37'

Elevations: Top of Casing 3.12' above ground 5403.24 MSL Ground 5400.12 MSL

Static Water Level 5.56' 4.52' (10:15 AM 1/15/91) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	8'	Top soil, silty sand
8'	15'	coarse sands, gravels, cobbles
15'	23'	sands, gravels, rocks
23'	25'	sands, gravels, rocks, some clay
25'	35'	coarse sands, gravel
35'	38'	coarse angular sand (tight); gravels
38'	-	bedrock

Driller Lee Lock of O'Keefe Drilling Date Started 1-12-91

Report by P. Helvas Date Completed 1-14-91

RANNEY METHOD

Ranney Method Western Corporation

Kennewick, Washington

Well No. TH-5 (CP-2) Survey No. SW-116

Owner BUTTE WATER COMPANY Location Big Hole River AT DIVIDE, MT.

Well Location approx 1700' downstream from ℄ State Hwy 43 Bridge; 70' from river edge

Diameter 8" Depth 36'-9"

Total Casing 40' Perforations: Top -31' Bottom -36'

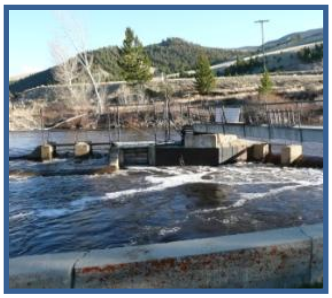
Elevations: Top of Casing 3.25' above grnd. 5402.78 MSL Ground 5399.53 MSL

Static Water Level 3.70' (2:45 PM 1/12/91) below ground surface.

FROM	TO	DESCRIPTION OF MATERIAL
0	6'	Top soil, sandy silt
6'	12'	sand, gravel, cobbles
12'	24'	sand, gravel, 3"-6" rock
24'	26'	fine sands, gravel
26'	30'	sand, gravel,
30	32'	fine sands, gravel, some clay; extremely hard to drive
32	36' 9"	sand, gravel, broken rock
36' 9"	—	bedrock

Driller Lee Lock of O'Keefe Drilling Date Started 1-10-91

Report by P. Heluso Date Completed 1-12-91



ENVIRONMENTAL ASSESSMENT

for the

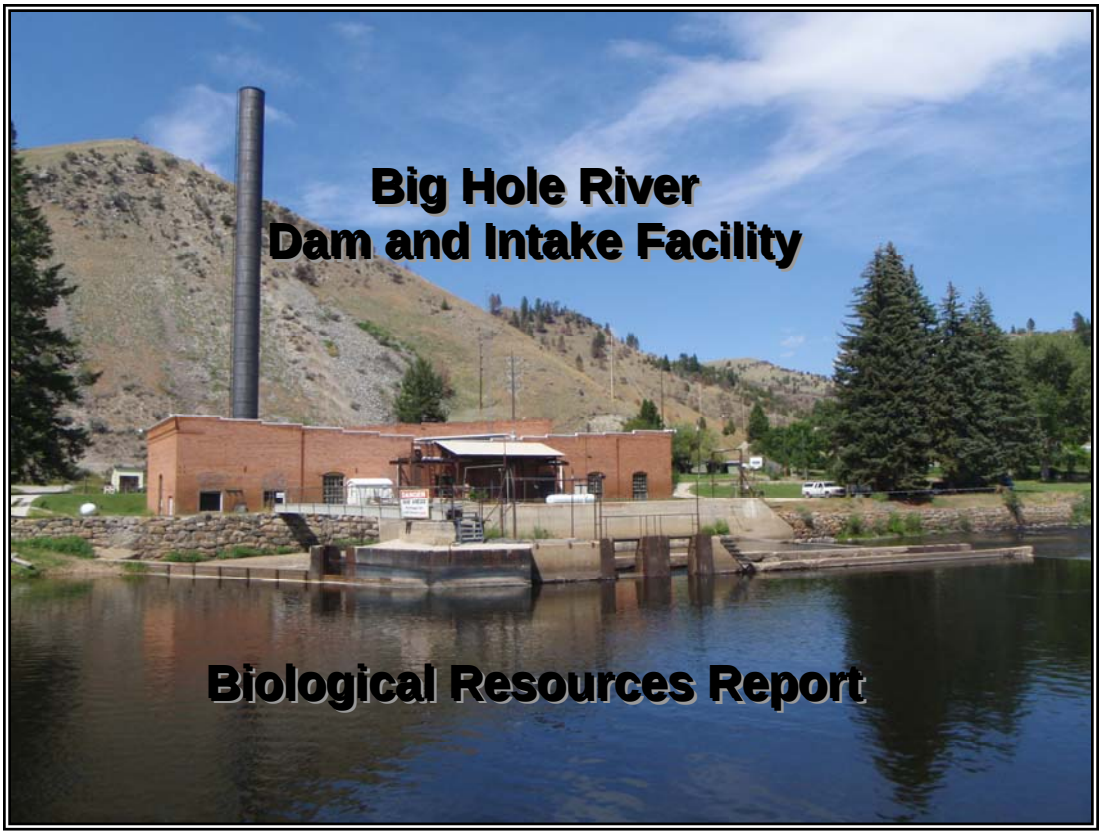
Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX F

BIOLOGICAL RESOURCES REPORT AND WETLAND DELINEATION



Big Hole River Dam and Intake Facility

Biological Resources Report

Prepared for:

DOWL HKM Engineering

November, 2009

Submitted by:

CONFLUENCE

P.O. Box 1133,
Bozeman, MT 59771-1133
p. 406-585-9500, f.406-582-9142

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1 Introduction

The Big Hole River diversion and intake structure provides a municipal water supply to the city of Butte Montana. The existing structure is failing due to age and is in need of repair or replacement. DOWL HKM Engineering is conducting an engineering and feasibility analysis for upgrading the facility to improve upon the existing structure for the benefit of functionality, safety, and fish and boater passage. DOWL HKM has retained the services of Confluence Consulting, Inc. to perform a natural resources inventory of the project area as part of an Environmental Assessment. The site inventory included soils, vegetation, jurisdictional wetlands, land use, wildlife, and any threatened/endangered fish and wildlife species potentially occurring on the site. The results of this survey are presented in this report, along with natural resource impacts and potential mitigation resulting from each of five preliminary engineering options selected during the engineering feasibility study.

2 Study Area and Methods

The focal point of the project area is the Big Hole Dam and Pump house, which lies approximately 2 miles to the west of Divide, MT (Figure 1). The biological inventory included compiling information on soils, land use, vegetation, wetlands, and threatened/endangered plant, wildlife, and fish species in the vicinity of the project area.

A site investigation was performed on August 4, 2009 to become familiar with the operation of the facility and to document vegetation and wetlands within the project area. The vegetation survey identified all species present within any potentially disturbed areas. All vegetation species were identified visually in the field or collected and identified using field manuals. A wetland delineation was conducted in accordance with the 1987 Army Corps of Engineers Wetland Delineation Manual and the Interim Regional Supplement for the Western Mountains, Valleys, and Coast Region. All jurisdictional wetlands within the project area were mapped and classified by wetland type. Soils data were drawn from the NRCS Soil Survey Geographic database (SSURGO). Soil map polygons within the vicinity of the project were mapped and identified for any rare or sensitive soil types. Fisheries data were gathered from the MFISH database for the Big Hole River. Threatened and endangered fish and wildlife species data were generated from the Montana Natural Heritage database for Township 1South, Range 10 West in Southwestern Silver Bow County.

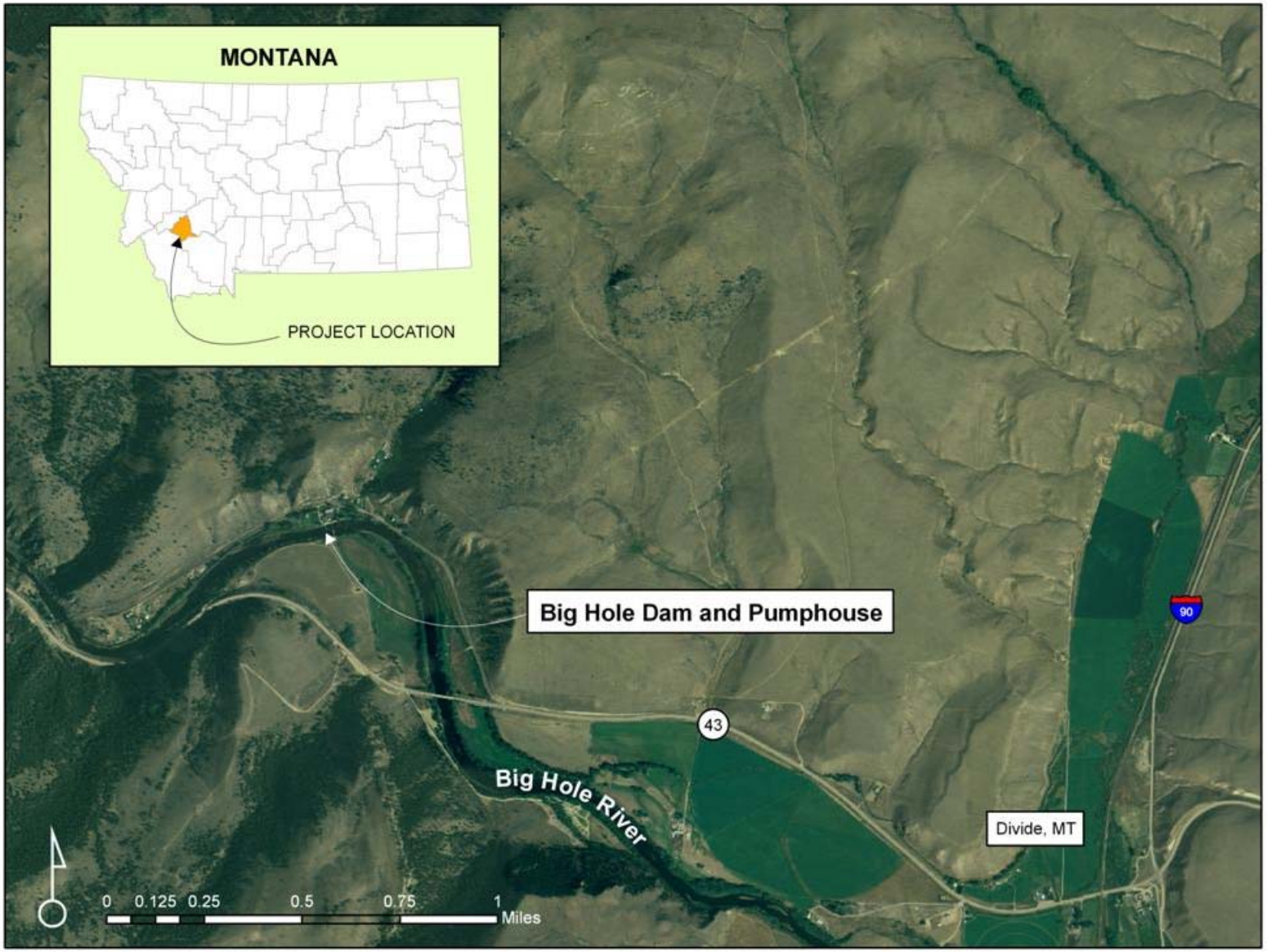


Figure 1. Location of Big Hole Dam and Pump house.

3 Vegetation Inventory

3.1 Vegetation Communities

The vegetation inventory identified 18 tree/shrubs, 30 forbs, 13 grasses, and one macrophyte species within the project area (Table 1). The riparian vegetation present along the banks of the Big Hole River consists of a mosaic of cottonwood/red-osier dogwood, willow/herbaceous, and Douglas fir-dominated community types (See photos, Appendix C). The presence of a minor amount of Douglas fir and senescent cottonwoods along the northern bank suggests that a portion of this community may be entering into a later successional stage. This is further supported by a lack of cottonwood seedlings in this area as this species does no regenerate in their own shade and generally requires moist, barren, fully exposed, newly deposited alluvial material as a suitable seedbed. A moderately rich diversity of shrubs and herbaceous understory is present along both banks of the river, with the exception of the maintained and manicured area directly adjacent to the intake facility. Willows, alder, serviceberry, currant, and chokecherry are the dominant shrubs throughout the riparian areas. The herbaceous community transitions from predominately hydrophytes, including water knotweed, spike rush and horsetail, to canary reedgrass, mannagrass and foxtail barely, then into upland species within a short distance (<10 feet) from the bank. Irrigation ditches run along both sides of the river and sustain narrow bands of hydrophytic vegetation along their fringes. The arid uplands adjacent to the southern bank are characterized by sagebrush, skeleton weed, wheatgrass and needle and thread grass. No threatened or endangered plant species were found during the inventory.

3.2 Weeds

Six category 1 and one category 2 noxious weeds were identified (Table 1). Category 1 noxious weeds are defined by the Montana Department of Agriculture as weeds that are currently established and generally widespread in many counties of the state. Management criteria include awareness and education, containment and suppression of existing infestations and prevention of new infestations. These weeds are capable of rapid spread and render land unfit or greatly limit beneficial uses. Category 2 noxious weeds are defined as having recently been introduced into the state or rapidly spreading from their current infestation sites. These weeds are capable of rapid spread and invasion of lands, rendering lands unfit for beneficial uses. Management criteria include awareness and education, monitoring and containment of known infestations and eradication where possible. As a result of multiple category 1 weeds present within the project area, efforts should be taken to prevent further spread of these weeds as a result of the project.

Table 1. Vegetation species present within the project area.

Common Name	Scientific Name	Noxious weeds
Trees/Shrubs		
Prickly currant	*Ribes lacustre*	
Sandbar willow	*Salix exigua*	
Pacific willow	*Salix lasiandra*	
Narrowleaf cottonwood	*Populus angustifolia*	
Black Cottonwood	*Populus tricocarpa*	
Red osier dogwood	*Cornus sericea*	
Speckled alder	*Alnus incana*	
Silver sagebrush	*Artemisia cana*	
Big sagebrush	*Artemisia tridentada*	
Silverberry	*Elaeagnus commutata*	
Yellow willow	*Salix lutea*	
Chokecherry	*Prunus virginiana*	
Yellow rabbitbrush	*Chrysothamnus viscidiflorus*	
Fringed sagebrush	*Artemisia frigida*	
Douglas Fir	*Pseudotsuga menziesii*	
Rocky mountain juniper	*Juniperus scopulorum*	
Saskatoon serviceberry	*Amelancher alnifolia*	
Grease wood	*Sarcobatus vermiculatus*	
Forbs		
Spotted knapweed	*Centaurea stoebe*	Category 1
American licorice	*Glycyrrhiza lepidota*	
Yellow sweet clover	*Melilotus officinalis*	
Common tansy	*Tanacetum vulgare*	Category 1
Canada thistle	*Cirsium arvense*	Category 1
Common mullen	*Verbascum thapsus*	
False salomon's seal	*Smilacina racemosa*	
Bee balm	*Monarda fistulosa*	
Canada godenrod	*Solidago canadensis*	
Field pennycress	*Thlaspi arvense*	
Common dandelion	*Taraxacum officinale*	
Western salsify	*Tragopogon dubius*	
Yellow toadflax	*Linaria vulgaris*	Category 1
Parrish's yampah	*Perideridia parishii*	
Field mint	*Menth arvense*	
Curly dock	*Rumex crispus*	
Houndstongue	*Cynoglossum officinale*	Category 1
Netseed lambsquarters	*Chenopodium berlandieri*	
Oxeye daisy	*Chrysanthemum leucanthemum*	Category 1
River bank grape	*Vitis riparia*	
Flixweed	*Descurainia sophia*	
Fireweed	*Epilobium angustifolium*	
Hooked spur violet	*Viola adunca*	
Spreading dogbane	*Apocynum androsaemifolium*	
Plains pricklypear	*Opuntia polyacantha*	
Wild bergamot	*Monarda fitulosa*	
Jungle rice	*Echinochloa colona*	
Rush skeletonweed	*Chondrilla juncea*	Category 2

Common Name	Scientific Name	Noxious weed
Forbs (cont)		
Skeleton weed	*Lygodesmia juncea*	
Creeping bellflower	*Campanula capunculoides*	
Grasses		
Slender wheatgrass	*Agropyron trachycaulum*	
Smooth brohme	*Bromus inermis*	
Kentucky bluegrass	*Poa pratensis*	
Fowl bluegrass	*Poa palustris*	
Alkali Grass	*Poa palustris*	
Cheatgrass	*Bromus tectorum*	
Crested wheatgrass	*Agropyron cristatum*	
Canary reedgrass	*Phlaris arundinacea*	
Alkali grass	*Puccinellia sp*	
American mannagrass	*Glyceria grandis*	
Common velvetgrass	*Holcus lanatus*	
Foxtail barley	*Hordeum jubatum*	
Needle and thread grass	*Stipa comata*	
Sedges/Rushes		
Field horsetail	*Equisetum arvense*	
Smooth scouring rush	*Equisetum laevigatum*	
Beaked spike rush	*Eleocharis rostellata*	
Macrophytes		
Water knowtweed	*Polygonum amphibium*	

3.3 Threatened/Endangered Plants

The Montana Natural Heritage Program identifies the Sapphire rockcress plant as occurring within the township and range of the Big Hole Dam and Pump house. The Sapphire rockcress is a state Species of Concern, defined as native taxa that are at-risk due to declining population trends, threats to their habitats, restricted distribution, and/or other factors. Designation as a Montana Species of Concern or Potential Species of Concern is based on the Montana Status Rank, and is not a statutory or regulatory classification. Rather, these designations provide information that helps resource managers make proactive decisions regarding species conservation and data collection priorities. No threatened or endangered plant species are known to exist within the project area. Sapphire rockcress was not observed during the vegetation inventory of the project area. Additional information including a general description, phenology, diagnostic characteristics, distribution, habitat, ecology, and management of the Sapphire rockcress can be found at the Montana Natural Heritage Program website http://fieldguide.mt.gov/detail_PDBRA06290.aspx.

4 Soils

The NRCS SSURGO database identifies six soil types within the vicinity of the project area, which are illustrated in Figure 2 and classified as shown in Table 2. None of the soil types found in the project are classified as sensitive or important farmland. Additional properties of each soil type can be found in the NRCS SSURGO database files.

Table 2. NRCS mapped soil series within the Big Hole Diversion Dam project area.

Map Unit Symbol	Map Unit Name
51D	Foxgulch-Libeg complex, 6 to 25 percent slopes, stony
74A	Bearmouth very cobbly sandy loam, 0 to 2 percent slopes, very stony
75A	Danielvil loam, 0 to 2 percent slopes
80A	Water-Riverwash complex
909G	Rubick, rubbly–Rubble land complex, 40 to 75 percent slopes
920G	Poin, rubbly-Rubble land-rock outcrop complex, 40 to 80 percent slopes

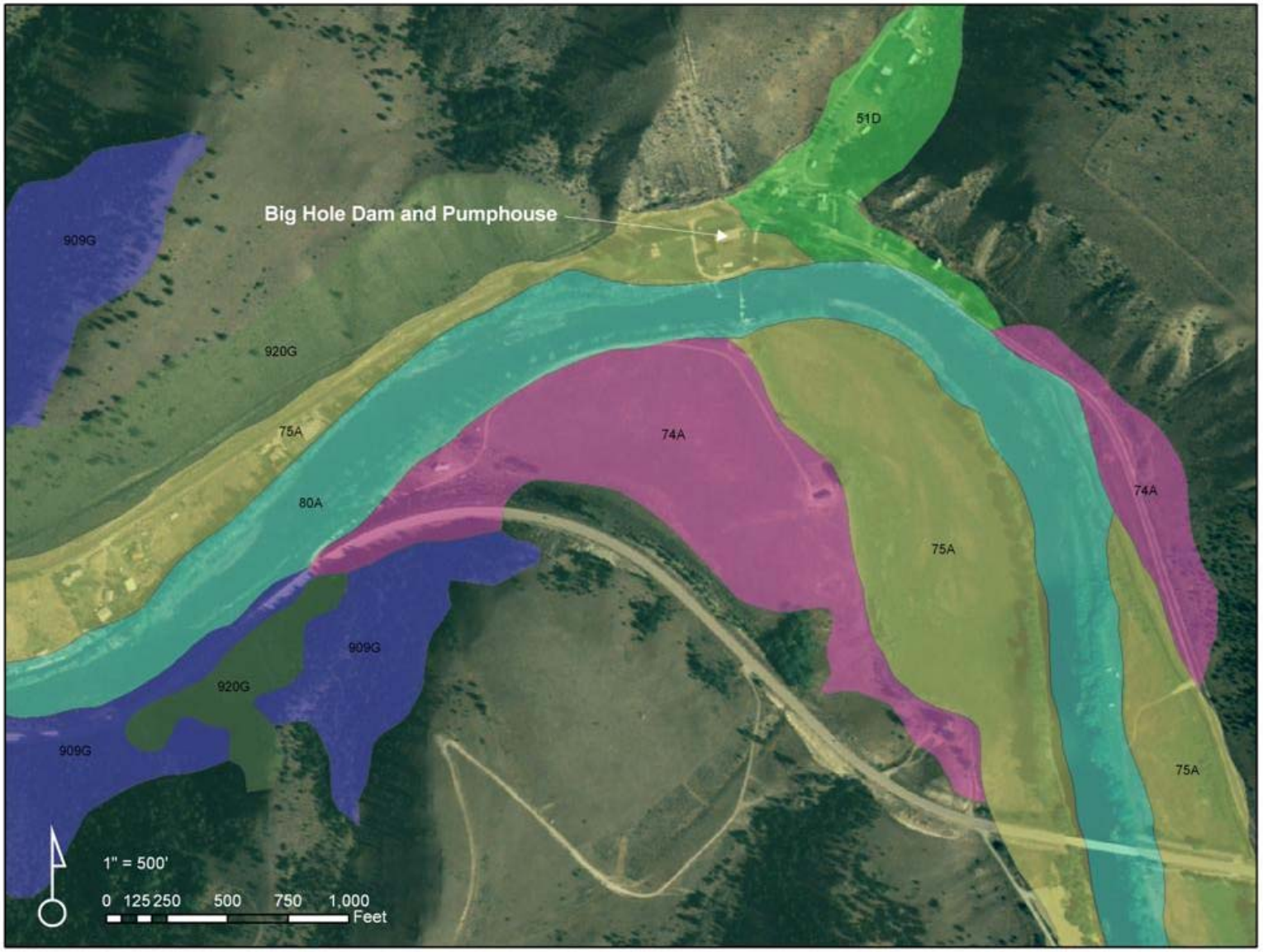


Figure 2. Soils map of the project area as classified by the NRCS SSURGO soil database.

5 Jurisdictional Wetlands and Waters of the U.S.

A delineation of wetlands and Waters of the U.S. was conducted from approximately 500 feet downstream of the Big Hole dam and pump house to approximately one-half mile upstream of this structure. A field investigation for jurisdictional wetlands and waters of the U.S. was completed on August 4, 2009. The delineation was conducted in compliance with the 1987 Corps of Engineers (USACE) Wetland Delineation Manual of the U.S. and the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (April 2008). A functions and values assessment of wetlands was also conducted using methods developed by the Montana Department of Transportation (MDT) (Berglund, 1999).

In order to delineate a representative area as jurisdictional, the technical criteria for hydrophytic vegetation, hydric soil and wetland hydrology, as described in the 1987 Corps Manual and Interim Supplement, must be satisfied. The routine, Level-2 on-site Determination Method was used to delineate the jurisdictional areas. The wetland boundary was determined in the field based on changes in plant communities and/or hydrology, and changes in soil characteristics. Topographic relief boundaries within the subject properties were also examined and cross referenced with soil and vegetation communities as supportive information for this wetland delineation. If vegetative characteristics, soils, and hydrologic properties met wetland criteria, the area was classified as wetland and mapped by the vegetation community type. If any one of the parameters did not exhibit positive wetland indicators, the area was determined to be upland.

Wetland assessment methods and forms developed by the Montana Department of Transportation (MDT) (Berglund 1999) were used for the functions and values assessment. The assessment was conducted at the time of the on-site wetland delineation in August of 2009. The following functions and values are evaluated by this method:

A. Habitat for federally listed or proposed threatened or endangered plants or animals (T&E species),
B. Habitat for plants or animals rated S1, S2, S3 by the Montana Natural, Heritage Program,
C. General wildlife habitat,
D. General fish/aquatic habitat,
E. Flood attenuation,
F. Long and short-term surface water storage,
G. Sediment/nutrient/toxicant retention and removal,
H. Sediment/shoreline stabilization,
I. Production export/food chain support,
J. Groundwater discharge/recharge,
K. Uniqueness, and
L. Recreation/education potential.

In performing a function and values assessment, a rating of low, moderate, high or NA (not applicable) is applied to each of the twelve functions and values (A-L) with accompanying point scores of 0.1 (lowest) to 1.0 (highest). Functional points are then summed and divided by the possible maximum score (functions and values ranked NA are not included) to yield a percentage score. This percentage is then used in conjunction with other criteria to provide an overall wetland ranking into one of four categories. A Category I ranking is the highest a wetland can receive, followed by Category II, Category III, and Category IV rankings.

The wetland areas within the Big Hole diversion dam project area are ranked as Category III. This rating was influenced by the moderately disturbed nature of the site and low to moderate ratings for wildlife habitat, flood attenuation, water storage, and uniqueness. The assessed area does support a high structural diversity including diverse herbaceous, shrub, and canopy layers. The area rated high with regard to general fish/aquatic habitat, sediment/nutrient removal, and shoreline stabilization.

5.1 Areas Classified as Waters of the U.S.

Areas of the project site that are subject to U.S. Army Corps regulatory jurisdiction are considered Waters of the U.S., and lie within the bed and banks of the Big Hole River (ordinary high water mark) and within an approximate 1-foot buffer of each side of irrigation ditches running to the north and south of the river. Figure 3 illustrates the boundary of all identified jurisdictional Waters of the U.S. and their respective regulatory classifications. Irrigation ditches were not surveyed during the site visit; therefore, jurisdictional boundaries associated with the ditches were more accurately determined from topographic survey maps of the project reach. Incidental groundwater seepage from the irrigation canal contributes to wetland hydrology along the margins of the riparian zone and extends the boundary of the wetland up gradient in these select areas. The irrigation ditch along the north bank has an apparent surface water nexus and would likely be considered jurisdictional by the Army Corps of Engineers (Corps). The irrigation ditch along the south bank does not appear to have a significant nexus and may not be considered jurisdictional. The Corps will make the final jurisdictional determination of these ditches and delineated wetland areas.

5.2 Areas Classified as Jurisdictional Wetlands

No isolated, jurisdictional wetlands were identified within the project area. As a result, all proposed impacts will be limited to the areas identified as Waters of the U.S. as discussed in Section 5.1. Fill material placed within regulated Waters of the U.S. and/or jurisdictional wetlands require compensatory mitigation at ratios determined by the U.S. Army Corps of Engineers. Potential impacts resulting from each feasibility option are discussed in section 8 of this report.

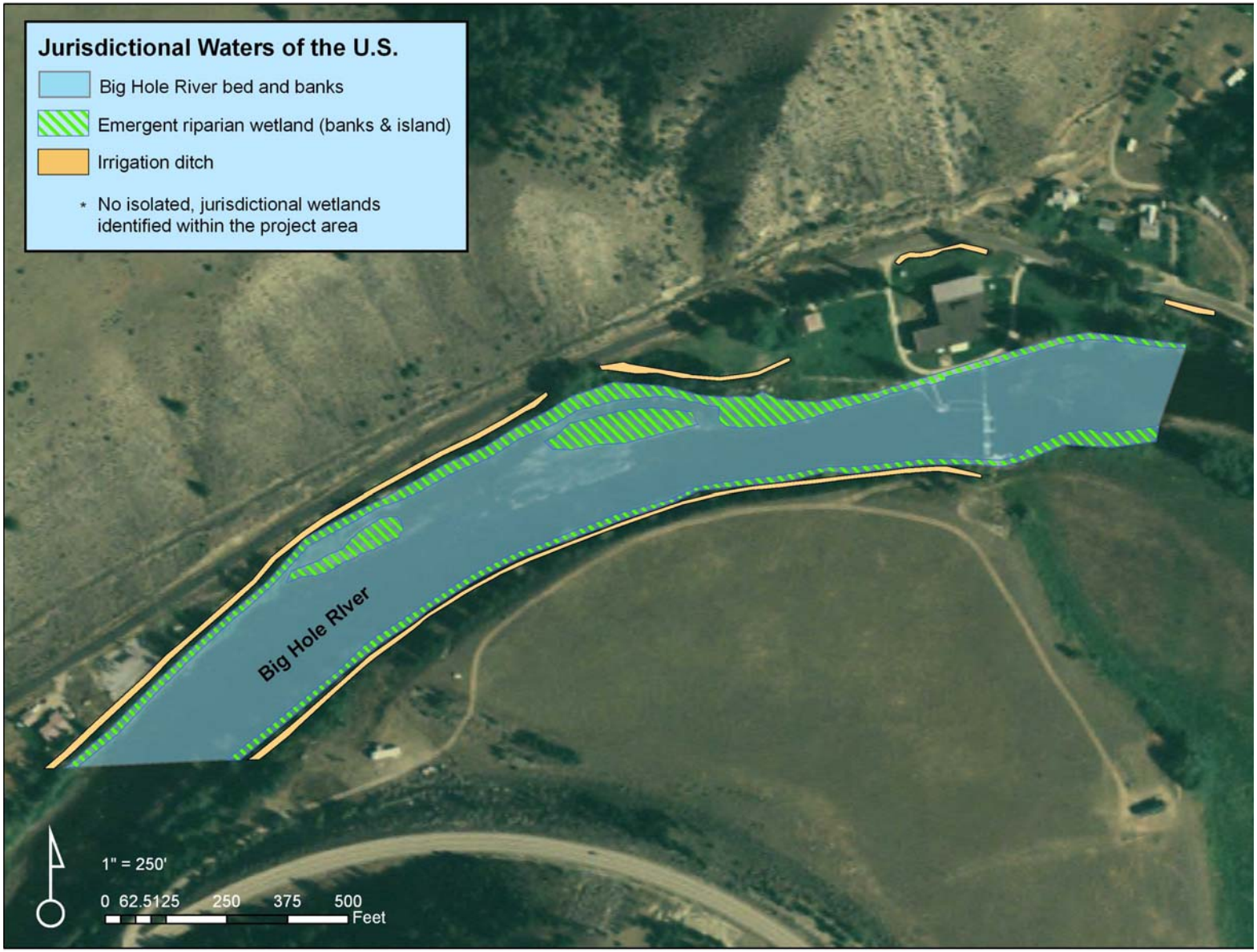


Figure 3. Waters of the U.S. identified within the project area.

6 Fisheries

6.1 Existing fisheries data for the Big Hole River

The Big Hole River is considered a “Blue Ribbon” trout stream due to its superb recreational fishing opportunities. Fish present within the Big Hole River include brook, brown, rainbow, and Westslope cutthroat trout, Arctic grayling, mountain whitefish, burbot, longnose dace, longnose sucker, white sucker, mountain sucker, and mottled sculpin. The Montana Fisheries Information System (MFISH) provides data on fish distribution, fisheries resource value, dewatered concern areas, and instream flow protection on rivers throughout the state. The MFISH database assigns upstream and downstream endpoints based on river stationing beginning at the mouth of the river (river mile 0.0 is at the confluence of the Big Hole River with the Jefferson River; river mile 153.1 is the upstream extent of the Big Hole River). The Big Hole Dam and Intake Facility are located at river mile 54.1. The information contained in Table 3 through Table 6 summarizes fisheries information pertaining to the Big Hole River within the vicinity of the Big Hole Dam.

Table 3. Fish distribution data for the Big Hole River in the vicinity of river mile 54.1

Begin Mile	End Mile	Species	Abundance	Use Type	Origin
0	56.5	Arctic Grayling*	Rare	Year-round resident	Native
56.5	115	Arctic Grayling*	Common	Year-round resident	Native
0	63	Brook Trout	Rare	Year-round resident	Introduced
63	95	Brook Trout	Common	Year-round resident	Introduced
0	81.4	Brown Trout	Abundant	Year-round resident	Introduced
0	73.6	Burbot	Common	Year-round resident	Native
0	153	Longnose Dace	Common	Year-round resident	Native
0	153	Longnose Sucker	Common	Year-round resident	Native
0	153	Mottled Sculpin	Common	Year-round resident	Native
0	153	Mountain Sucker	Rare	Year-round resident	Native
0	143.4	Mountain Whitefish	Abundant	Year-round resident	Native
6.2	86.7	Rainbow Trout	Abundant	Year-round resident	Introduced
54.9	68.8	Westslope Cutthroat Trout*	Rare	Unknown	Native
61.5	68.7	Westslope X Rainbow	Rare	Unknown	Unknown
0	89.3	White Sucker	Common	Year-round resident	Native

*** State Species of Special Concern**

Table 4. Fisheries Resource Value for the Big Hole river in the vicinity of river mile 54.1

Begin Mile	End Mile	Sport Class	Habitat Class	Final Rating
0	71.3	1	2	Outstanding (1)

Table 5. Dewatered Concern Areas along the Big Hole river in the vicinity of river mile 54.1

Begin Mile	End Mile	Level of Concern	Lower Bound	Upper Bound
24.4	105.5	Periodic Dewatering	Glen Bridges	Swamp Creek

Table 6. Instream Flow Protection/Quantification for the Big Hole River in the vicinity of river mile 54.1

Section: DIVIDE CR to PINTLAR CR **Type:** Water Reservation Granted **River Miles:** 49.9 to 94.5			
Begin Date	**End Date**	**Flow (CFS)**	**Priority Date**
01 / 01	12 / 31	800	07/01/1985

The Big Hole River contains two state species of special concern within the vicinity of the Big Hole Dam, including Arctic grayling and Westslope cutthroat trout. No threatened or endangered fish species exist within the Big Hole River. Montana Fish, Wildlife, and Parks has an instream flow protection of 800 cfs in the Big Hole River year-round. No water leases or protected areas are in effect on any portion of the Big Hole River.

6.2 Fish Passage

The existing intake and diversion facility includes a concrete dam approximately 10 feet wide at the base, which rises five feet above the bed of the river and spans 190 feet, the entire width of the river. The dam includes a series of gates across the face, which enables control of the water level upstream via placement of boards within the gates. Water levels are typically kept at the maximum height of the dam to ensure the pumps have adequate submergence. An apron was constructed along the downstream side of the dam, and is approximately 12 feet wide.

When considering fish passage at structural facilities, three aspects of fish swimming speeds may be considered. 1) cruising speed – a speed that can be maintained for long periods of time (hours); 2) sustained speed – a speed that can be maintained for minutes; and 3) darting speed – a single, bursting effort, not sustainable. Fish passage may be restricted if water velocities in the vicinity of in-stream structures exceed the sustained speed of a particular fish species.

Table 7 indicates cruising, sustained, and darting speeds for adult fish that are known to exist within the project area (Bell, 1990)[1]. It is assumed each of these species will attempt to pass upstream of the dam during seasonal migrations. No data for rainbow trout were available in this study; however, it is assumed rainbow trout have similar swimming speeds as brown and cutthroat trout. Based on these data, fish passage will be achievable for trout and grayling when water velocities at the dam are below 6 feet/sec; and below 4 cfs for whitefish. These data support Montana Fish, Wildlife and Parks' conclusion that fish passage is restricted at velocities which exceed 6 fps.

Table 7. Swimming speeds for adult fish found in the Big Hole River (from Bell, 1990)

Species	Cruising speed (ft/sec)	Sustained speed (ft/sec)	Darting speed (ft/sec)
Cutthroat trout	2	6	14
Brown trout	2	7	13
Grayling	2	7	14
Whitefish	1	4	9

1. Bell, M.C. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria. Fish Passage Development and Evaluation Program 1991. U.S. Army Corps of Engineers North Pacific Division. 3rd Edition.

Passage above the dam may also be limited by fish size. While larger, stronger fish may be capable of successfully jumping over or swimming past the dam crest, younger and smaller size classes may not. The swimming speeds of fish in Table 7 are for adult trout and whitefish, which typically reach maturity at 3 years. Therefore, the presence of the dam could additionally limit passage by age classes <3 years during higher flows. During these flows, passage may be capable only to the largest age classes.

Seasonal behavior of grayling and trout includes upstream migration during spawning periods. Spawning habitat has been documented in many tributary streams and upper reaches of the mainstem Big Hole River above the Big Hole Dam. Fish species that spawn during spring months (April-June) include Arctic grayling, rainbow trout, and cutthroat trout. These species may incur a barrier to upstream movement at the Big Hole Dam during spawning migrations which can overlap with high flow events during spring runoff. Species which spawn in the fall include brown and brook trout, which may incur a barrier to upstream movement at the dam during periods of low flow (September-November) due to the height of the dam as compared to jumping heights of fish.

6.3 Passage barriers as management tools

Fish passage barriers are increasingly being utilized by fisheries managers to protect the genetic integrity of native species. Genetically pure populations of Westslope cutthroat trout currently exist in headwater and tributary streams upstream of the Big Hole Dam. The placement or maintenance of passage barriers at strategic locations within the watershed may aid in protecting the genetic integrity of cutthroats from introgression by rainbow trout. Barriers may also restrict colonization by non-native species such as brown and brook trout, which may out-compete native cutthroat trout and grayling in overlapping habitats. However, maintenance of the existing dam as a passage barrier would not be an effective strategy for protecting cutthroat genetics or preventing non-native species from inhabiting the upper portions of the river, as these non-natives have already colonized upstream of the dam. Brown trout and rainbow trout have been documented well upstream of the Big Hole Dam; as such, removal of the dam will not “open the gates” to upstream migration of these species to areas where they do not currently exist. Removal of the dam will provide year-round passage opportunities for all fish, both native and non-native, to reaches of the Big Hole River upstream of the dam.

7 Wildlife

The Big Hole Dam lies within an area that is diverse in wildlife habitat. The dam and intake facility are located within a transitional area of the Big Hole River as it exits a canyon and enters a broader valley. The facility lies at the foot of the Pioneer Mountains, which provide habitat for several big-game species including whitetail deer, mule deer, moose, and elk. The facility lies adjacent to dry, upland habitats, suitable for mountain lion, coyotes, red fox, bobcats, black bear, and upland birds such as Hungarian partridge and ruffed grouse. Birds of prey, including owls, hawks, eagles, and osprey are commonly found within the area. The site lies within the riparian zone of the river, which provides habitat for several species of migratory songbirds and mammals such as otter, beaver, and muskrat. Several species of waterfowl utilize the river corridor for feeding, nesting, and migration.

The Montana Natural Heritage Program database identifies three mammals, two birds, and one amphibian as species of special concern within the vicinity of the project area. Table 8 includes global rank, state rank, and agency status of each species. No evidence of these species was noted during the site investigation, although this does not discount the potential of these species inhabiting the project area.

Table 8. Wildlife species of special concern in the vicinity of the project area (MT Natural Heritage Program database).

Species	Global Rank	State Rank	USFWS status	USFS status	BLM status
Mammals					
Gray Wolf (*Canis lupus*)	G4	S3	DM	Sensitive	Sensitive
Wolverine (*Gulo gulo*)	G4	S3		Sensitive	Sensitive
Canada Lynx (*Lynx canadensis*)	G5	S3	LT	Threatened	Special Status
Birds					
Northern Goshawk (*Accipiter gentilis)*	G5	S3			Sensitive
Brewer's Sparrow (*Spizella breweri*)	G5	S3B			Sensitive
Amphibians					
Western Toad (*Bufo boreas*)	G4	S2		Sensitive	Sensitive

S1 At high risk because of extremely limited and/or rapidly declining population numbers, range, and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.
S2 At risk because of very limited and/or potentially declining population numbers, range, and /or habitat, making it vulnerable to global extinction or extirpation in the state
S3 Potentially at risk because of limited and/or declining numbers, range and/or habitat, may be abundant in some areas.
S4 Apparently secure, thought it may be quite rare in parts of its range, and/or suspected to be declining.
S5 Demonstrably secure, though it may be quite rare in parts of its range
B Breeding – Rank refers to the breeding population of the species in Montana.

8 Project Impacts and Mitigation

DOWL HKM Engineering has developed a series of design options to address structural and functional issues at the existing facility. With the exception of the "Do Nothing" approach (Option 1), each option will result in both temporary and permanent impacts to natural resources within the project area. This section includes a description of anticipated impacts to vegetation, wildlife, and fisheries, as well as quantified areas of impacts within regulated Waters of the U.S. Finally, this section includes a discussion on potential mitigation requirements resulting from the projected impacts.

8.1 Temporary Impacts Within Regulated Areas

Impacts within regulated Waters of the U.S. that are considered temporary include the installation of intake pipes along the north bank of the river. Temporary impacts in regulated areas were identified where sections of pipe will be buried within the delineated boundary of the Big Hole River. This activity will result in the temporary removal of riparian vegetation along the bank during placement of the pipes. Once these intake pipes are buried, the affected area will regenerate with vegetation along the river bank. The impact area was calculated by multiplying the length of pipe section by a standard trench width of 8 feet. Areas of temporary impacts in regulated areas for each option are included in Table 9.

Table 9. Area of projected temporary impacts in regulated Waters of the U.S.

Temporary Impacts		Units	Option 1	Option 2	Option 3	Option 4	Option 5
Regulated Areas (Waters of the U.S.)	Intake pipes and walls	sq. ft.	-	-	229	922	544
		acres	-	-	0.01	0.02	0.01

8.2 Temporary Impacts Within Non-Regulated Areas

Temporary impacts that are anticipated within non-regulated areas include a staging area, installation of intake pipes to the pump house, and buried riprap. The staging area is required for storing equipment, materials, and vehicles during construction. The staging area will occur to the south of the project area on the terrace above the river. The terrace currently has an access road to the dam; however, the staging area would temporarily disturb an additional 1/2 acre of arid, sage brush habitat. This area would be reclaimed following the project's completion. The installation of intake pipes will temporarily disturb the existing vegetation along an 8' trench width. Option #5 includes burying riprap along the north bank outside of the delineated high water mark of the Big Hole River to secure the new dam structure. Areas of temporary impact within non-regulated areas are included in Table 10.

Table 10. Areas of projected temporary impacts in non-regulated areas.

Temporary Impacts		Units	Option 1	Option 2	Option 3	Option 4	Option 5
Non-Regulated Areas	Staging Area	sq. ft.	-	21,760	21,760	21,760	21,760
		acres	-	0.50	0.50	0.50	0.50
	Intake pipes	sq. ft.	-	1,618	4,728	3,947	3,277
		acres	-	0.04	0.11	0.09	0.08
	Buried riprap	sq. ft.	-	-	-	-	1,072
		acres	-	-	-	-	0.02
	Total	**sq. ft.**	**-**	**23,378**	**26,488**	**25,707**	**26,109**
		acres	**-**	**0.54**	**0.61**	**0.59**	**0.60**

8.3 Permanent Impacts Within Regulated Areas

With the exception of the "Do Nothing" approach, each proposed option will result in permanent impacts that lie within regulated Waters of the U.S. These impacts include permanent removal of riparian vegetation along the north and south river banks, placement of fill over an island which exhibits emergent riparian vegetation, and placement of fill within the active river bed. None of the proposed options will affect irrigation ditches along either side of the river. No isolated, jurisdictional wetlands occur within the project area; therefore, no regulated wetlands will be affected by any of the proposed options. The area of permanent impacts within regulated areas for each option is included in Table 11, and are discussed in subsections 8.5 through 8.9.

8.4 On-Site Mitigation

Options #2-5 include the removal of the existing dam and stilling basin walls, which lie within regulated Waters of the U.S. As a result, the associated footprints of the dam and stilling basin can be utilized as on-site mitigation to offset anticipated permanent impacts. The area of eligible on-site mitigation is constant for all options which propose to remove the existing dam, and are included in Table 11. Permanent project impacts proposed within regulated areas that exceed the area of on-site mitigation will need additional, off-site mitigation (indicated by the net area of permanent impacts at the bottom of Table 11). Final areas and specific types of mitigation required will be determined by the U.S. Army Corps of Engineers

Table 11. Anticipated Permanent Impacts in Regulated Areas and On-Site Mitigation Area

Impacts in Regulated Areas			Option 1	Option 2	Option 3	Option 4	Option 5
Jurisdictional Wetlands		(sq.ft.)	** No Jurisdictional Wetlands In Project Area				
		(acre)					
Waters of the U.S.	Emergent Riparian Veg on North Bank	(sq.ft.)	No Impact	1,304	3,155	2,885	6,028
		(acre)		0.03	0.07	0.07	0.14
	Emergent Riparian Veg on South Bank	(sq.ft.)		656	2,464	2,465	3,906
		(acre)		0.02	0.06	0.05	0.09
	Emergent Riparian Veg on Island	(sq.ft.)		-	-	-	2,886
		(acre)		-	-	-	0.07
	River Bed	(sq.ft.)		4,211	48,665	49,008	44,311
		(acre)		0.10	1.12	1.13	1.02
Gross Area of Impacts In Regulated Areas		**(sq.ft.)**	**-**	**6,171**	**54,284**	**54,358**	**57,131**
		(acre)	**-**	**0.15**	**1.25**	**1.25**	**1.31**
On-Site Mitigation			**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Removal of Existing Dam		(sq.ft.)	No Removal	**4165**			
		(acre)		0.10			
Removal of Stilling Basin		(sq.ft.)		2480			
		(acre)		0.06			
Total		**(sq.ft.)**	**-**	**6645**			
		(acre)	**-**	**0.16**			
Net Area of Permanent Impacts (Gross Impact) - (On Site Mitigation)		**(sq.ft.)**	No Impacts	**-474**	**47,639**	**47,713**	**50,486**
		(acre)		**-0.01**	**1.09**	**1.09**	**1.15**

8.5 Option 1 - Do Nothing

This option would result in no natural resource impacts within the project reach. Existing riparian and upland vegetation, soils, wildlife and fisheries habitat, and jurisdictional wetlands and waterways would not be affected. The existing dam would remain a partial fish passage barrier and safety hazard for boaters and maintenance personnel. No compensatory mitigation would be required as a result of this option.

8.6 Option 2 - Replace in Kind

This option includes constructing a new dam in the vicinity of the existing dam to replace the degraded structure. In order to reduce overall project cost, this option would include no alterations to improve fish and boater passage across the dam, and would use as much of the existing facility as possible.

Impacts to Vegetation
Construction of the new dam would include the use of large rock or concrete to tie the newly constructed dam into the stream banks. The use of riprap or concrete in these locations is necessary for structural stability of the dam, and would result in the permanent removal of approximately 1960 sq. ft. (0.05 acres) of riparian vegetation on the river banks.

Impacts to Wildlife
Removal of riparian vegetation as a result of constructing the new dam is the primary impact to wildlife utilizing riparian habitats. The removal of 1960 sq. ft. (0.05 ac) of riparian vegetation will reduce the use of this area by migratory birds and other species which utilize riparian habitats.

Impacts to Fishery
In-kind replacement of the dam will maintain the existing fish passage and boater safety issues. The existing dam creates a backwater pool upstream, which provides important habitat for fish. The proposed option includes positioning the new dam approximately 160 feet upstream of the existing dam, and will be nearly 1 foot higher than the existing dam. Constructing this new dam will create a backwater pool which extends further upstream of the current pool; however, it is unlikely that overall pool size and habitat quality will be affected by moving the dam upstream of its current location.

Construction activities may temporarily increase turbidity in the Big Hole River; however, control measures such as dewatering and/or diverting water away from active construction activity should minimize increases in turbidity. Replacement of the stilling basin with a screened intake may reduce fish losses, as the existing intake structure is not screened to prevent fish entrainment. Future design phases should attempt to incorporate intake system hydraulics and screen mesh sizes to prevent fish losses.

Impacts to Regulated Waters of the U.S.
The construction of a new dam would include the permanent placement of 6,170 sq. ft (0.15 ac) of rock riprap, grouted rock and/or concrete within regulated Waters of the U.S. Areas affected by these impacts include emergent riparian vegetation along the north and south river banks and the existing river bed (Table 11).

Mitigation for Option #2
On-site mitigation credit is available for the removal of concrete and rock across the river and the material used to tie the dam into the banks. Reclamation of the riverbed, both banks, and

the stilling basin would total approximately 6,645 sq. ft. of mitigation (Table 11). The footprint of the new dam is less than equivalent to the in-kind mitigation potential for removing the existing dam. As a result, no additional compensatory mitigation should be required for this option.

8.7 Option 3 - Modify existing facility with measures to allow fish and boater passage

This option includes the installation of a notched rock spillway and rock drop structure to improve boater safety and fish passage through the dam. The new structure will include gradual steps to provide the change in elevation necessary to maintain the pool height while providing safe passage for boats and fish.

Impacts to Vegetation
Construction of the modified dam would include the use of large rock or concrete to tie the structure into the stream banks. The use of riprap or concrete in these locations is necessary for structural stability of the dam, and would result in the permanent removal of approximately 5619 sq. ft. (0.13 acres) of riparian vegetation on the river banks.

Impacts to Wildlife
The removal of riparian vegetation as a result of keying structures into the stream banks is the primary impact to wildlife which utilize these portions of the project area. Approximately 5,619 sq. ft (0.13 ac) of riparian vegetation will be permanently removed, and will no longer be available habitat to species utilizing riparian habitats.

Impacts to Fishery
This option will modify the dam to improve fish passage by gradually stepping the drop in water elevation downstream of the dam. This will allow for smaller fish to pass over the dam due to shorter jumping heights, as well as reducing the water velocity across the dam crest. Fish passage will be improved during all times of the year as a result of improved hydraulics. Providing fish passage will allow trout, grayling, suckers, burbot, and whitefish to freely move throughout this portion of the Big Hole watershed, whereas the existing dam may prevent fish passage to spawning and rearing habitats. The re-establishment of fish passage at the Big Hole Dam is considered a significant benefit to fish populations utilizing this portion of the watershed.

Under this option, the new dam structure will be set approximately 145 feet upstream of the existing dam. The crest of the new dam will be at nearly the same elevation as the existing dam, and will maintain a backwater pool upstream of the new dam crest. The length of the existing backwater pool will be shortened by 145 feet (approximately 20% of the existing pool length), which is equivalent to the distance between the existing dam and the proposed location of the new dam.

Modification of the existing dam will include placing grouted rock within the channel. The use of large stone within these areas will create aquatic features which may attract fish due to increased habitat complexity. Conversely, the use of large stone will replace native bed materials which currently provide habitat for macroinvertebrates, a key source of food for fish. Overall, the conversion of native bed materials to large stone, when combined with the creation of fish passage and screened intake, is considered a significant improvement as compared to existing conditions for fish.

Construction activities may temporarily increase turbidity in the Big Hole River; however, control measures such as dewatering and/or diverting water away from active construction activity should minimize increases in turbidity.

Impacts to Regulated Waters of the U.S.
Modifying the existing dam as proposed would include the permanent placement of rock riprap, grouted rock and/or concrete within regulated Waters of the U.S. Affected areas would include approximately 5,619 sq. ft (0.13 ac) of emergent vegetation along the river banks and 48,665 sq. ft. (1.12 ac) of river bed (Table 11). Total gross impacts within Waters of the U.S. are 54,284 sq. ft. (1.25 ac)

Mitigation for Option #3
This option aims to utilize the existing site as much as possible and would place the new rock drops in the area of the existing dam. The existing dam and concrete walls associated with the stilling basin would be removed and count toward mitigation for the projected impacts resulting from construction of the new dam. The total area occupied by the existing dam and the associated concrete walls is approximately 6,645 sq. ft (0.16 ac). The gross area of impacts within regulated Waters of the U.S. total 54,284 sq. ft. (1.25 ac). The resulting net area of permanent impacts in regulated Waters of the U.S. is 47,639 sq. ft. (1.09 acres).

The net area of permanent impacts within regulated Waters of the U.S. exceeds the standard threshold of 0.1-acre for requiring mitigation. As a result, 1.09 acres of mitigation would likely be required to compensate for projected impacts. Mitigation for the removal of riparian vegetation could include off-site riparian enhancement measures such as cottonwood and willow planting, or livestock fencing in sensitive riparian areas. Mitigation for fill within the Big Hole River could include river and tributary habitat restoration projects or spawning habitat enhancement projects. Montana Fish, Wildlife and Parks, the U.S. Fish and Wildlife Service, and the Big Hole Watershed Committee are entities currently involved in many restoration and enhancement projects in the Big Hole Watershed, and may be resources for identifying applicable mitigation projects. Final mitigation requirements will be determined by the Army Corps.

8.8 Option 4 – Modify existing facility with improved boater and fish passage and utilize existing pool feature

Option 4 has been designed to provide safe boater and fish passage and to utilize the pool feature upstream of the dam as part of the intake system. As in Option #3, both the dam and stilling basin would be removed with this option. Option #4 includes the addition of River Tee screens upstream of the dam with a secondary intake system, also upstream of the new dam.

Impacts to Vegetation
Construction of the modified dam would include the use of large rock or concrete to tie the structure into the stream banks. The use of riprap or concrete in these locations is necessary for structural stability of the dam, and would result in the permanent removal of approximately 5,350 sq. ft. (0.12 acres) of riparian vegetation on the river banks.

Impacts to Wildlife
The removal of riparian vegetation as a result of keying structures into the stream banks is the primary impact to wildlife which utilize these portions of the project area. Approximately 5,350 sq. ft (0.12 ac) of riparian vegetation will be permanently removed, and will no longer be available habitat to species utilizing riparian habitats.

Impacts to Fishery
Option #4 will modify the dam to improve fish passage. This option will improve fish passage by gradually stepping the drop in water elevation downstream of the dam. This will allow for

smaller fish to pass over the dam due to shorter jumping heights, as well as reducing the water velocity across the dam crest. Fish passage will be improved during all times of the year as a result of improved hydraulics. Providing fish passage will allow trout, grayling, suckers, burbot, and whitefish to freely move throughout this portion of the Big Hole watershed, whereas the existing dam may prevent fish passage to spawning and rearing habitats. The re-establishment of fish passage at the Big Hole Dam is considered a significant benefit to fish populations utilizing this portion of the watershed.

Under Option #4, the new dam structure will be set approximately 145 feet upstream from the existing dam. The crest of the new dam will be at nearly the same elevation as the existing dam, and will maintain a backwater pool upstream of the new dam crest. The length of the existing backwater pool will be shortened by 145 feet (approximately 20% of the existing pool length), which is equivalent to the distance between the existing dam and the proposed location of the new dam.

Modification of the existing dam will include placing grouted rock within the channel. The use of large stone within these areas will create aquatic features which may attract fish due to increased habitat complexity. Conversely, the use of stone will replace native bed materials which currently provide habitat for macroinvertebrates, a key source of food for fish. Overall, the conversion of native bed materials to large stone, when combined with the creation of fish passage, is considered a significant improvement as compared to existing conditions for fish.

Construction activities may temporarily increase turbidity in the Big Hole River; however, control measures such as dewatering and/or diverting water away from active construction activity should minimize increases in turbidity.

Impacts to Regulated Waters of the U.S.
Modifying the existing dam and intake facilities as proposed in Option #4 would include the permanent placement of rock riprap, grouted rock and/or concrete within regulated Waters of the U.S. Affected areas would include approximately 5,350 sq. ft (0.12 ac) of emergent vegetation along the river banks and 49,008 sq. ft. (1.13 ac) of river bed (Table 11). Total gross area of permanent impacts in Waters of the U.S. under this option is 54,358 sq. ft. (1.25 ac).

Mitigation for Option #4
This option would place the new rock drops in the area of the existing dam. The existing dam and concrete walls associated with the stilling basin would be removed and count toward mitigation of the projected permanent impacts. The total area occupied by the existing dam and the associated concrete walls is approximately 6,645 sq. ft (0.16 ac). The gross area of impacts within regulated Waters of the U.S. total 54,358 sq. ft. (1.25 ac). The resulting net area of permanent impacts in regulated Waters of the U.S. is 47,713 sq. ft. (1.09 acres).

The net area of permanent impacts within regulated Waters of the U.S. exceeds the standard threshold of 0.1-acre for requiring mitigation. As a result, the equivalent of 1.09 acres of mitigation would likely be required to compensate for projected impacts. Mitigation for the removal of riparian vegetation could include off-site riparian enhancement measures such as cottonwood and willow planting, or livestock fencing in sensitive riparian areas. Mitigation for fill within the Big Hole River could include river and tributary habitat restoration projects or spawning habitat enhancement projects. Montana Fish, Wildlife and Parks, the U.S. Fish and Wildlife Service, and the Big Hole Watershed Committee are entities currently involved in many restoration and enhancement projects in the Big Hole Watershed, and may be resources for identifying applicable mitigation projects. Final mitigation requirements will be determined by the Army Corps.

8.9 Option 5 - Replace facility with a new dam and intake facility upstream of the existing structure

Option 5 includes the construction of a new dam with drop pool features to allow for improved boater and fish passage. The new facility would be moved approximately 450 feet upstream of the existing dam to allow for improved pump efficiency.

Impacts to Vegetation
Construction of the modified dam would include the use of large rock or concrete to tie the structure into the stream banks. The use of riprap or concrete in these locations is necessary for structural stability of the dam and new intake structure, and would result in the permanent removal of approximately 9,934 sq. ft. (0.23 acres) of riparian vegetation on the river banks. The increase in impact to riparian vegetation as compared to options #2 and #3 are due to the location of the dam further upstream, where there are currently no existing walls along the north or south banks.

Impacts to Wildlife
The removal of riparian vegetation as a result of keying structures into the stream banks is the primary impact to wildlife which utilize these portions of the project area. Approximately 9,934 sq. ft (0.23 ac) of riparian vegetation will be permanently removed, and will no longer be available habitat to species utilizing riparian habitats.

Impacts to Fishery
As in Options #3 and #4, Option #5 will be designed specifically to improve fish passage. This option will modify the dam to improve fish passage by gradually stepping the drop in water elevation downstream of the dam. This will allow for smaller fish to pass over the dam due to shorter jumping heights, as well as reducing the water velocity across the dam crest. Fish passage will be improved during all times of the year as a result of improved hydraulics. Providing fish passage will allow trout, grayling, suckers, burbot, and whitefish to freely move throughout this portion of the Big Hole watershed, whereas the existing dam may prevent fish passage to spawning and rearing habitats. The re-establishment of fish passage at the Big Hole Dam is considered a significant benefit to fish populations utilizing this portion of the watershed.

Option #5 includes placing the new dam approximately 630 feet upstream of the existing dam. The new dam crest will be 1.1 feet higher than the existing dam crest, and will create a backwater pool which extends further upstream from the existing backwater pool feature. The increase in crest elevation as compared to the existing dam will maintain equivalent, important habitat upstream of the new dam.

The proposed structure in Option #5 includes placing grouted rock and riprap within the channel. The use of large stone within these areas will create aquatic features which may attract fish due to increased habitat complexity. Conversely, the use of stone will replace native bed materials which currently provide habitat for macroinvertebrates, a key source of food for fish. Overall, the conversion of native bed materials to large stone, when combined with the creation of fish passage, is considered a improvement as compared to existing conditions for fish.

Construction activities may temporarily increase turbidity in the Big Hole River; however, control measures such as dewatering and/or diverting water away from active construction activity should minimize increases in turbidity.

Impacts to Regulated Waters of the U.S.
Reconstructing the dam and intake facilities as proposed in Option #5 would include the permanent placement of rock riprap, grouted rock and/or concrete within regulated Waters of the U.S. Affected areas would include approximately 9,934 sq. ft (0.23 ac) of emergent vegetation along the river banks, 2,886 sq. ft. (0.07 ac) of emergent vegetation on an island upstream of the existing dam, and 44,311 sq. ft. (1.02 ac) of river bed (Table 11). Total gross area of permanent impacts in Waters of the U.S. under this option is 57,131 sq. ft. (1.31 ac), and constitutes the greatest area of projected impacts of the five options.

Mitigation for Option #5
Option #5 includes the removal of the existing dam and stilling basin. This activity will result in a total of 6,645 sq. ft. (0.16 ac) of on-site mitigation to offset the footprint impact of the proposed new dam and intake facility. The proposed footprint for Option #5 is 57,131 sq. ft. (1.31 ac), which, when reduced for on-site mitigation, results in a net impact area of 50,486 sq. ft. (1.16 ac).

The net area of permanent impacts within regulated Waters of the U.S. exceeds the standard threshold of 0.1-acre for requiring mitigation. As a result, the equivalent of 1.16 acres of mitigation would likely be required to compensate for projected impacts. Mitigation for the removal of riparian vegetation could include off-site riparian enhancement measures such as cottonwood and willow planting, or livestock fencing in sensitive riparian areas. Mitigation for fill within the Big Hole River could include river and tributary habitat restoration projects or spawning habitat enhancement projects. Montana Fish, Wildlife and Parks, the U.S. Fish and Wildlife Service, and the Big Hole Watershed Committee are entities currently involved in many restoration and enhancement projects in the Big Hole Watershed, and may be resources for identifying applicable mitigation projects. Final mitigation requirements will be determined by the Army Corps.

8.10 Compensatory Mitigation Ratios and Options

No mitigation would be required if Option 1 or 2 was implemented. As Option 2 includes the in-kind replacement of the existing structure, this project would be permitted as a Nationwide Permit 3 and include the maintenance, repair, rehabilitation, or replacement of previously authorized structures. The net increase in footprint impacts of Options 3, 4, and 5 would likely require compensatory mitigation to offset the additional impacts of the proposed structures. Table 12 lists the potential ratios for each type of compensatory mitigation. Each mitigation type may be used in conjunction with each other to maximize mitigation potential within the project area. In general, mitigation completed prior to any anticipated impacts are generally a 1:1 ratio (Column 1 in Table 12), meaning that one square foot compensatory wetlands will be required for each square foot of proposed impact. If mitigation is completed at the same time (Column 3 in Table 12), or after the impact, mitigation ratios vary and may range from 1.5:1 to 5:1, depending on the quality of wetland impacted and the type of compensatory mitigation proposed. Final negotiations with the Army Corps will be required to determine the actual compensatory mitigation required for each option.

Table 12. Wetland Compensatory Mitigation Ratios, Montana Regulatory Program

Mitigation Completed Prior to Project	Compensatory Mitigation Type	Mitigation Completed Simultaneously or After Project
1:1	Restoration (Re-establishment)	1.5:1
1.5:1	Restoration (Rehabilitation)	2:1
1:1	Creation (Establishment)	2:1
3:1	Enhancement	4:1
4:1	Preservation (Protection)	5:1
5:1	Upland Buffer	

Potential compensatory mitigation options for impacts to the riparian corridor and river bed include the enhancement of the existing riparian corridor along the Big Hole River, preservation of the existing riparian areas through a conservation easement, and/or establishing an upland buffer. Potential wetland mitigation options, if desired by the Army Corps include a constructed wetland, expansion of an existing wetland, or incorporating project impacts to a wetland mitigation bank. The potential for off-site mitigation may be an option if a suitable mitigation site is identified within the watershed or service area of the proposed impacts. The mitigation ratios, however, may increase with distance from the impact site. Coordination with the regulatory agencies is necessary to determine the applicability of an off-site mitigation option.

8.11 Bioengineering Alternatives to Riprap

Bioengineered bank treatments have become a viable alternative to the use of large stone and rock structures for stabilizing river banks. Bioengineering techniques aim to use native materials such as soil lifts, biodegradable fabric, and dense vegetation to stabilize eroding banks and to either slow or prevent lateral movement of stream banks. These techniques have been used successfully in many projects across Montana as a softer approach to the traditional use of riprap.

The use of bioengineered banks was considered in Options 2-5 in areas where large rock, stone, grouted stone or concrete is proposed along the banks of the Big Hole River. Upon consideration of these techniques, it was noted that all proposed hardened rock features are designed to permanently secure the structural components of the dam, drop structures, and intake pipe walls to the river's bed and banks. It is critically important that each of these structures is permanently secured in place to meet the project's maintenance and operational objectives. As a result, the use of bioengineered river banks was determined an inappropriate technique for each of the options selected.

Appendix A – Wetland Functional Assessment Form

MDT Montana Wetland Assessment Form (revised 5/25/1999)

1. Project Name: Big Hole Diversion Dam EA **2. Project #:** _____ **Control#:**_____

3. Evaluation Date: Mo. August **Day** 4th **Yr.** 2009 **4. Evaluator(s):** Confluence **5. Wetlands/Site #(s):** Riparian

6. Wetland Location(s): i. Legal: T 1S ; R 10W ; S_____; T_____N or S; R_____E or W; S_____
ii. Appprox. Stationing or Mileposts:_____
iii. Watershed: Big Hole **GPS Reference No. (if applies):**_____
Other Location Information:

7. a. Evaluating Agency: Confluence Consulting Inc. **8. Wetland size:** (total acres) ~1/2mile (visually estimated)
b. Purpose of Evaluation:
1. ____Wetlands potentially affected by MDT project
2. ____ Mitigation wetlands; pre-construction
3. ____Mitigation wetlands; post-construction
4. _X_ Other: Wetlands potentially impacted

9. Assessment Area: (AA, tot., ac., see instructions on determining AA) ~10-acre (visually estimated) _____ (measured, e.g. by GPS [if applies])

10. Classification of Wetland and Aquatic Habitats in AA (HGM according to Brinson, first col.; USFWS according to Cowardin [1979], remaining cols.)

HGM Class	System	Subsystem	Class	Water Regime	Modifier	% of AA
Riverine	Riverine	Lower Perennial	Em	G	none	0.17
			RB/UB	H	none	0.78
			AB	H	none	0.05

(Abbreviations: **System**: palustrine (P)/**Subsyst**: none/ **Classes**: rock bottom (RB), unconsolidated bottom (UB, aquatic bed (AB), unconsolidated shore (US), moss-lichen wetland (ML), emergent wetland (EM), scrub-shrub wetland (SS), forested wetland (FO)/ **System**: lacustrine (L) / **Subsyst**: limnetic (2)/ **Classes**: RB,UB, AB,US/ **Subsystem**: littoral (4) **Classes**: RB, UB, AB, US, EM/ **System**: riverine (R) **Subsyst**: lower perennial (2)/ **Classes**: RB, UB, AB, US, EM/ **Subsystem**: upper perennial (3)/ **Classes**: RB, UB, AB, US/ **Water Regime**: permanently flooded (H), intermittently exposed (G), semi-permanently flooded (F), seasonally flooded (C), saturated (B), temporarily flooded (A), intermittently flooded (J)/ **Modifiers**: excavated (e), impounded (I), diked (D), partly drained (PD), farmed (F), artificial (A)/ **HGM Classes**: riverine, depressional, slope, mineral soil flats, organic soil flats, lacustrine fringe.)

11. Estimated relative abundance: (of similarly classified sites within the same Major Montana Watershed Basin, see definitions)
(Circle one) Unknown Rare Common Abundant
Comments:

12. General condition of AA:
i. Regarding disturbance: (use matrix below to determine [circle] appropriate response)

Conditions within AA	*Predominant conditions adjacent to (within 500 feet of) AA*		
	Land managed in predominantly natural state; is not grazed, hayed, logged, or otherwise converted; does not contain roads or buildings.	Land not cultivated, but moderately grazed or hayed or selectively logged; or has been subject to minor clearing; contains few roads or buildings.	AA cultivated or heavily grazed or logged; subject to substantial fill placement, grading, clearing, or hydrological alteration; high road or building density.
AA occurs and is managed in predominantly natural state; is not grazed, hayed, logged, or otherwise converted; does not contain roads or occupied buildings.	Low disturbance	Low disturbance	Moderate disturbance
AA not cultivated, but moderately grazed or hayed or selectively logged; or has been subject to relatively minor clearing, fill placement, or hydrological alteration; contains few roads or buildings.	Moderate disturbance	Moderate disturbance	High disturbance
AA cultivated or heavily grazed or logged; subject to relatively substantial fill placement, grading, clearing, or hydrological alteration; high road or building density.	High disturbance	High disturbance	High disturbance

Comments: (types of disturbance, intensity, season, etc.): Adjacent roads, maintained landscaping, diversion dam
ii. Prominent weedy, alien, & introduced species (including those not domesticated, feral): (list) Oxeye daisy, houndstounge, Canada thistle, common tansy, spotted knapweed

iii. Provide brief descriptive summary of AA and surrounding land use/habitat:
Riparian wetland along banks of Big Hole River, used extensively for recreation (river). Area encompasses diversion dam.

13. Structural Diversity: (Based on number of "Cowardin" **vegetated** classes present [do not include unvegetated classes], see #10 above)

# of "Cowardin" vegetated classes present in AA (see #10)	≥ 3 vegetated classes (or ≥ 2 if one is forested)	2 vegetated classes (or 1 if forested)	≤ 1 vegetated class
Rating (circle)	High	Moderate	Low

Comments: S

SECTION PERTAINING TO FUNCTION & VALUES ASSESSMENT

14A. Habitat for Federally Listed or Proposed Threatened or Endangered Plants or Animals:

i. **AA is documented (D) or suspected (S) to contain** (circle one based on definitions contained in instructions):

Primary or critical habitat (list species) D S _____
Secondary habitat (list species) D S _____
Incidental habitat (list species) D S _____
No usable habitat D **S** _____

ii. **Rating** (use the conclusions from i above and the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, L=low] for this function)

Highest Habitat Level	Doc./primary	Sus./primary	Doc./secondary	Sus./secondary	Doc./incidental	Sus./incidental	None
Functional Points and Rating	1 (H)	.9 (H)	.8 (M)	.7 (M)	.5 (L)	.3 (L)	0 (L)

Sources for documented use (e.g. observations, records, etc.):
Montana Natural Heritage, MFISH

14B. Habitat for plant or animals rated S1, S2, or S3 by the Montana Natural Heritage Program: (not including species listed in 14A above)

i. **AA is documented (D) or suspected (S) to contain** (circle on based on definition contained in instructions):

Primary or critical habitat (list species) D S _____
Secondary habitat (list species) D S _____
Incidental habitat (list species) D **S** Sapphire rockcress, Arctic Grayling
No useable habitat D S _____

ii. **Rating** (use the conclusions from i above and the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function)

Highest Habitat Level	Doc./primary	Sus./primary	Doc./secondary	Sus./secondary	Doc./incidental	Sus./incidental	None
Functional Points and Rating	1 (H)	.8 (H)	.7 (M)	.6 (M)	.2 (L)	.1 (L)	0 (L)

Sources for documented use (e.g. observations, records, etc):
Montana Natural Heritage Program, MFISH

14C. General Wildlife Habitat Rating:

i. **Evidence of overall wildlife use in the AA** (circle substantial, moderate or low based on supporting evidence):

Substantial (based on any of the following [check]):
___ observations of abundant wildlife #'s or high species diversity (during any period)
___ abundant wildlife sign such as scat, tracks, nest structures, game trails, etc.
___ presence of extremely limiting habitat features not available in the surrounding area
___ interviews with local biologists with knowledge of the AA

Low (based on any of the following [check]):
___ few or no wildlife observations during peak use periods
___ little to no wildlife sign
___ sparse adjacent upland food sources
___ interviews with local biologists with knowledge of the AA

Moderate (based on any of the following [check]):
___ observations of scattered wildlife groups or individuals or relatively few species during peak periods
_X_ common occurrence of wildlife sign such as scat, tracks, nest structures, game trails, etc.
___ adequate adjacent upland food sources
___ interviews with local biologists with knowledge of the AA

ii. **Wildlife habitat features** (working from top to bottom, circle appropriate AA attributes in matrix to arrive at exceptional (E), high (H), moderate (M), or low (L) rating. Structural diversity is from #13. For class cover to be considered evenly distributed, vegetated classes must be within 20% of each other in terms of their percent composition of the AA (see #10). Abbreviations for surface water durations are as follows: P/P=permanent/perennial; S/I=seasonal/intermittent; T/E=temporary/ephemeral; and A=absent [see instructions for further definitions of these terms].)

Structural Diversity (see #13)	High								Moderate								Low			
Class cover distribution (all vegetated classes)	Even				Uneven				Even				Uneven				Even			
Duration of surface water in ≥ 10% of AA	P/P	S/I	T/E	A	P/P	S/I	T/E	A	P/P	S/I	T/E	A	P/P	S/I	T/E	A	P/P	S/I	T/E	A
Low disturbance at AA (see #12i)	E	E	E	H	(E)	E	H	H	E	H	H	M	E	H	M	M	E	H	M	M
Moderate disturbance at AA (see #12i)	H	H	H	H	H	H	H	M	H	H	M	M	H	M	M	L	H	M	L	L
High disturbance at AA (see #12i)	M	M	M	L	M	M	L	L	M	M	L	L	M	L	L	L	L	L	L	L

iii. **Rating** (use the conclusions from i and ii above and the matrix below to arrive at [circle] the functional points and rating [E=exceptional, H=high, M=moderate, or L=low] for this function)

Evidence of wildlife use (i)	*Wildlife habitat features rating (ii)*			
	Exceptional	High	Moderate	Low
Substantial	1 (E)	.9 (H)	.8 (H)	.7 (M)
Moderate	.9 (H)	.7 (M)	.5 (M)	.3 (L)
Minimal	.6 (M)	.4 (M)	.2 (L)	.1 (L)

Comments:

14D. General Fish/Aquatic Habitat Rating: (Assess this function if the AA is used by fish or the existing situation is "correctable" such that the AA cold be used by fish [i.e., fish use is precluded by perched culvert or other barrier, etc.]. If the AA is not or was not historically used by fish due to lack of habitat, excessive gradient, etc., circle (NA) here and proceed to the next function. If fish use occurs in the AA but is not desired from a resource management perspective [such as fish use within an irrigation canal], the Habitat Quality [i below] should be marked as "Low", applied accordingly in ii below, and noted in the comments.)

i. **Habitat Quality** (circle appropriate AA attributes in matrix to arrive at exceptional (E), high (H), moderate (M), or low (L) quality rating.

Duration of surface water in AA	Permanent/ Perennial			Seasonal/ Intermittent			Temporary/ Ephemeral		
Cover - % of waterbody in AA containing cover objects such as submerged logs, large rocks & boulders, overhanging banks, floating-leaved vegetation, etc.	>25%	10-25%	<10%	>25%	10-25%	<10%	>25%	10-25%	<10%
Shading - >75% of streambank or shoreline within AA contains riparian or wetland scrub-shrub or forested communities	E	E	H	H	H	M	M	M	M
Shading – 50 to 75% of streambank or shoreline within AA contains rip. Or wetland scrub-shrub or forested communities	H	H	M	M	M	M	M	L	L
Shading - <50% of streambank or shoreline within AA contains rip. Or wetland scrub-shrub or forested communities	H	M	M	M	L	L	L	L	L

ii. **Modified Habitat Quality** (Circle the appropriate response to the following question. If answer is Y, then reduce rating in i above by one level [E=H, H=M, M=L, L=L]). *Is fish use of the AA precluded or significantly reduced by a culvert, dike, or other man-made structure or activity or is the waterbody included on the MDEQ list of waterbodies in need of TMDL development with listed "Probable Impaired Uses" including cold or warm water fishery or aquatic life support?* Y N Modified habitat quality rating = (circle) E H M L

iii. **Rating** (use the conclusions from i and ii above and the matrix below to arrive at [circle] the functional points and rating [E=exceptional, H=high, M=moderate, L=low] for this function)

Types of fish known or suspected within AA	*Modified Habitat Quality (ii)*			
	Exceptional	High	Moderate	Low
Native game fish	1 (E)	.9 (H)	.7 (M)	.5 (M)
Introduced game fish	.9 (H)	.8 (H)	.6 (M)	.4 (M)
Non-game fish	.7 (M)	.6 (M)	.5 (M)	.3 (L)
No fish	.5 (M)	.3 (L)	.2 (L)	.1 (L)

Comments:

14E. Flood Attenuation: (applies only to wetlands subject to flooding via in-channel or overbank flow. If wetlands in AA are not flooded from in-channel or overbank flow, circle **NA** here and proceed to the next function.)

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function.

Estimated wetland area in AA subject to periodic flooding	≥ 10 acres			<10>2 acres			≤ 2 acres		
% of flooded wetland classified as forested, scrub/shrub, or both	75%	25-75%	<25%	75%	25-75%	<25%	75%	25-75%	<25%
AA contains not outlet or restricted outlet	1 (H)	.9 (H)	.6 (M)	.8 (H)	.7 (H)	.5 (M)	.4 (M)	.3 (L)	.2 (L)
AA contains unrestricted outlet	.9 (H)	.8 (H)	.5 (M)	.7 (H)	.6 (M)	.4 (M)	.3 (L)	.2 (L)	.1 (L)

ii. Are residences, businesses, or other features which may be significantly damaged by floods located within 0.5 miles downstream of the AA (circle)? Y (N)

Comments:

14F. Short and Long Term Surface Water Storage: (Applies to wetlands that flood or pond from overbank or in-channel flow, precipitation, upland surface flow, or groundwater flow. If no wetlands in the AA are subject to flooding or ponding, circle **NA** here and proceed with the evaluation.)

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function. Abbreviations for surface water durations are as follows: P/P=permanent/perennial; S/I=seasonal/intermittent; and T/E=temporary/ephemeral [see instructions for further definitions of these terms].)

Estimated maximum acre feet of water contained in wetlands within the AA that are subject to periodic flooding or ponding	>5 acre feet			<5, >1 acre feet			≤ 1 acre foot		
Duration of surface water at wetlands within the AA	P/P	S/I	T/E	P/P	S/I	T/E	P/P	S/I	T/E
Wetlands in AA flood or pond ≥ 5 out of 10 years	1 (H)	.9 (H)	.8 (H)	.8 (H)	.6 (M)	.5 (M)	.4 (M)	.3 (L)	.2 (L)
Wetlands in AA flood or pond < 5 out of 10 years	.9 (H)	.8 (H)	.7 (M)	.7 (M)	.5 (M)	.4 (M)	.3 (L)	.2 (L)	.1 (L)

Comments:

14G. Sediment/Nutrient/Toxicant Retention and Removal: (Applies to wetlands with potential to receive excess sediments, nutrients, or toxicants through influx of surface or ground water or direct input. If no wetlands in the AA are subject to such input, circle NA here and proceed with the evaluation.)

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function.

Sediment, nutrient, and toxicant input levels within AA	AA receives or surrounding land use with potential to deliver low to moderate levels of sediments, nutrients, or compounds such that other functions are not substantially impaired. Minor sedimentation, sources of nutrients or toxicants, or signs of eutrophication present.				Waterbody on MDEQ list of wawterbodies in need of TMDL development for "probably causes" related to sediment, nutrients, or toxicants or AA receives or surrounding land use with potential to deliver high levels of sediments, nutrients, or compounds such that other functions are substantially impaired. Major sedimentation, sources of nutrients or toxicants, or sighns of eutrophication present.			
% cover of wetland vegetation in AA	≥ 70%		< 70%		≥ 70%		< 70%	
Evidence of flooding or ponding in AA	Yes	No	Yes	No	Yes	No	Yes	No
AA contains no or restricted outlet	1 (H)	.8 (H)	.7 (M)	.5 (M)	.5 (M)	.4 (M)	.3 (L)	.2 (L)
AA contains unrestricted outlet	.9 (H)	.7 (M)	.6 (M)	.4 (M)	.4 (M)	.3 (L)	.2 (L)	.1 (L)

Comments:

14H. Sediment/Shoreline Stabilization: (applies only if AA occurs on or within the banks or a river, stream, or other natural or man-made drainage, or on the shoreline of a standing water body which is subject to wave action. If does not apply, circle (NA) here and proceed to next function.)

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [E=exceptional, H=high, M=moderate, or L=low] for this function.

% Cover of wetland streambank or shoreline by species with deep, binding rootmasses	*Duration of surface water adjacent to rooted vegetation*		
	Permanent/ perennial	Seasonal/ Intermittent	Temporary/ Ephemeral
≥ 65%	1 (H)	.9 (H)	.7 (M)
35-64%	.7 (M)	.6 (M)	.5 (M)
< 35%	.3 (L)	.2 (L)	.1 (L)

Comments:

14I. Production Export/Food Chain Support:

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function. Factor A = acreage of vegetated component in the AA; Factor B = Structural diversity rating from #13; Factor C = whether or not the AA contains a surface or subsurface outlet; the final three rows pertain to duration of surface water in the AA, where P/P=permanent/perennial; S/I=seasonal/intermittent; T/E/A=temporary/ephemeral or absent [see instructions for further definitions of these terms].)

A	Vegetated component >5 acres						Vegetated component 1-5 acres						Vegetated Component <1 acre					
B	High		Moderate		Low		High		Moderate		Low		High		Moderate		Low	
C	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
P/P	1H	.9H	.9H	.8H	.8H	.7M	.9H	.8H	.8H	.7M	.7M	.6M	.7M	.6M	.6M	.4M	.4M	.3L
S/I	.9H	.8H	.8H	.7M	.7M	.6M	.8H	.7M	.7M	.6M	.6M	.5M	.6M	.5M	.5M	.3L	.3L	.2L
T/E/A	.8H	.7M	.7M	.6M	.6M	.5M	.7M	.6M	.6M	.5M	.5M	.4M	.5M	.4M	.4M	.2L	.2L	.1L

Comments:

14J. Groundwater Discharge/Recharge: (Check the indicators in i and ii below that apply to the AA)

i. **Discharge Indicators**

____ Springs are known or observed
_X_ Vegetation growing during dormant season/drought
____ Wetland occurs at the toe of a natural slope
_X_ Seeps are present at the wetland edge (irrigation seep)
____ AA permanently flooded during drought periods
____ Wetland contains an outlet, but no inlet
____ Other

ii. **Recharge Indicators**

____ Permeable substrate present without underlying impeding layer
____ Wetland contains inlet but no outlet
____ Other

iii. **Rating:** Use the information from i and ii above and the table below to arrive at [circle] the functional points and rating [H=high, L=low] for this function.

Criteria	*Functional Points and Rating*
AA is known Discharge/Recharge area or one or more indicators of D/R present	1 (H)
No Discharge/Recharge indicators present	.1 (L)
Available Discharge/Recharge information inadequate to rate AA D/R potential	N/A (Unknown)

Comments: Irrigation canal provides seep discharge along bank; however, water not from groundwater seep

14K. Uniqueness:

i. **Rating** (working from top to bottom, use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function.

Replacement potential	AA contains fen, bog, warm springs or mature (>80 yr-old) forested wetland or plant association listed as "S1" by the MNHP			AA does not contain previously cited rare types and structural diversity (#13) is high or contains plant association listed as "S2" by the MNHP			AA does not contain previously cited rare types or associations and structural diversity (#13) is low-moderate		
Estimated relative abundance (#11)	Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Low disturbance at AA (#12i)	1 (H)	.9 (H)	.8 (H)	.8 (H)	.6 (M)	.5 (M)	.5 (M)	.4 (M)	.3 (L)
Moderate disturbance at AA (#12i)	.9 (H)	.8 (H)	.7 (M)	.7 (M)	.5 (M)	.4 (M)	.4 (M)	.3 (L)	.2 (L)
High disturbance at AA (#12i)	.8 (H)	.7 (M)	.6 (M)	.6 (M)	.4 (M)	.3 (L)	.3 (L)	.2 (L)	.1 (L)

Comments:

14L. Recreation/Education Potential: **i. Is the AA a known rec./ed. site:** (circle) Y N (If yes, rate as [circle] High [1] and go to ii; if no go to iii)

ii. **Check categories that apply to the AA:**____Educational/;scientific study;____Consumptive rec.;____Non-consumptive rec.;____Other

iii. **Based on the location, diversity, size, and other site attributes, is there strong potential for rec./ed. use?** Y N (If yes, o to ii, then proceed to iv; if no, then rate as [circle] Low [0.1])

iv. **Rating** (use the matrix below to arrive at [circle] the functional points and rating [H=high, M=moderate, or L=low] for this function)

Ownership	*Disturbance at AA (#12i)*		
	Low	Moderate	High
Public ownership	1 (H)	.5 (M)	.2 (L)
Private ownership	.7 (M)	.3 (L)	.1 (L)

Comments:

FUNCTION & VALUE SUMMARY & OVERALL RATING

Function & Value Variables	**Rating**	**Actual Functional Points**	**Possible Functional Points**	**Functional Units;** (Actual Points*Estimated AA Acreage)
A. Listed/Proposed T&E Species Habitat	L	0	1	
B. MT Natural Heritage Program Species Habitat	L	0.1	1	
C. General Wildlife Habitat	M	0.5	1	
D. General Fish/Aquatic Habitat	H	0.9	1	
E. Flood Attenuation	H	0.9	1	
F. Short and Long Term Surface Water Storage	M	0.4	1	
G. Sediment/Nutrient/Toxicant Removal	H	0.9	1	
H. Sediment/Shoreline Stabilization	H	1	1	
I. Production Export/Food Chain Support	M	0.6	1	
J. Groundwater Discharge/Recharge	N/A	N/A	N/A	
K. Uniqueness	M	0.5	1	
L. Recreation/Education Potential	L	0.3	1	
Totals:		6.1	11	

OVERALL ANALYSIS AREA (AA) RATING: (Circle appropriate category based on the criteria outlined below) **I** **II** **III** **IV**

Category I Wetland: (Must satisfy **one** of the following criteria; if does not meet criteria, go to Category II)
___ Score of 1 functional point for Listed/Proposed Threatened or Endangered Species; **or**
___ Score of 1 functional point for Uniqueness; **or**
___ Score of 1 functional point for Flood Attenuation **and** answer to Question 14E.ii is "yes"; **or**
___ Total actual functional points > 80% (round to nearest whole #) of total possible functional points

Category II Wetland: (Criteria for Category I not satisfied **and** meets any **one** of the following criteria; if not satisfied, go to Category IV)
___ Score of 1 functional point for Species Rated S1,S2, or S3 by the MT Natural Heritage Program; **or**
___ Score of .9 or 1 functional point for General Wildlife Habitat; **or**
___ Score of .9 or 1 functional point for General Fish/Aquatic Habitat; **or**
___ "High" to "Exceptional" ratings for **both** General Wildlife Habitat **and** General Fish/Aquatic Habitat; **or**
___ Score of .9 functional point for Uniqueness; **or**
___ Total Actual Functional Points > 65% (round to nearest whole #) of total possible functional points.

Category III Wetland: (Criteria for Categories I, II, or IV not satisfied)

Category IV Wetland: (Criteria for Categories I or II are not satisfied and all of the following criteria are met; if does not satisfy criteria go to Category III)
___ "Low" rating for Uniqueness; **and**
___ "Low" rating for Production Export/Food Chain Support; **and**
___Total actual functional points < 30% (round to nearest whole #) of total possible functional points

Appendix B – Wetland Delineation Field Data Sheets

WETLAND DETERMINATION DATA FORM – WESTERN MOUNTAINS, VALLEYS, AND COAST REGION

Project Site:	Big Hole Diversion	Date:	8/4/09	Investigator:	Confluence	Plot ID:	North Bank
Do normal circumstances exist on the site?			Yes / No	City/CountyState:	Silver Bow County, MT	Wetland	☒
Is the site significantly disturbed (Atypical Situation?)			Yes / No	Subregion (LRR):	LRR E	Upland	☐
Is the area a Problem Area (if needed, explain on reverse)?			Yes / No	If wetland, community type (NWI):	Emergent, Shrub/scrub riverine		
Landform (hillslope, terrace, etc): sloping river bank				Local relief (concave, convex, none): linear to convex			

VEGETATION

Plant Species	Stratum	Indicator Status	Absolute % Cover Species	Normalized % Cover Species	*D	Plant Species	Stratum	Indicator Status	Absolute % Cover Species	Normalized % Cover Species	*D
Ribes lacustre	S	FAC+	10	10	☐	*Eleocharis rostellata*	H	OBL	45	53	☒
Salix exigua	S	OBL	60	60	☒	*Populus trichocarpa*	T	FAC	50	100	☒
Cornus sericea	S	FACW	20	20	☒						☐
Prunus virginiana	S	FACU	10	10	☐						☐
Glycyrrhiza lepidota	H		30	35	☒						☐
Mentha arvense	H		10	11	☐						☐

*Dominance = % of dominant species that are OBL, FACW, or FAC: 62.5% | Prevalence Index: | Morphological Adaptations:

Remarks: Hydrophytic plant community based on dominance

HYDROLOGY

Recorded Data

☐ Recorded Data Available ☐ Aerial Photos ☐ Stream Gauge ☐ Other ☒ No Recorded Data Available

Field Data

Depth of inundation: | Depth to saturation: <12” | Depth to free water:

Wetland Hydrology Indicators

Primary Indicators (minimum of one required; check all that apply):						Secondary (2 or more req'd):	
☐	Surface Water (A1)	☐	Iron Deposits (B5)	☐	Hydrogen Sulfide Odor (C1)	☐	Drainage patterns (B10)
☐	High Water Table (A2)	☐	Surface Soil Cracks (B6)	☐	Oxidized Rhizospheres (C3)	☐	Dry-season WaTab (C2)
☒	Saturation (A3)	☐	Inundation visible on aerial (B7)	☐	Reduced Iron (C4)	☐	Sat vis on aerial (C9)
☒	Water Marks (B1)	☐	Sparse veg'd concave surf (B8)	☐	Fe reduce in tilled soils (C6)	☐	Geomorph position (D2)
☒	Sediment Deposits (B2)	☐	Water-stained Leaves (B9)	☐	Stunted/stressed plants (D1)	☐	FAC-neural test (D5)
☒	Drift Deposits (B3)	☐	Salt Crust (B11)	☐	Other (Explain in remarks)	☐	Raised ant mounds (D6)
☐	Algal Mat or Crust (B4)	☐	Aquatic Invertebrates (B13)			☐	Frost-h've humm'ks (D7)

Remarks:
Saturation observed in soil pit dug approximately 7 feet from water's edge

SOILS

Map Unit Name (series and phase):	Taxonomy (subgroup):	Drainage Class:	Field observations confirm mapped type? Yes, with new alluvium on surf.
Danielvil loam	Ustic Haplocryolls	Well-drained	

Depth (inches)	Matrix Color	Matrix %	Redox Features Color	Redox Features %	Type[1]	Location[2]	Texture	Remarks
0-7	10YR4/2	>90	N/A				Sandy Loam	Moderate stripping of matrix, likely result of depositional events
7-12	10YR4/2	90	10YR3/3	<10	C	M	Fine SL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore lining, M=Matrix

Hydric Soil Indicators:				Indicators for Problematic Hydris Soils[3]:	
☐	Histosol (A1)	☐	Sandy Redox	☐	2cm Muck (A10)
☐	Histic epipedon (A2)	☒	Stripped Matirx (S6)	☐	Red Parent Material (TF2)
☐	Black Histic (A3)	☐	Loamy Mucky material (F1)	☐	Other (Explain in Remarks
☐	Hydrogen Sulfide (A4)	☐	Loamy Gleyed Matrix (F2)	[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.	
☐	Depleted below black surface (A11)	☒	Depleted Matrix (F3)		
☐	Thick Dark Surface (A12)	☐	Redox Dark Surface (F6)		
☐	Sundy Mucky Material (S1)	☐	Depleted Dark Surface (F7)	Restrictive Layer (if present):	
☐	Sandy Gleyed Matrix (S4)	☐	Redox Depressions (F8)	Type:	Depth (in):

Remarks:
Soils appear well-drained, with high water table and moderate wicking of moisture

WETLAND DETERMINATION

Hydrophytic vegetation?	☒ yes ☐ no	Wetland hydrology?	☒ yes ☐ no	Hydric Soils?	☒ yes ☐ no

(Add separate page or write on back if discussion is needed to explain determination)

WETLAND DETERMINATION DATA FORM – WESTERN MOUNTAINS, VALLEYS, AND COAST REGION

Project Site:	Big Hole Diversion	Date:	8/4/09	Investigator:	Confluence	Plot ID:	South Bank
Do normal circumstances exist on the site?			Yes / No	City/CountyState:	Silver Bow County, MT	Wetland	☒
Is the site significantly disturbed (Atypical Situation?)			Yes / No	Subregion (LRR):	LRR E	Upland	☐
Is the area a Problem Area (if needed, explain on reverse)?			Yes / No	If wetland, community type (NWI):	Emergent, Shrub/scrub riverine		
Landform (hillslope, terrace, etc): sloping river bank				Local relief (concave, convex, none): linear to convex			

VEGETATION

Plant Species	Stratum	Indicator Status	Absolute % Cover Species	Normalized % Cover Species	*D	Plant Species	Stratum	Indicator Status	Absolute % Cover Species	Normalized % Cover Species	*D
Alnus incana	S	FACW	25	31	☒	*Epilobium angustifol*	H	FACU+	15	15	☐
Salix lutea	S	OBL	30	37	☒	*Glyceria grandis*	H	FACW	25	26	☒
Cornus sericea	S	FACW	15	18	☐	Hordeum jubatum	H	FAC-	5	5	☐
Amelanchier alnifolia	S	FACU	10	12	☐	*Equisetum arvense*	H	FAC	10	10	☐
Verbascum thapsus	H	NA	10	10	☐	*Apocynum androsa*	H	FAC	20	21	☒
Monarda fistulosa	H	FACU	10	10	☐						☐

*Dominance = % of dominant species that are OBL, FACW, or FAC: 100% | Prevalence Index: | Morphological Adaptations:

Remarks: Hydrophytic plant community based on dominance. Community includes several FACU and drier species along margin of plot, vegetation extended into stream channel

HYDROLOGY

Recorded Data

☐ Recorded Data Available ☐ Aerial Photos ☐ Stream Gauge ☐ Other ☒ No Recorded Data Available

Field Data

Depth of inundation: | Depth to saturation: 10” | Depth to free water:

Wetland Hydrology Indicators

Primary Indicators (minimum of one required; check all that apply):						Secondary (2 or more req'd):	
☐	Surface Water (A1)	☐	Iron Deposits (B5)	☐	Hydrogen Sulfide Odor (C1)	☐	Drainage patterns (B10)
☐	High Water Table (A2)	☐	Surface Soil Cracks (B6)	☐	Oxidized Rhizospheres (C3)	☐	Dry-season WaTab (C2)
☒	Saturation (A3)	☐	Inundation visible on aerial (B7)	☐	Reduced Iron (C4)	☐	Sat vis on aerial (C9)
☒	Water Marks (B1)	☐	Sparse veg'd concave surf (B8)	☐	Fe reduce in tilled soils (C6)	☐	Geomorph position (D2)
☒	Sediment Deposits (B2)	☐	Water-stained Leaves (B9)	☐	Stunted/stressed plants (D1)	☐	FAC-neural test (D5)
☒	Drift Deposits (B3)	☐	Salt Crust (B11)	☐	Other (Explain in remarks)	☐	Raised ant mounds (D6)
☐	Algal Mat or Crust (B4)	☐	Aquatic Invertebrates (B13)			☐	Frost-h've humm'ks (D7)

Remarks: Obvious overbank flooding and sediment deposition along banks

SOILS

Map Unit Name (series and phase):	Taxonomy (subgroup):	Drainage Class:	Field observations confirm mapped type? Yes
Bearmouth	Ustic Haplocryolls	Well-drained	

Depth (inches)	Matrix Color	Matrix %	Redox Features Color	Redox %	Type[1]	Location[2]	Texture	Remarks
0-4	10YR4/1	100	N/A				sandy Loam	very cobbly
4-10	10YR4/2	95	10YR3/3, 2/2	5	C	M	sandy loam	Cobbly/gravelly
10-12+	10YR4/2	85	10YR3/3, 2/2	15	C	M	fine sandy L	gravelly

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore lining, M=Matrix

Hydric Soil Indicators:				Indicators for Problematic Hydris Soils[3]:	
☐	Histosol (A1)	☐	Sandy Redox	☐	2cm Muck (A10)
☐	Histic epipedon (A2)	☐	Stripped Matirx (S6)	☐	Red Parent Material (TF2)
☐	Black Histic (A3)	☐	Loamy Mucky material (F1)	☐	Other (Explain in Remarks
☐	Hydrogen Sulfide (A4)	☐	Loamy Gleyed Matrix (F2)	[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.	
☐	Depleted below black surface (A11)	☒	Depleted Matrix (F3)		
☐	Thick Dark Surface (A12)	☐	Redox Dark Surface (F6)		
☐	Sundy Mucky Material (S1)	☐	Depleted Dark Surface (F7)	Restrictive Layer (if present):	
☐	Sandy Gleyed Matrix (S4)	☐	Redox Depressions (F8)	Type:	Depth (in):

Remarks:
Increase of soil mottling with depth, soil pit dug along margin of wetland at upland boundary. Manganese concretions account for the 10YR2/2 redox features. Soils within floodplain

WETLAND DETERMINATION

Hydrophytic vegetation?	☒ yes ☐ no	Wetland hydrology?	☒ yes ☐ no	Hydric Soils?	☒ yes ☐ no

(Add separate page or write on back if discussion is needed to explain determination)

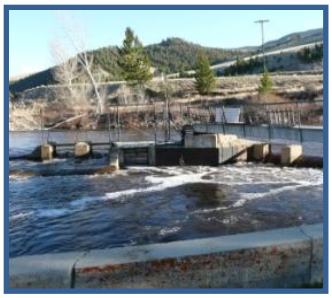
Appendix C – Vegetation Photo Sheet

Photo 1. Willow scrub/shrub vegetation community with cottonwood overstory

Photo 2. Willow dominated scrub/shrub community on instream island.

Photo 3. Mosaic of emergent, scrub/shrub, and cottonwood dominated community types.

Photo 4. Maintained riparian vegetation directly adjacent to existing dam and intake structures.



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX G

HISTORIC AND CULTURAL RESOURCES REPORT

Big Hole Diversion Dam
Historic and Cultural Resources Report

Submitted to

DOWL HKM

Helena, Montana

Submitted by

Historical Research Associates

Natalie Perrin, Architectural Historian
Heather Lee Miller, Ph.D., Associate Historian
Seattle, Washington

November 2009

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Figure 4. The Big Hole Pump Station and settling basin, viewing northeast. The dam is just visible through the brush, pictured right. Photo courtesy of HRA, 2009. 8

Figure 5. Remnants of the original diversion dam, built in 1899, are still evident in the rubble walk retaining wall on the north shore. The concrete abutment wall was added in 1927-1928 during the replacement dam construction. The suction tank is the cylindrical structure visible behind the abutment wall. Photo courtesy of HRA, 2009. 9

Figure 6. Viewing southwest. Sluice gates off the central concrete platform appear to be from the 1927 construction. Note the spalling of the concrete on the channel wall inside the settling basin. Photo courtesy of HRA, 2009. 10

Figure 7. Deterioration of the concrete cap and wall of the settling basin, facing southwest. Photo courtesy of HRA, 2009. 11

Figure 8. The Big Hole Diversion Dam and settling basin, facing southwest. Photo courtesy of HRA, 2009. 12

Figure 9. The Big Hole Diversion Dam, settling basin, and pump house with the riveted metal smoke stack visible. The house, pictured left, is not affiliated with the facility. Photo courtesy of HRA, 2009. 12

Figure 10. Looking over the north abutment into the settling basin. Concrete is extremely deteriorated in this area, and rebar is often completely exposed. Photo courtesy of HRA, 2009. 13

Figure 11. Conceptual 1. 17

Figure 12. Conceptual 2. 19

Figure 13. Conceptual 3. 21

Figure 14. Conceptual 4. 23

Figure 15. Conceptual 5. 25

1.0 Introduction

The Big Hole Diversion Dam, owned and operated by the City-County of Butte–Silver Bow and the Butte Water Company, is located approximately 20 miles southwest of Butte, Montana. The dam, and associated settling basin, are considered contributing resources to the Big Hole Pump Station (built in 1899, expanded in 1906), which was listed on the National Register of Historic Places (NRHP) in 1980 (Smithsonian Trinomial 24SB257). The extant concrete dam and settling basin, constructed in 1927, replaced the original timber and rock dam located on this site, which was destroyed by flood in June 1927.

The diversion dam and settling basin are in poor condition, and represent a safety hazard both to workers and to members of the public who use the Big Hole River recreationally. The dam is also an impediment to fish passage, which results in negative environmental effects. The purpose of this report is to assess five preliminary design alternatives developed to repair or replace the dam.

1.1 Methodology

Historical Research Associates, Inc. (HRA) Architectural Historian Natalie Perrin and Associate Historian Heather Lee Miller, Ph.D., met with Senior Civil Engineer Dick Talley, P.E., of DOWL HKM at the Big Hole Pump Station on August 3, 2009. Design alternatives were reviewed on site, and an assessment of the dam and settling basin was conducted at that time.

Research into the history of the Big Hole Diversion Dam was conducted at the Butte–Silver Bow Archives and the Butte Public Library on August 4, 2009. Additional research was conducted at the Butte Water Company and the World Museum of Mining on August 5, 2009. Online archival research was conducted through the Northwest Digital Archives, which contains catalog indexes to the Montana Historical Society, University of Montana, Missoula, and various other archival collections throughout the Pacific Northwest.

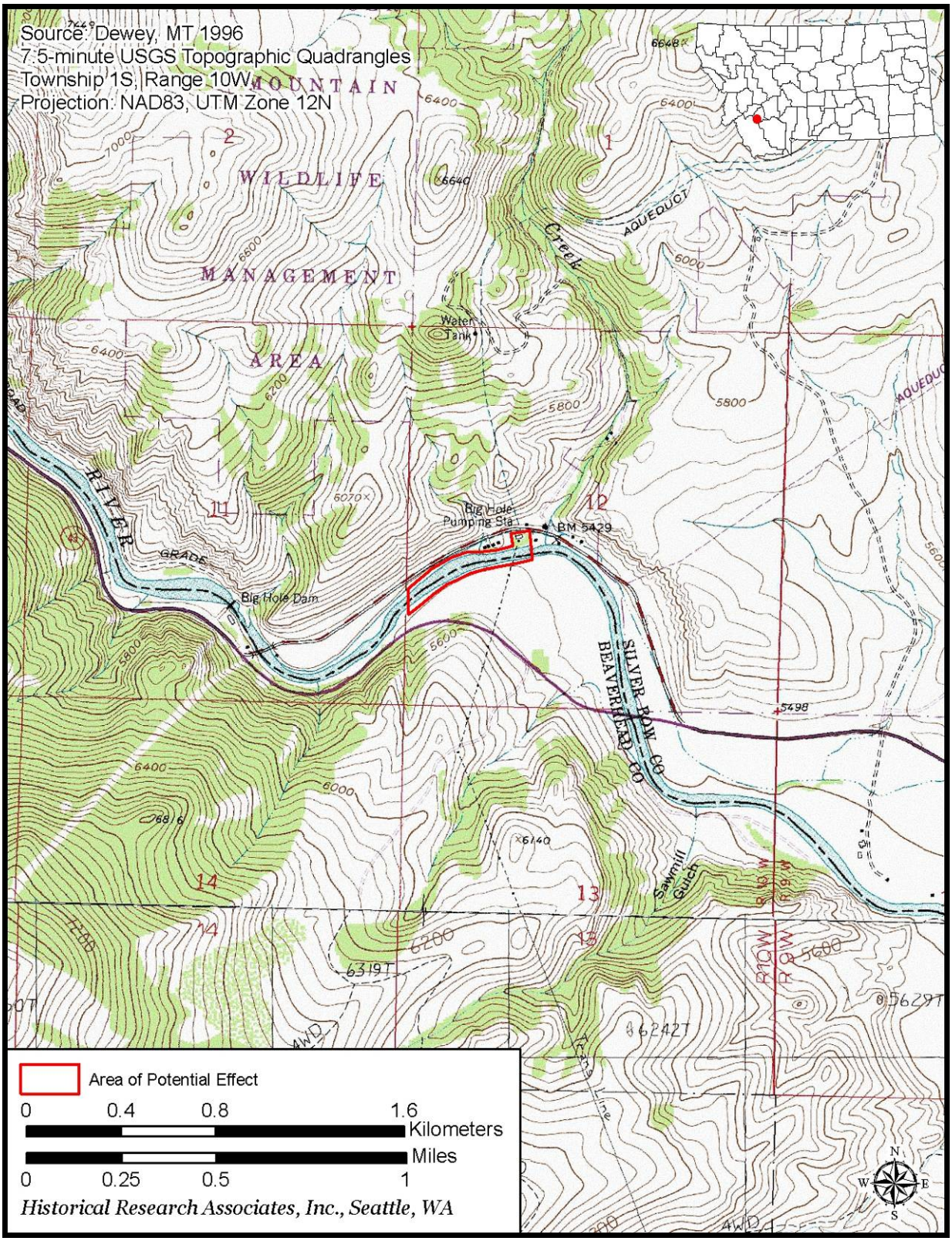


Figure 1. Topographical map depicting the Big Hole River and the location of the diversion dam, settling basin, and pump station.

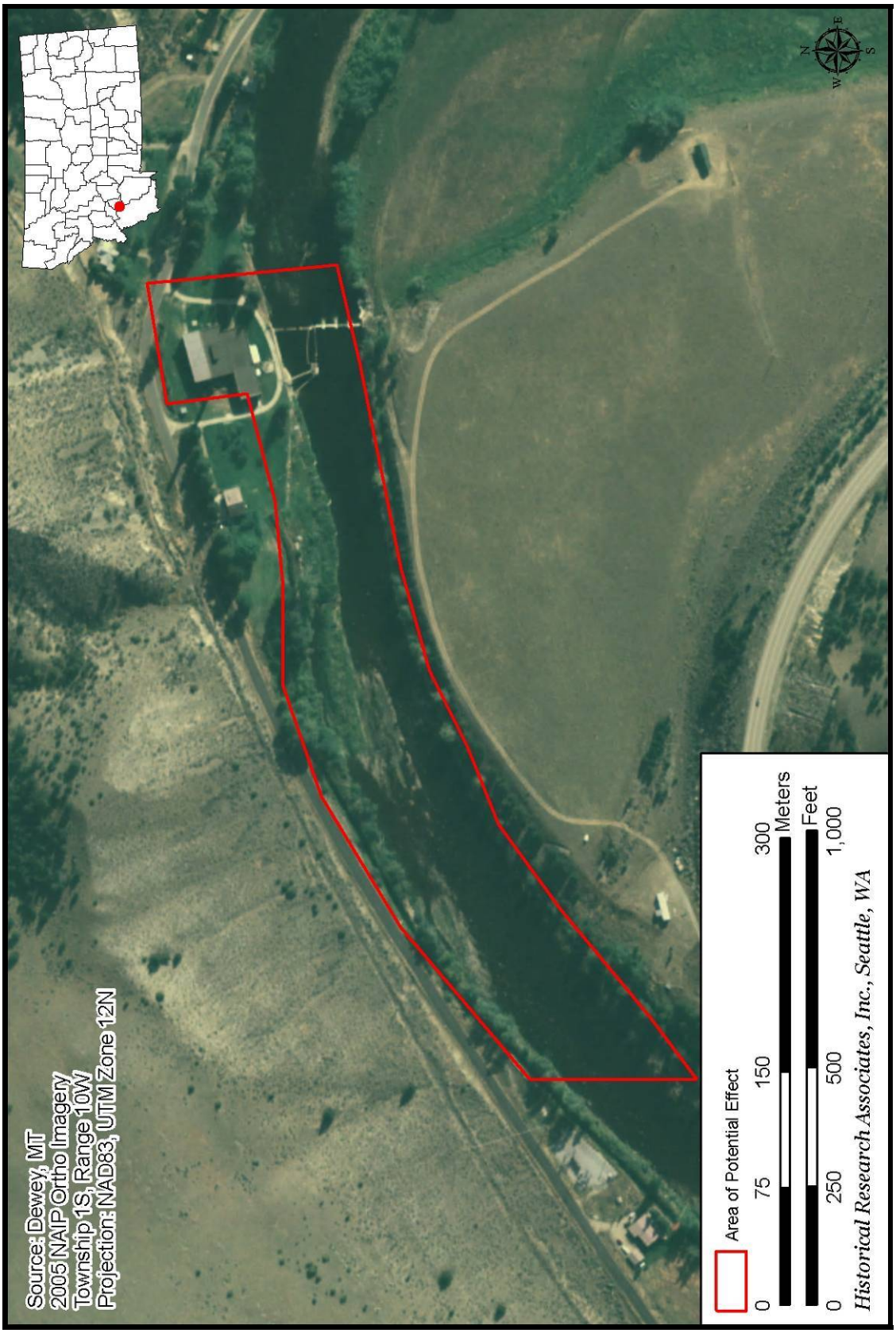


Figure 2. Aerial site map of the Big Hole diversion dam site.

2.0 Historic Context

When Lewis and Clark passed through the region in 1805, they named the stream they encountered the Philanthropy River.[1] Later, French-Canadian trappers capitalizing on the rich game in the area christened the area "Le Grand Trou," which literally translates as "the big hole." The name stuck and the region, as well as the river that supplies it, are today known as the Big Hole. After gold was first discovered in Montana, in 1857, cattle were brought to the Big Hole to rest along the trail to the gold camps and to fatten on the abundant grasses.

In nearby Butte, Montana, the first prospectors relied on fresh water supplies from the Silver Bow Creek and its tributaries. During the 1880s, the population of Butte tripled, creating greater demands for potable water. Increases in mining activities, however, meant water was diverted from human needs to those of the mining industry. Soon, the water of Silver Bow Creek was not potable due to the "general sewage of mines and inhabitants."[2]

In 1898, the Butte Water Company was established from the previously named Butte City Water Company, which had in turn purchased the Silver Bow Water Company in 1891. Supplying water to the ever-increasing population and mining interests presented challenges in a region nearly encircled by the Continental Divide. The solution to the growing problems was "both creative and far sighted[,] . . . a significant engineering accomplishment" that enabled the town and mining industry to continue to grow.[3]

In 1899, the Butte Water Company conceived of a project to pump water from the Big Hole River, a pristine water supply located more than 27 miles from Butte, over the Continental Divide and into town. The Big Hole water system encompassed miles of continuous stave redwood and fir pipelines, five separate distributing systems, reservoirs, dams, pump stations, and treatment centers, and still serves as the main water source for Butte. Arguably, the most important component in the system is the Big Hole Pump Station, the source for the water.

---

[1] "Engineers Start Work Today on Route of New Railway," *The Butte Miner*, July 30, 1913. 11.

[2] "Butte, Montana, Water Works," *Mueller Record* 221 (January 1931): 21, Folder VF2145, Utilities: Butte Water Company General Information, Butte–Silver Bow Archives, Butte, Montana (hereafter BSBA)

[3] Miles Tuttle and Patricia Bick, "Big Hole Pumpstation (24SB257)," National Register of Historic Places Inventory Nomination Form, listed September 24, 1980, 7-2, Montana State Historic Preservation Office, Helena, Montana (hereafter Montana SHPO).

In 1899, the Big Hole Pump Station was completed, "capable of lifting 15 million gallons of water a day over the Continental Divide to reservoirs on Basin Creek."[4] At that time, the pump station building housed a single triple-expansion two-stage plunger pump manufactured by Nordberg Manufacturing Company of Madison, Wisconsin. The pump was powered by a coal-fired steam system, and operated solo until the pump station was expanded in 1906. At that time, a second pump was installed and, in 1907, both pumps were electrified.

Feeding the entire system was the diversion dam, which funneled water into the pump house for transferral into the Big Hole system and, eventually, delivery to the people of Butte. The original dam, built contemporary with the pump station in 1899, was a low profile structure built of rock and timber.[5] Water trapped behind the dam flowed through a conduit and into a concrete settling basin just south of the pump station. From there, water was diverted through pipes to the pumps. The pumps forced the water through redwood stave pipes that then transported the water up and over the Continental Divide. A third pump was added to the system in 1916, providing an additional six million gallons to the approximately eight million gallons already entering the system daily.

Due to the isolated location of the pump station, housing for engineers and workmen was constructed on site (Figure 3). Seven buildings, providing housing and storage, were included in the 1980 NRHP nomination of the Big Hole Pump Station. The Chief Engineer's House, constructed in 1900, and associated garage (c. 1920) were located east of the pump station. The Boarding House, built in 1912, housed up to fifteen workers and was located west of the pump station. Employee House 1, built in 1916, and Employee Houses 2 and 3, built in 1937, were also located west of the pump station. A hose house is the only surviving ancillary building from the turn of the twentieth century, and today still houses the hand-pulled fire cart.

On June 14, 1927, heavy snow melts and swollen creeks led to the failure of the Wise River Dam. The Wise River, a tributary of the Big Hole, flooded the valley, causing at least four deaths and significant damage. The Butte Miner reported, on Wednesday, June 15, 1927, that "the disaster, tragic as it was, would have been incalculably more serious if the Butte Water Company's dam at Divide had failed to hold. The pumping

[4] Ibid.

[5] Ibid., 7-1.

plant was flooded, but has been closed for some time. Several empty buildings at Divide floated off."[6]

Though it appears that the diversion dam held for a time, failure of the dam on Pattingale Creek (a tributary to the Wise River) eventually devastated the diversion dam. "The company that owned the Pattingale dam assumed responsibility and constructed the existing dam, intake, and settling basin in 1928."[7] Chas. T. Main, Inc., an engineering company from Boston, Massachusetts, designed the new reinforced concrete structure for the Butte Water Company in August 1927.[8]

Three more pumps were added to the pump station, including Pump No. 4 in 1930, and Pumps Nos. 5 and 6 in 1954. Pump No. 1 was removed in 1953. New pumps were installed in the 1990s, with the 1950s pumps decommissioned but left in place as a back-up system. The Big Hole pump station and diversion dam continue to provide necessary drinking water to the community of Butte.

---

[6] "River Dam Breaks Taking Heavy Toll," *Butte Miner*, June 15, 1927, 2.

[7] Tuttle and Bick, "Big Hole Pumpstation (24SB257)," 7-1.

[8] Chas. T. Main. Inc., Engineers, "Butte Water Company, Butte, Montana, Big Hole River Dam," Drawing B-2, August 1927, Butte Water Company, Butte, Montana.

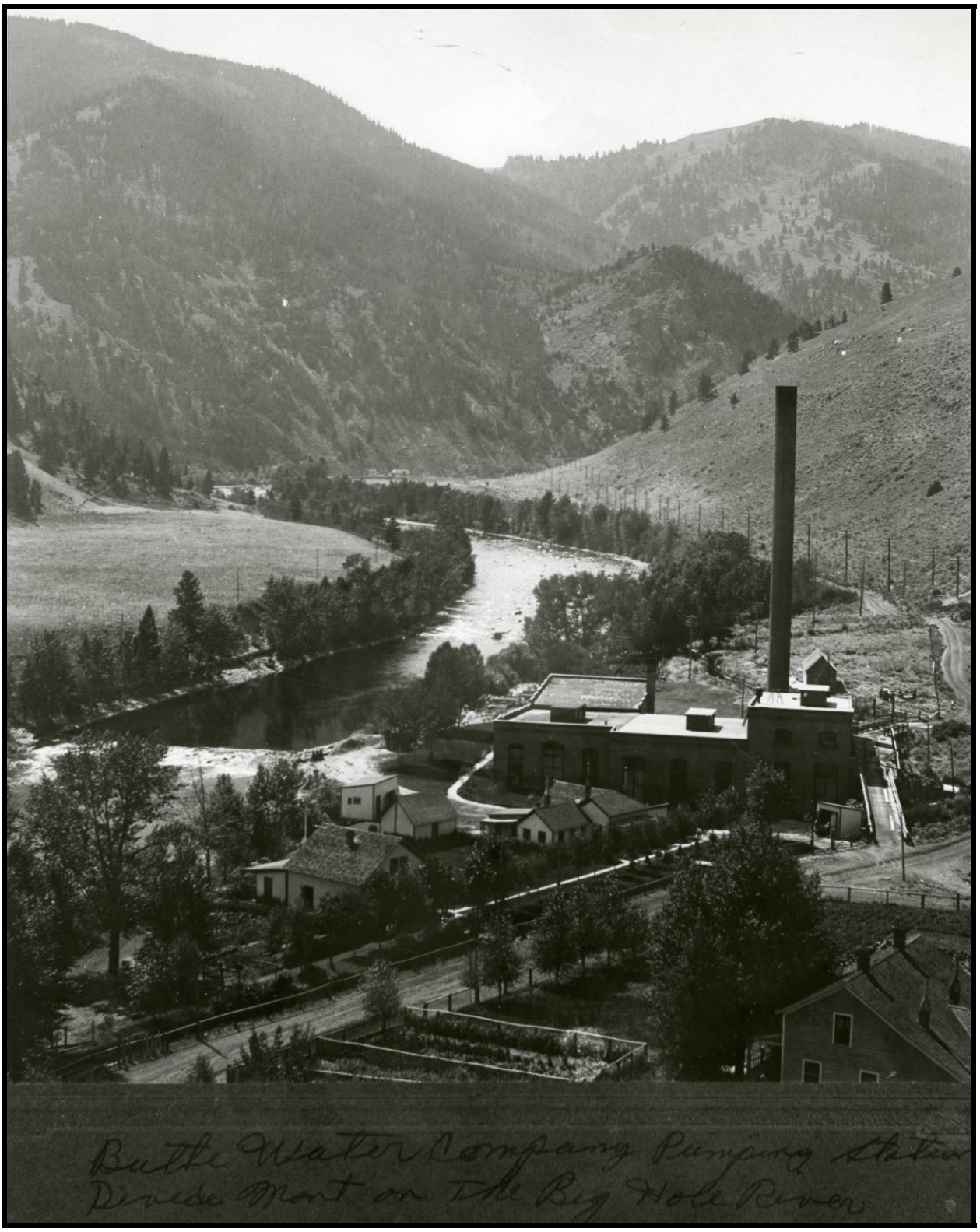


Figure 3. "Butte Water Company Pumping Station, Divide Montana, on the Big Hole River," c. 1920. Image courtesy of the World Museum of Mining, Butte, Montana.

3.0 Physical Description

The Big Hole Diversion Dam, built in 1927, is located in the canyon of the Big Hole River, approximately 27 miles southwest of Butte, Montana, and 2.5 miles west of Divide, Montana (Figure 4). The dam and settling basin are constructed of reinforced, poured-in-place concrete, with concrete abutment walls along the banks of the river. Remnants of the original dam, constructed contemporary with the Big Hole Pump Station in 1899, are visible in rock wall extant on either side of the concrete abutment on the north bank (Figure 5).

Figure 4. The Big Hole Pump Station and settling basin, viewing northeast. The dam is just visible through the brush, pictured right. Photo courtesy of HRA, 2009.

Figure 5. Remnants of the original diversion dam, built in 1899, are still evident in the rubble walk retaining wall on the north shore. The concrete abutment wall was added in 1927-1928 during the replacement dam construction. The suction tank is the cylindrical structure visible behind the abutment wall. Photo courtesy of HRA, 2009.

The diversion dam spans the width of the Big Hole River, running roughly northeast to southwest. The span, approximately 190 feet in length, also acts as the downstream wall of the settling basin, a concrete enclosure on the north side of the river. The settling basin is trapezoidal in shape, extending approximately 70 feet into the river at the dam, 100 feet upstream of the dam, and 50 feet back to the north shore. Water enters the basin through a series of sluice gates, and then flows by gravity into an underground conduit that channels the water into a concrete settling basin (Figure 6).

Figure 6. Viewing southwest. Sluice gates off the central concrete platform appear to be from the 1927 construction. Note the spalling of the concrete on the channel wall inside the settling basin. Photo courtesy of HRA, 2009.

The settling basin, located on the north bank of the river, south of, and adjacent to, the pump house, is a cylindrical concrete structure 20 feet in diameter that acts as a holding tank. The settling basin feeds water to the pumps in the pump station through a series of suction pipes. The pumps then move the water through 36-inch steel pipelines, completed in 1979, to the treatment facility near Feely, Montana, approximately 9 miles north of the diversion dam.

The vertical upstream face of the diversion dam is approximately 5 feet high and 10 feet wide at the bottom, tapering to a width of approximately one foot at the top. The top is covered with a concrete cap, and significant deterioration of the wall has revealed the rubble stone and concrete beneath (Figure 7). The dam is bisected by a concrete channel that carries excess water from the settling basin sluice gates to the downriver side of the dam.

Figure 7. Deterioration of the concrete cap and wall of the settling basin, facing southwest. Photo courtesy of HRA, 2009.

A concrete platform (or pier) in the center of the river provides access to both the sluice gates and the channel. The sluice gates are in fair condition, and appear to be in their original metal housing with wood gates. The platform is accessed by a concrete catwalk that spans the settling basin to the north shore. The catwalk appears to be original to the dam itself, though the metal access stairs on the platform are obviously a recent replacement.

The diversion dam and settling basin are in poor condition, specifically due to the advanced deterioration of the concrete (Figure 8). Spalling, steel jacking, and other damage to the concrete are evident throughout all visible areas of the dam (Figure 9). The condition of the dam span downstream of the settling basin is likely indicative of excessive deterioration below the water line.

Figure 8. The Big Hole Diversion Dam and settling basin, facing southwest. Photo courtesy of HRA, 2009.

Figure 9. The Big Hole Diversion Dam, settling basin, and pump house with the riveted metal smoke stack visible. The house, pictured left, is not affiliated with the facility. Photo courtesy of HRA, 2009.

The site of the Big Hole diversion dam and pump station has changed significantly since the 1920s. It is unclear if outbuildings were damaged in the 1927 flood and removed at that time, or were removed slowly over time. Of the outbuildings from the 1920s, only the hose house is extant. Based on photographic evidence c. 1920 (see Figure 3), the hose house was relocated from its original site, on the northeast side of the pump station, to its current site, northwest of the pump station. A bungalow style residence borders the pump station to the west, but is not affiliated with the facility and is not one of the original worker's residences (Figure 9). The residence is bordered on the south by a small irrigation ditch/creek. This irrigation ditch parallels the Big Hole River west of the house before diverting northeast, just west of the pump station.

Figure 10. Looking over the north abutment into the settling basin. Concrete is extremely deteriorated in this area, and rebar is often completely exposed. Photo courtesy of HRA, 2009.

4.0 Alternatives Assessment

A list of proposed and preliminary alternatives has been developed in consultation with Butte–Silver Bow (BSB). Alternatives were developed after review of the available operating and maintenance data regarding the diversion of water from the Big Hole River. The river is a source of raw water for the Big Hole Water Treatment Plant, and subsequently for the citizens of BSB County. The list of alternatives has taken into account the following factors, which evaluate parameters in no particular order of preference:

1. System reliability and design life.
2. Maximum, minimum, and water right flow into the intake due to cold weather and icing conditions in the river.
3. Minimize disruption of water flow into the intake due to cold weather and icing conditions in the river.
4. Improve safety for the maintenance and operations of the facility by BSB personnel.
5. Reduce ongoing maintenance and operations costs.
6. Improve available pump suction head.
7. Improve the safety of boat passage.
8. Improve the conditions for fish passage.
9. Better account for low water diversion to meet the demand periods for water in Butte.
10. Decrease sediment loading and improve trash removal efficiency.
11. Maintain integrity of the intake during construction or provide a temporary water supply to the pumps.
12. Minimize project costs to maintain budget compliance.

In consideration of these factors, the following five alternatives have been developed:

ALTERNATIVE 1: Do nothing.

ALTERNATIVE 2: Replace in kind.

ALTERNATIVE 3: Rock weir with new pump station.

ALTERNATIVE 4: Rock weir with floating intake.

ALTERNATIVE 5: Upstream rock weir.

Within each alternative, consideration will be given to the existing intake structure to include the following alternatives for replacement:

A. **Rebuild Existing System.** Rebuild a new system that is similar to the existing system that captures pooled water, temporarily stores sediment, and then allows for periodic flushing.

B. **Infiltration Gallery.**

   1. **Concrete Channel with Wall Screens.** In this alternative water is constricted in a narrow chute and forced at high velocity to pass through screens vertically mounted in a wall. Raw water is drawn off the screens, allowing sediment and debris to pass by in the main channel.

   2. **River Tee Screens on a Sled.** Tee screens will be mounted on a heavy plate that is sunk into the natural pool below the water surface (even at low flows). Lockjoint ball and socket pipe follows the natural terrain stream bottom and conveys water from the screens to the pump station.

   3. **Fine Screens Built into a Drop Structure.** A boat and fish bypass structure will be combined into a structure that also functions as the water intake.

Each of the five alternatives is reviewed here under the lens of the Secretary of the Interior's *Standards for the Treatment of Historic Properties*, with specific attention given to the potential to affect historic resources.

4.1 Archaeological Considerations

The scope of this assessment did not include archaeological survey. It should be noted that, with the exception of Alternative 1 (the "do-nothing" option), all proposed alternatives will require ground-disturbing activities. As with any project that will include ground-disturbing activities, there is a possibility of encountering archaeological resources.

Architectural historians, conducting pedestrian survey of the site during the evaluation of resources for this report, encountered a trash scatter of bricks, worked stone, and concrete upstream of the pump station along the north bank. Ground disturbing activities may encounter archaeological evidence from the initial

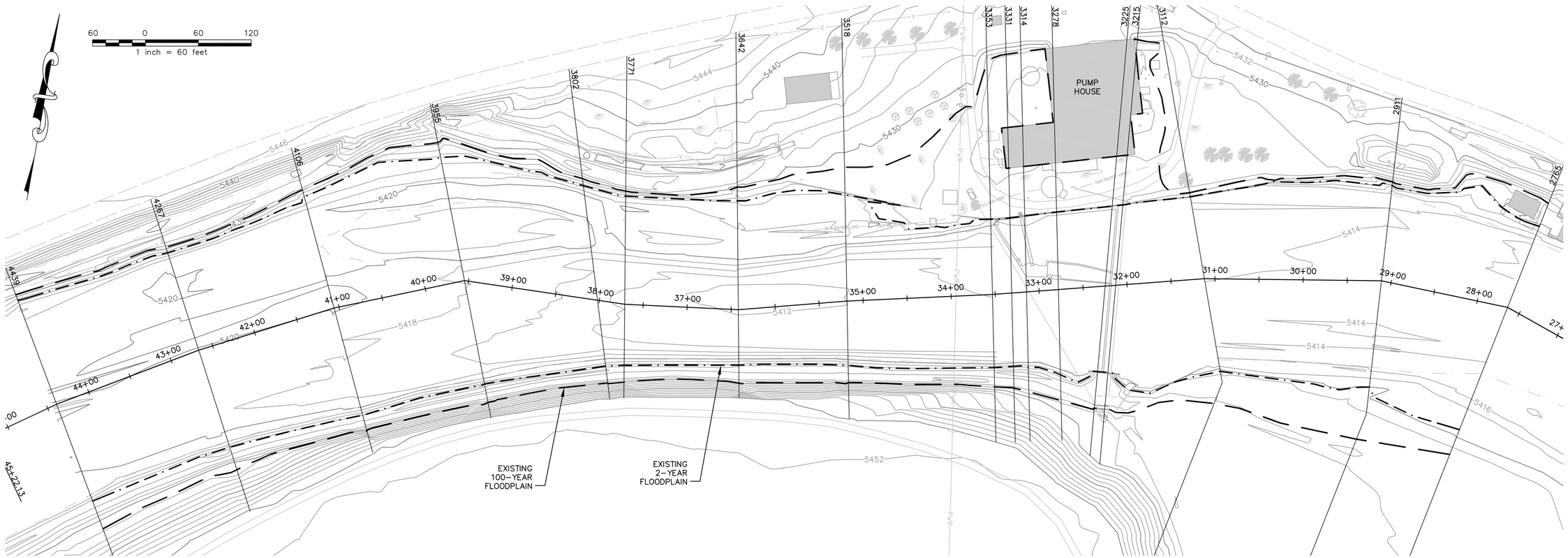
construction of the Big Hole Pump Station (1899) and subsequent addition (1906), construction of the extant dam (1929), and possible foundation remains from outbuildings at the site that have since been removed. Because the site is located at a river, the chance of encountering prehistoric archaeological resources is probable.

In the event that archaeological resources are discovered during construction, appropriate mitigation measures should be followed to ensure their identification, evaluation, and disposition. BSB should assess the site, in conjunction with a qualified archaeologist and in consultation with the Montana SHPO, regarding the nature and condition of the discovered item(s). All construction activity should be suspended until the site is handled properly, and in accordance with state and federal laws.

4.2 Alternative 1: Do Nothing

Description: Alternative 1 consists of leaving the facility in its current configuration and state of operation. Concerns regarding safety for workers and the public, as well as environmental concerns regarding fish passage, remain unsolved in this alternative. Alternative 1 has been in place for several years, resulting in high maintenance costs. Alternative 1 is presented as a baseline for comparison of the other alternatives.

Evaluation: No potential to affect historic resources. Continued deterioration of the structure will likely occur, resulting in preservation by neglect.



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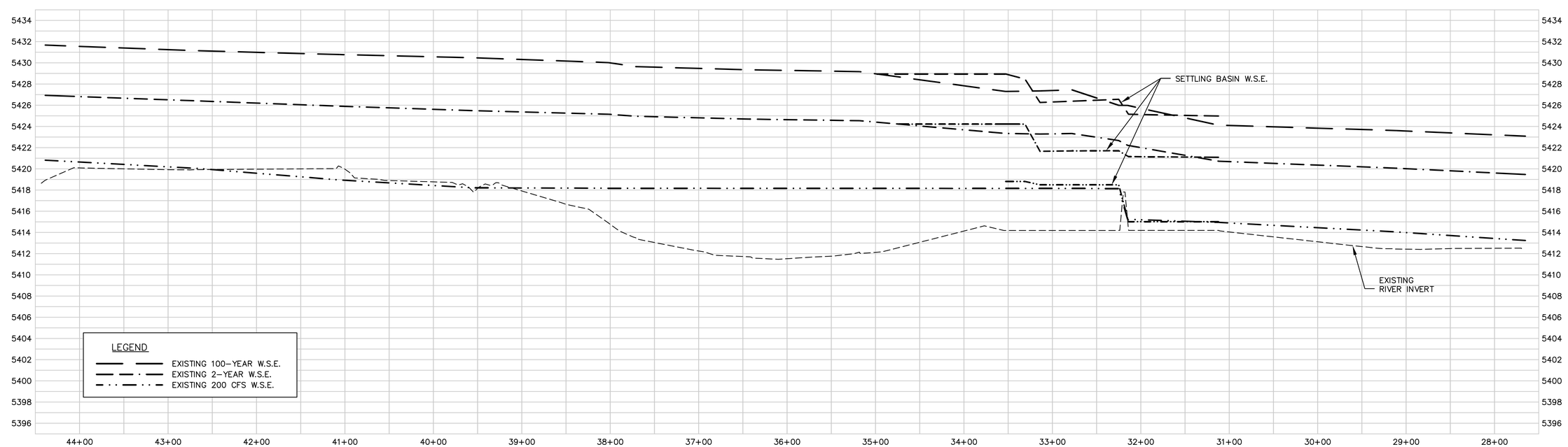

PROFILE

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BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

OPTION 1 PLAN AND PROFILE

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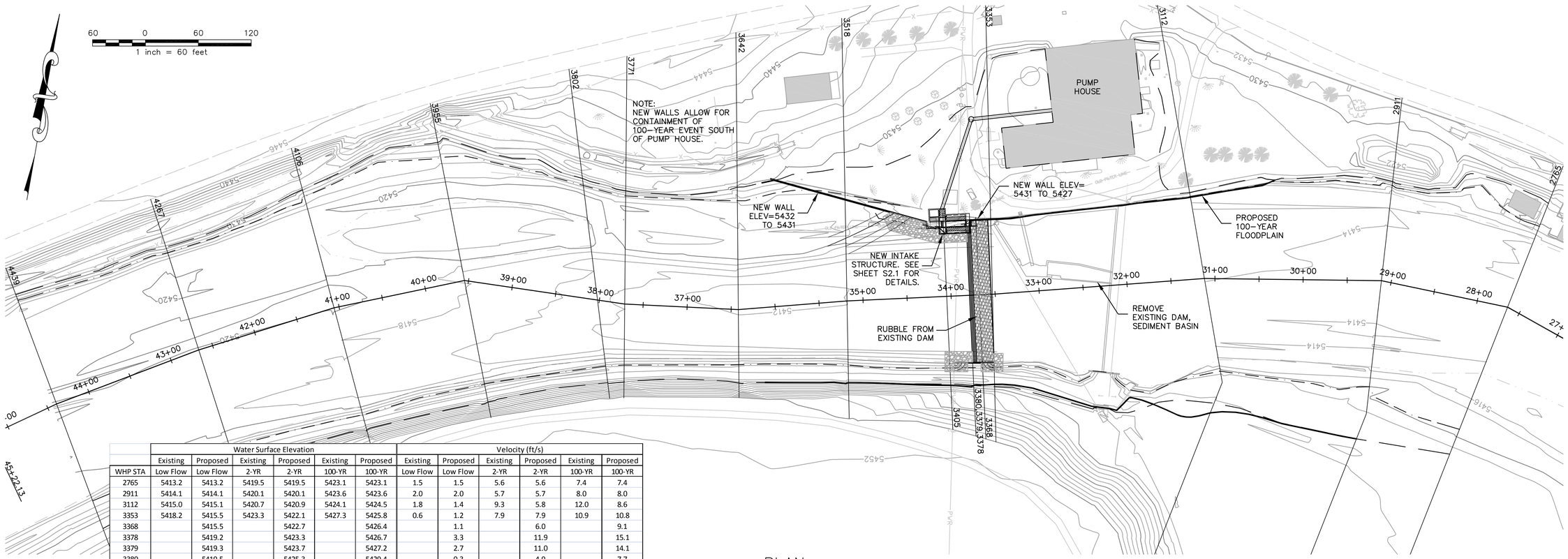
4.3 Alternative 2: Replace in Kind

Description: Alternative 2 consists of replacing the existing concrete diversion dam, intake structure, and intake piping with a new system that is similar in alignment and configuration as currently exists, and would be located directly upstream of the current location. Alternative 2 recognizes the need for improvements while being designed to minimize improvement costs. Specifically, Alternative 2 does not incorporate boat bypass and fish passage into the facility in an effort to save on costs. Alternative 2 would improve safety conditions for workers, but will have minimal improvements for general public safety. Environmental concerns regarding fish passage remain unsolved in this alternative.

The new structures would be located immediately upstream of the existing dam, and would create a higher water pool to improve existing pump performance. New intake screens would replace the existing settling basin, and new piping would convey water directly to the pumps. New penetration of the existing pump house would be required, and all in-stream components of the existing dam would be removed. A significant modification from the existing dam is the gradual stepping of the downstream face of the new dam, necessary to reduce the possibility of "keeper waves." Keeper waves form at the base of the downstream face of the existing dam, causing boaters to become trapped in the resulting undercurrent.

Evaluation: The design for Alternative 2 will vary significantly from that of the extant dam and waterworks, and necessitate the complete removal of the existing diversion dam, intake structure, settling basin, and piping. Alternative 2 is not classifiable as a preservation treatment, as defined by the National Park Service in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Removal would constitute an adverse effect, which will likely require mitigation. In addition, new piping and other new construction will impact the Big Hole Pump Station, a historic property listed in the NRHP.



PLAN

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2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3353	5418.2	5415.5	5423.3	5422.1	5427.3	5425.8	0.6	1.2	7.9	7.9	10.9	10.8
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3379		5419.3		5423.7		5427.2		2.7		11.0		14.1
3380		5419.5		5425.3		5429.4		0.3		4.9		7.7
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3518	5418.2	5419.5	5424.5	5425.5	5429.2	5430.0	0.3	0.3	4.8	4.3	6.9	6.4
3642	5418.2	5419.5	5424.7	5425.6	5429.3	5430.1	0.4	0.3	5.5	4.9	7.9	7.4
3771	5418.2	5419.5	5425.0	5425.8	5429.6	5430.3	0.5	0.4	5.6	5.1	8.2	7.8
3802	5418.2	5419.5	5425.2	5426.0	5430.0	5430.7	0.6	0.4	4.8	4.3	6.8	6.4
3955	5418.2	5419.5	5425.5	5426.2	5430.5	5431.1	1.5	0.7	4.8	4.3	6.1	5.8
4106	5419.0	5419.5	5425.9	5426.5	5430.8	5431.3	2.5	1.5	4.9	4.4	6.2	5.9
4267	5420.0	5420.0	5426.4	5426.9	5431.1	5431.6	1.4	1.4	4.9	4.6	6.6	6.3
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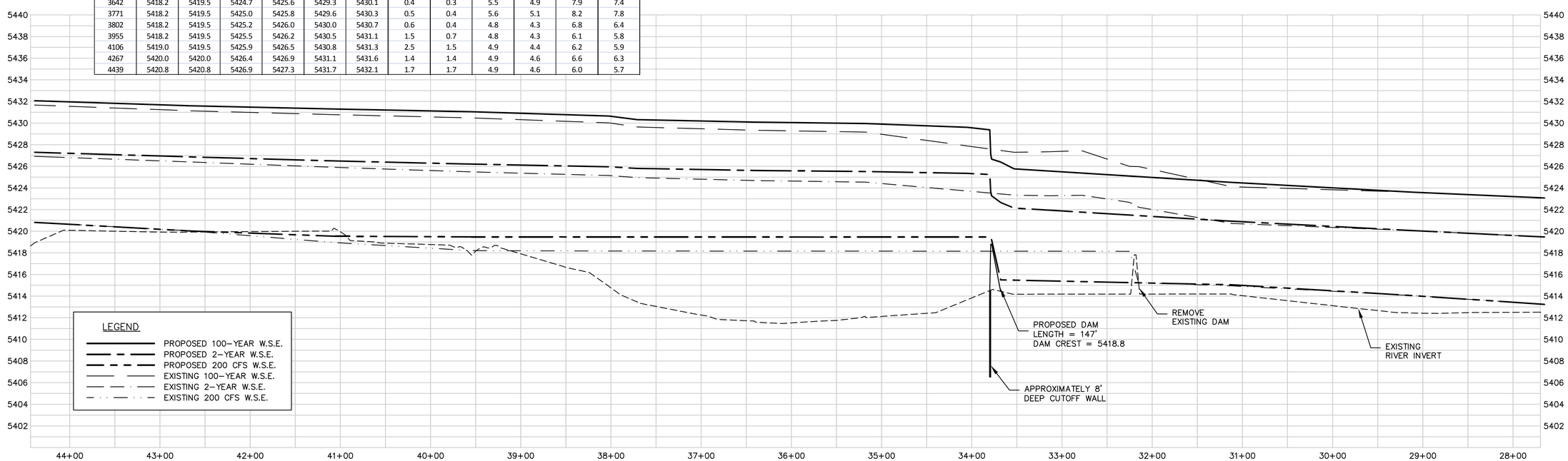

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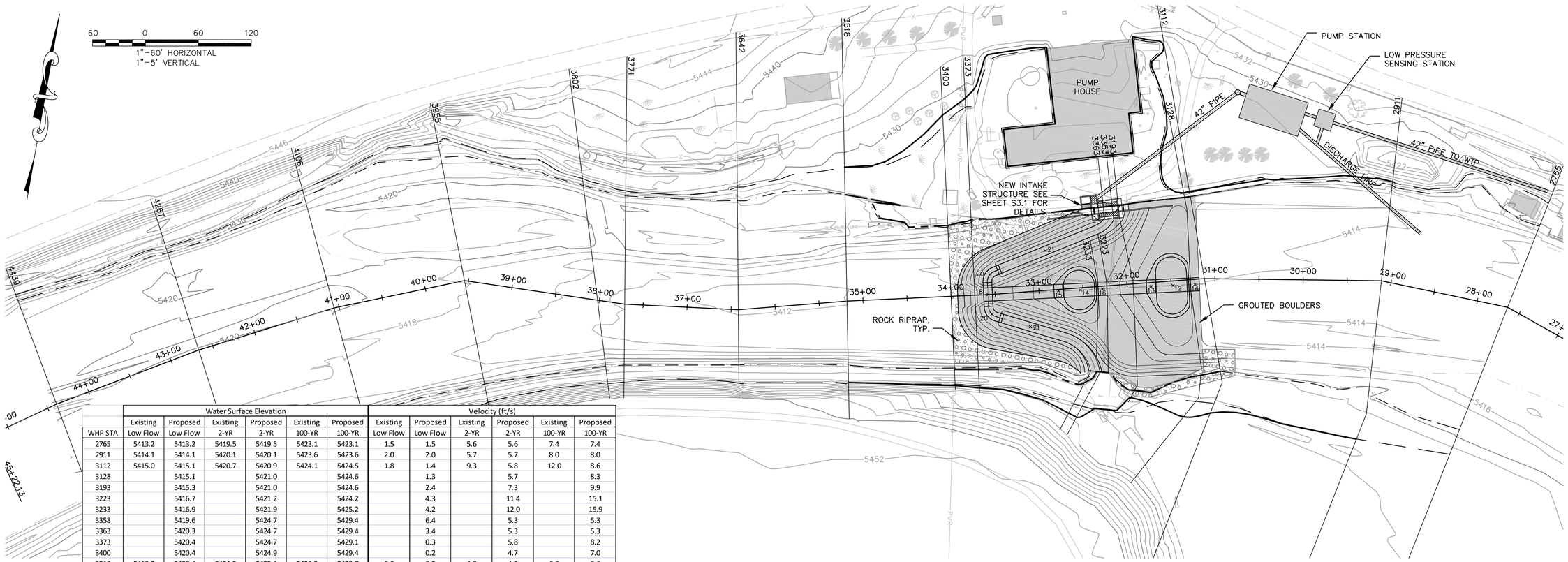
4.4 Alternative 3: Rock Weir with New Pump Station

Description: Alternative 3 will remove the existing diversion dam and associated features. Alternative 3 will relocate existing cased pumps to a new pump house, to be constructed on the northeast side of the existing pump station. The new pump house will alleviate existing pump efficiency problems by installing pumps at proper elevations. With Alternative 3, all water delivery components will be removed from the existing pump station.

Alternative 3 will utilize the same location for the point of diversion as the existing dam. The design would include new primary and secondary intake systems to allow for future repair and maintenance. The design would also include a notched rock spillway, or weir, which would replace the function of the existing dam and allow for boat and fish passage. The profile of the new rock structure would include gradual steps, optimized to provide the desired upstream water surface and safe boat and fish passage. The rock weir would be constructed in approximately the same location as the existing diversion dam.

Evaluation: The design for Alternative 3 varies significantly from that of the extant dam and waterworks, and necessitates the complete removal of the existing diversion dam, intake structure, settling basin, and piping. Alternative 3 is not classifiable as a preservation treatment, as defined by the National Park Service in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Removal would constitute an adverse effect, which will likely require mitigation.

Alternative 3 also incorporates construction of a new pump house, relocating existing water conveyance functions from the historic Big Hole pump station. This aspect may allow for easier public access to and preservation of the historic resource; however, it will alter the primary use of the facility from a pump station, which may be considered an adverse effect and will likely require mitigation.



PLAN

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2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3128		5415.1		5421.0		5424.6		1.3		5.7		8.3
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3223		5416.7		5421.2		5424.2		4.3		11.4		15.1
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3642	5418.2	5420.5	5424.7	5425.2	5429.3	5429.8	0.4	0.3	5.5	5.2	7.9	7.5
3771	5418.2	5420.5	5425.0	5425.4	5429.6	5430.1	0.5	0.3	5.6	5.3	8.2	8.0
3802	5418.2	5420.5	5425.2	5425.6	5430.0	5430.4	0.6	0.3	4.8	4.5	6.8	6.5
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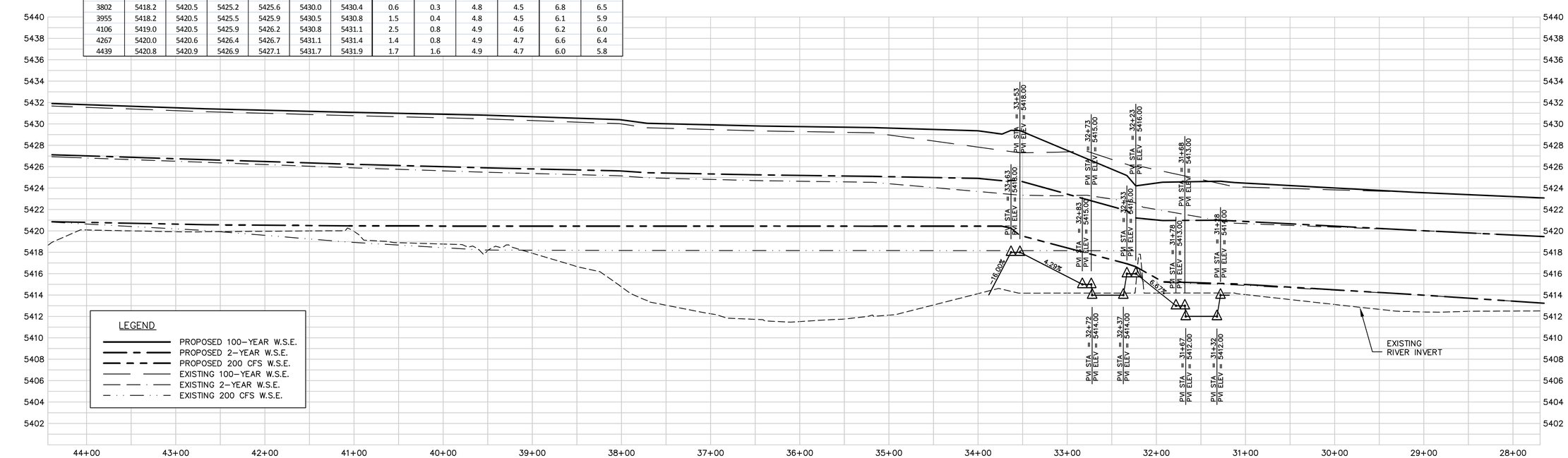

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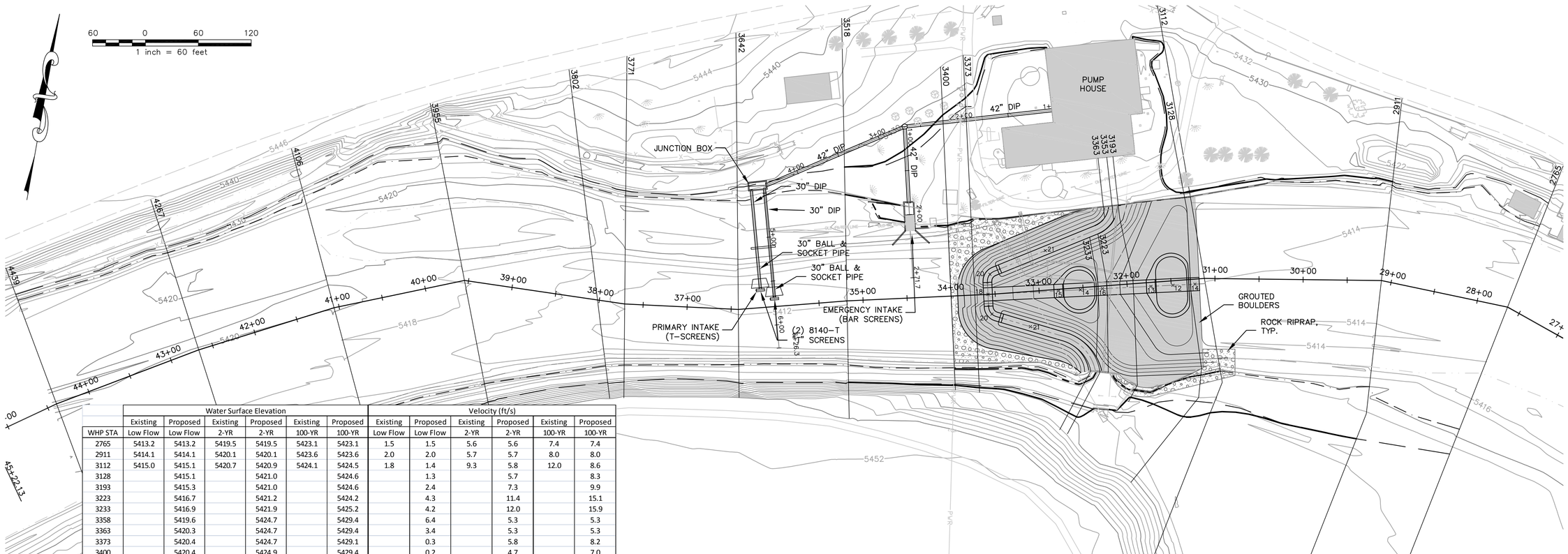
4.5 Alternative 4: Rock Weir with Floating Intake

Description: Alternative 4 involves removing and replacing the existing concrete diversion dam with a concave rock weir. As with Alternative 3, the rock weir will create stepped drops designed for safe boat and fish passage, which would be constructed in approximately the same location as the existing diversion dam. The rock weir would be visible during low flow conditions, while the intakes and intake structures would remain relatively hidden from view at all times. The rock weir would be constructed of quarried rock or native round rock. The resulting design would provide a visual aesthetic as close to natural and native conditions as possible while maintaining functionality.

By locating the new intake facilities upstream, Alternative 4 takes advantage of the stream gradient to increase pump suction and pump performance. A new raw water delivery system would penetrate the west pump house wall.

Evaluation: The design for Alternative 4 varies significantly from that of the extant dam and waterworks, and necessitates the complete removal of the existing diversion dam, intake structure, settling basin, and piping. Alternative 4 is not classifiable as a preservation treatment, as defined by the National Park Service in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Removal of the extant dam would constitute an adverse effect, which will likely require mitigation.

Alternative 4 bears a marked resemblance to Alternative 3, but would continue to utilize the existing Big Hole Pump Station. However, new piping and other new construction will impact the Big Hole Pump Station, a historic property listed in the NRHP.



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2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3128		5415.1		5421.0		5424.6		1.3		5.7		8.3
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4106	5419.0	5420.5	5425.9	5426.2	5430.8	5431.1	2.5	0.8	4.9	4.6	6.2	6.0
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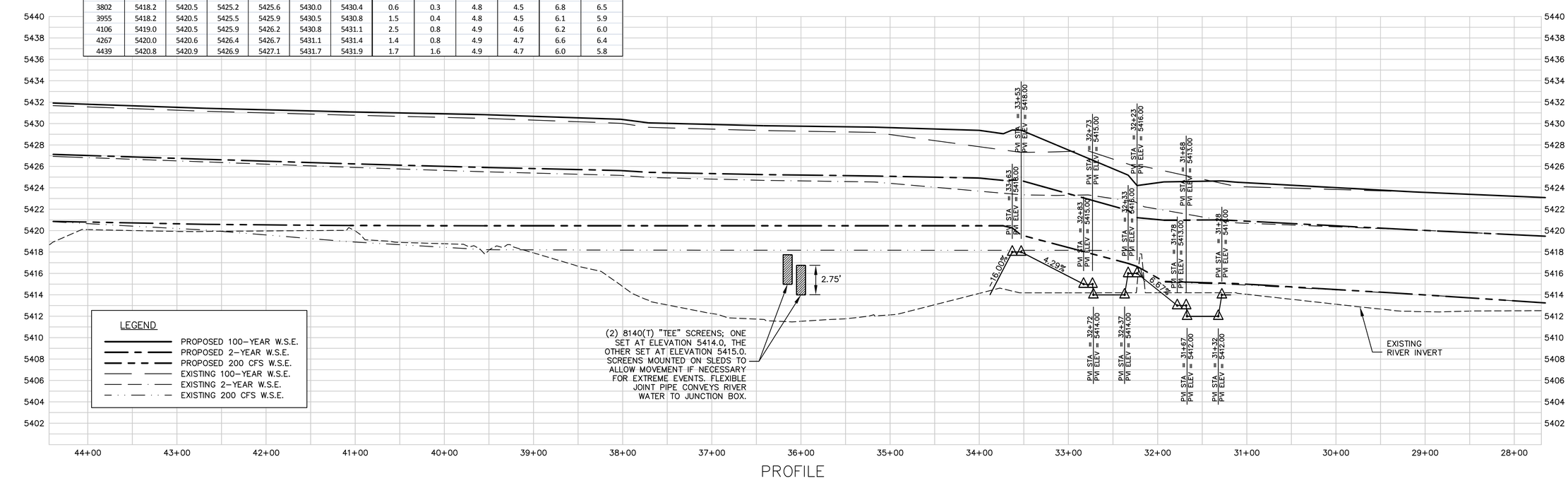

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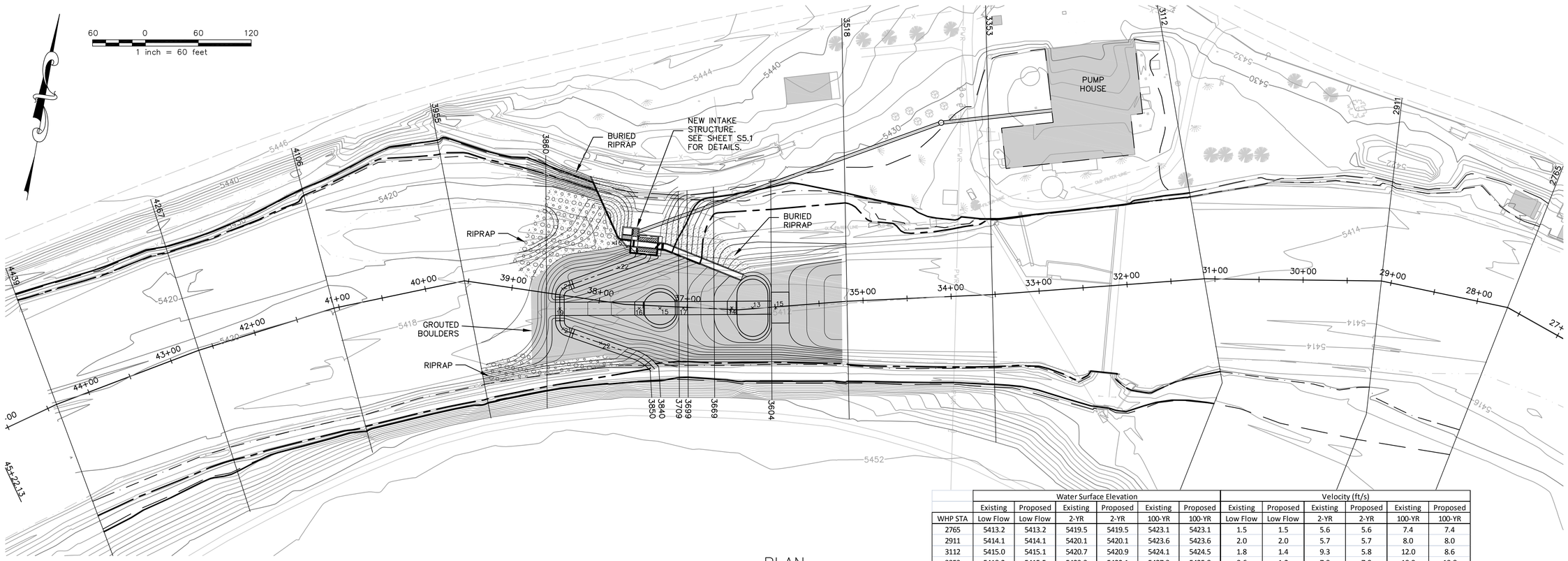
4.6 Alternative 5: Upstream Rock Weir

Description: Alternative 5 involves removing and replacing the existing concrete diversion dam with a concave rock weir upstream of the extant dam. The profile of the new drop structure would include gradual steps, the shape and elevation of which would be optimized to provide the desired upstream water surface for safe boating and fish passage. The design will allow floating objects and sediments to pass through the main channel relatively uninhibited, which will allow for increased intake efficiency and fewer maintenance concerns.

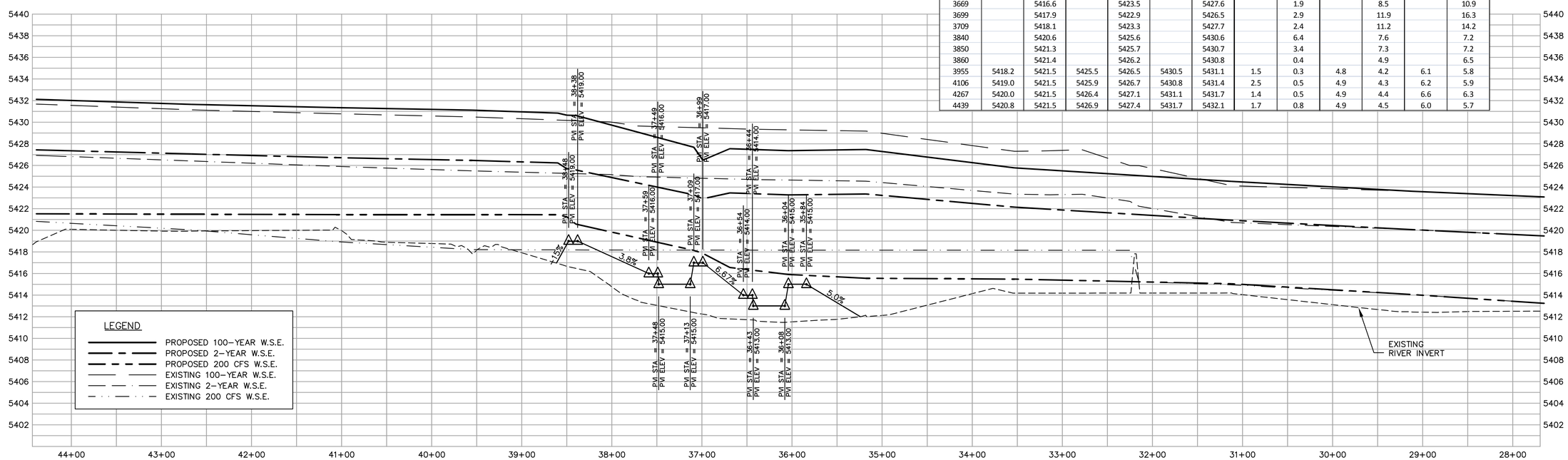
Alternative 5 requires the removal of the existing dam, though some elements may remain in place to add stability to the stream bank. The new rock weir and primary and secondary intakes will be located upstream of the extant dam, taking advantage of higher elevations at the existing pump station to improve pump efficiency.

Evaluation: The design for Alternative 5 varies significantly from that of the extant dam and waterworks, and necessitates the complete removal of the existing diversion dam, intake structure, settling basin, and piping. Alternative 5 is not classifiable as a preservation treatment, as defined by the National Park Service in the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Alternative 5 would require the complete removal of the existing Big Hole Diversion Dam, which would constitute an adverse effect and will likely require mitigation. In addition, new piping and other new construction may impact the Big Hole Pump Station, a historic property listed in the NRHP.



PLAN

	Water Surface Elevation						Velocity (ft/s)					
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
WHP STA	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR	Low Flow	Low Flow	2-YR	2-YR	100-YR	100-YR
2765	5413.2	5413.2	5419.5	5419.5	5423.1	5423.1	1.5	1.5	5.6	5.6	7.4	7.4
2911	5414.1	5414.1	5420.1	5420.1	5423.6	5423.6	2.0	2.0	5.7	5.7	8.0	8.0
3112	5415.0	5415.1	5420.7	5420.9	5424.1	5424.5	1.8	1.4	9.3	5.8	12.0	8.6
3353	5418.2	5415.5	5423.3	5422.1	5427.3	5425.8	0.6	1.2	7.9	7.9	10.9	10.8
3518	5418.2	5415.6	5424.5	5423.4	5429.2	5427.5	0.3	0.6	4.8	5.6	6.9	8.1
3604		5415.9		5423.3		5427.4		4.1		8.1		10.5
3669		5416.6		5423.5		5427.6		1.9		8.5		10.9
3699		5417.9		5422.9		5426.5		2.9		11.9		16.3
3709		5418.1		5423.3		5427.7		2.4		11.2		14.2
3840		5420.6		5425.6		5430.6		6.4		7.6		7.2
3850		5421.3		5425.7		5430.7		3.4		7.3		7.2
3860		5421.4		5426.2		5430.8		0.4		4.9		6.5
3955	5418.2	5421.5	5425.5	5426.5	5430.5	5431.1	1.5	0.3	4.8	4.2	6.1	5.8
4106	5419.0	5421.5	5425.9	5426.7	5430.8	5431.4	2.5	0.5	4.9	4.3	6.2	5.9
4267	5420.0	5421.5	5426.4	5427.1	5431.1	5431.7	1.4	0.5	4.9	4.4	6.6	6.3
4439	5420.8	5421.5	5426.9	5427.4	5431.7	5432.1	1.7	0.8	4.9	4.5	6.0	5.7



PROFILE

No.	Revision	By	Date

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

BIG HOLE RIVER DIVERSION DAM REPLACEMENT PROJECT

OPTION 5 PLAN AND PROFILE

WHPacific
12596 W Bayaud Ave., Suite 200
Lakewood, CO 80228
303-458-5550 Fax 303-480-9766
www.whpacific.com

DOWL HKM
130 N. MAIN ST.
SUITE 100
PO BOX 3588
BUTTE, MT 59701-2839
406-723-8213
406-723-8328 (FAX)
DOWLHKM.COM

Sheet No.
11

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5.0 Potential Mitigation Measures

Discussions with regulatory agencies indicate that removal of the existing diversion dam in its entirety would be the most beneficial course of action from an environmental standpoint. For alternatives that include removal, and which will constitute an adverse effect, BSB will need to consult with SHPO and other stakeholders and come to agreement on which mitigation measures should be undertaken (to be memorialized in a memorandum of understanding). HRA recommends that BSB consider one of the following mitigation measures:

- Historic American Engineering Record (HAER) recordation (Level II).
- Interpretation and education (e.g., install signs or salvaged components at the Water Department office or a city park; print a brochure or small pamphlet telling the history of the project; develop a brief documentary film and mount it on the County's website).
- Mitigation through "positive effects" on an historic resource, specifically restoration of the Big Hole Pump Station building. Appropriate positive effects mitigation of the Big Hole Pump Station could be limited to exterior character-defining features. This may include re-pointing and repair to structural brick and masonry on the building and smoke stack, and restoration of window and door openings, where appropriate.

6.0 Conclusion

HRA reviewed each alternative through the lens of the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. Of the five alternatives presented, all except Alternative 1 (the "do-nothing" option) will result in a complete loss of integrity of materials, design, workmanship, location, feeling, and association of the extant diversion dam.

Based on the likelihood of adverse effects evident in the alternatives presented, HRA recommends that greatest consideration be given to alternatives that significantly improve visual and environmental considerations along the Big Hole River while maintaining the Big Hole pump station as a working facility. Specifically, these are Alternatives 4 and 5.

Alternative 4 addresses concerns for boater and fish passage, worker and public safety, and maintains use of the Big Hole pump station building in its historic function. Though Alternative 4 is not a reconstruction of the original 1899 dam, it in some ways recalls the original diversion dam, which was a low profile dam constructed of native materials. Alternative 4 will limitedly visually impact the Big Hole River by incorporating a rock weir.

Like Alternative 4, Alternative 5 addresses concerns for boater and fish passage, worker and public safety, and maintains use of the Big Hole pump station building in its historic function. Alternative 5 will also have a limited visual impact on the Big Hole River by incorporating a rock weir. Alternative 5 would also be constructed of native materials.

Based on these considerations, HRA recommends either Alternative 4 or 5, maintaining a slight preference for Alternative 5 because of the limited visual impact of the upstream rock weir concept. Final preference should be given to the alternative with the greatest cost-benefit ratio for the citizens and staff of BSB County.

Appendix A
Montana Cultural Resources Information (CRIS) Form

MONTANA CULTURAL RESOURCES INFORMATION SYSTEM (CRIS) FORM

1. IDENTIFICATION

***required to receive Smithsonian number**

1.1 Smithsonian Number: 24SB257 **1.2 Field Designation:**

1.3 Project Name: Big Hole Diversion Dam Environmental Assessment

1.4 Agency Project Number: 4428.10198.01 **1.5 Consultant Project Number:** HRA 1569

2. LOCATION

***2.1 Township:** 1S **Range:** 10W **Section:** 12 **¼ Section(s):** SW, NE, SW ***2.2 County:** Butte – Silver Bow

***2.3 UTM Coordinates:** Zone 12 E 360771.108 m; N 5069314.481m ***Datum used:** ☒NAD 83 conus

***2.4 Administrative/Surface Ownership:** (Agency/Region/District/Office)
Butte Water Company, 124 W Granite Street, Butte, MT

***2.5 7.5' USGS Map Name, Date:** Dewey, MT (1996)

2.6 Narrative of access: From Butte, take I-15 South to Divide (exit 102). Turn right (west) on Montana Highway 43 and travel approximately two (2) miles. Turn right (north) onto Pumphouse Road, and travel approximately half a mile to the Big Hole Pumpstation. The Diversion Dam is located due south of the Pumpstation, in the Big Hole River.

2.7 City/Town: **Vicinity of:** Divide, Montana

3. DESCRIPTION

***3.1 Site Category** (choose one)**:** ☐ Prehistoric ☒ Historic ☐ Paleontological ☐ Combination ☐ Other

***3.2 Site Type** (see recommended site type list, choose all that apply)**:** Historic Reclamation

3.3 Narrative Description of Site:
The Big Hole Diversion Dam, built in 1927, is located in the canyon of the Big Hole River, approximately 27 miles southwest of Butte, Montana, and 2 ½ miles west of Divide, Montana. The dam and settling basin are constructed of reinforced, poured-in-place concrete, with concrete abutment walls along the banks of the river. Remnants of the original dam, constructed contemporary with the Big Hole Pump Station in 1899, are visible in the form of the rock wall extant on either side of the concrete abutment on the north bank.

The diversion dam spans the width of the Big Hole River, running roughly northeast to southwest. The span, approximately 190 feet in length, also acts as the downstream wall of the settling basin, a concrete enclosure on the north side of the river. The settling basin is trapezoidal in shape, extending approximately 70 feet into the river at the dam, 100 feet upstream of the dam, and 50 feet back to the north shore wall. Water enters the basin through a series of sluice gates, and is then sucked into an underground conduit that channels the water into a concrete suction well.

The suction well, located on the north bank of the river south of and adjacent to the pump house, is a cylindrical concrete structure 20 feet in diameter that acts as a holding tank. The suction well feeds water to the pumps in the pump station through a series of suction pipes. The pumps then move the water through 36-inch steel pipelines, completed in 1979, to the treatment facility near Feely, Montana, approximately 9 miles north of the diversion dam.

The vertical upstream face of the diversion dam is approximately 5 feet high and 10 feet wide at the bottom, tapering to a width of approximately one foot at the top. The top is covered with a concrete cap, and significant deterioration of the wall has revealed the rubble stone and concrete beneath. The dam is bisected by a concrete channel that carries excess water from the settling basin sluice gates to the downriver side of the dam. A concrete platform in the center of the river provides access to both the sluice gates and the channel. The sluice gates are in fair condition, and appear to be the original metal housing with wood gates. The platform is accessed by a concrete catwalk which spans the settling basin to the north shore. The catwalk appears to be original to the dam itself, though the metal access stairs on the platform are a recent replacement.

The diversion dam and settling basin are in poor condition, specifically due to the advanced deterioration of the concrete. Spalling, steel jacking, and other damage to the concrete are evident throughout all visible areas of the dam.

The condition of the dam span downstream of the settling basin is likely indicative of excessive deterioration below the water line.

The site of the Big Hole Diversion Dam and Pump Station has changed significantly since the 1920s. All but one of the outbuildings has been removed, with only the hose house remaining. Based on photographic evidence c. 1920, the hose house appears to have been relocated to its current site northwest of the pump station. A bungalow style residence borders the pump station to the west, but is not affiliated with the facility and is not one of the original worker's residences. The residence is bordered on the south by a small irrigation ditch/creek, which parallels the Big Hole River west of the house before diverting northeast just west of the pump station.

3.4 Site Dimensions: approximately 646,000 square feet (15 acres)
Surface visibility: 50% (good visibility)

3.5 Feature Descriptions:

3.6 Artifacts: (✔ all that apply) ☐Chipped Stone ☐Wood ☐Ground Stone ☐Ceramics ☐Bone ☐Trade ☒Other
Description: brick, stone and concrete from dam construction

3.7 Diagnostic Artifacts: N/A

3.8 Subsurface Testing: N/A

3.9 Site function/interpretation: The Big Hole Diversion Dam channels water into the Big Hole Pump Station from the Big Hole River. The water is then pumped through a series of metal pipes over the continental divide to the city of Butte, and serves as the primary potable water source for that town. There is currently no on-site interpretation of the facilities.

4. PERIOD

4.1 Apparent Time Period of Site (use dropdowns)**:**
Prehistoric **Historic:** 1920-1929 **Paleontological**

5. ENVIRONMENTAL SETTING

5.1 Geographic Setting: River Canyon

5.2 Contour: ☐ Known ☐ Approximate ☒ Unknown **5.3 Elevation:** approximately 5400 ft

5.4 View/Aspect (estimated direction and distance): Unknown

5.5 Sediments: Unknown
Deposition: ☐ Surface Only ☐ Buried Only ☐ Surface and Buried ☐ Redeposited ☐ Other

5.6 Available Water Sources (use dropdown)**:** Stream/River/Creek

5.7 Major River Drainage (name, distance, elevation): Big Hole River, at site, 5400 feet.

5.8 Minor Drainage (name, distance, elevation):

5.9 Local Vegetation: Unknown **Regional Vegetation:** Unknown

6. ASSESSMENT, RECORDING & MANAGEMENT

6.1 Significance: The Big Hole Diversion Dam, constructed in 1927, replaced an earlier timber and rock structure built concurrent with the Pump Station in 1899. The diversion dam, though constructed outside of the period of significance (1899) established in the Big Hole Pumpstation nomination, is considered a contributing resource to the Big Hole Pumpstation, which was listed on the National Register of Historic Places in 1980.

6.2 Condition/Integrity: Condition: Poor. Integrity: Good.

MONTANA CULTURAL RESOURCES INFORMATION SYSTEM (CRIS) FORM

6.3 Possible impacts to site: Impacts may include significant alterations to or complete removal of the extant Big Hole Diversion Dam. Other impacts may include alterations to the Big Hole Pump Station building, including modifications to or additions of openings for water intake pipes.

6.4 Evaluation: Does this property meet National Register criteria for eligibility? ☒ **Yes** ☐ **No** ☐ **Unevaluated**
Evaluation Procedures/Justification: Property was listed on the National Register as a contributing structure

6.5 Recording status: ☐ surface examination ☒ photo ☒ map ☐ subsurface tested

6.6 Recommendations (use dropdown)**:** Removal of dam with appropriate mitigation measures
Comments: Options for a replacement dam include a "no dam" option, with an upstream constriction constructed of native stone replacing a traditional dam. This option restores fish passage, alleviates concerns for public and worker safety, and evokes the original 1899 timber and rock dam built concurrent with the Pump Station.

6.7 Site Located by: N/A **Date Located:** N/A

6.8 Site Recorded by: N. Perrin and H. Miller, HRA - Seattle **Date Recorded:** August 3, 2009

6.9 Site form update and revisions by: N. Perrin **Date updated:** August 10, 2009

6.10 Federal/State Permit No:

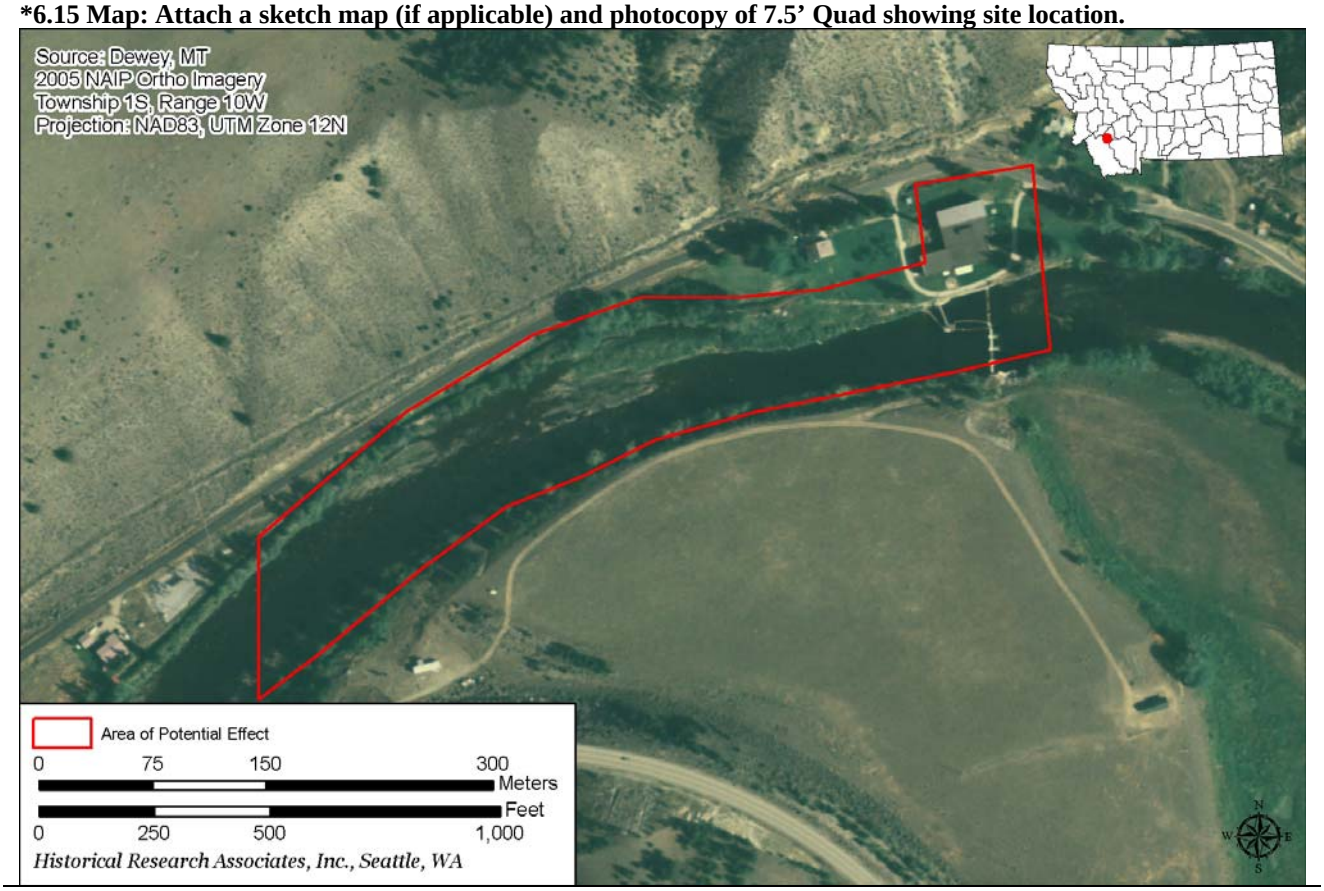
6.11 Publication(s)/Report(s) where site is described:
"Butte, Montana, Water Works," *The Mueller Record*, v. 221. January, 1931.On file at the Butte Silver Bow Archives, Folder VF2145, Utilities: Butte Water Company General Information.

6.12 Artifact Repository: N/A

6.13 Field notes/maps/photos repository:
HRA – Seattle, 1904 Third Avenue, Suite 240, Seattle, WA 98101

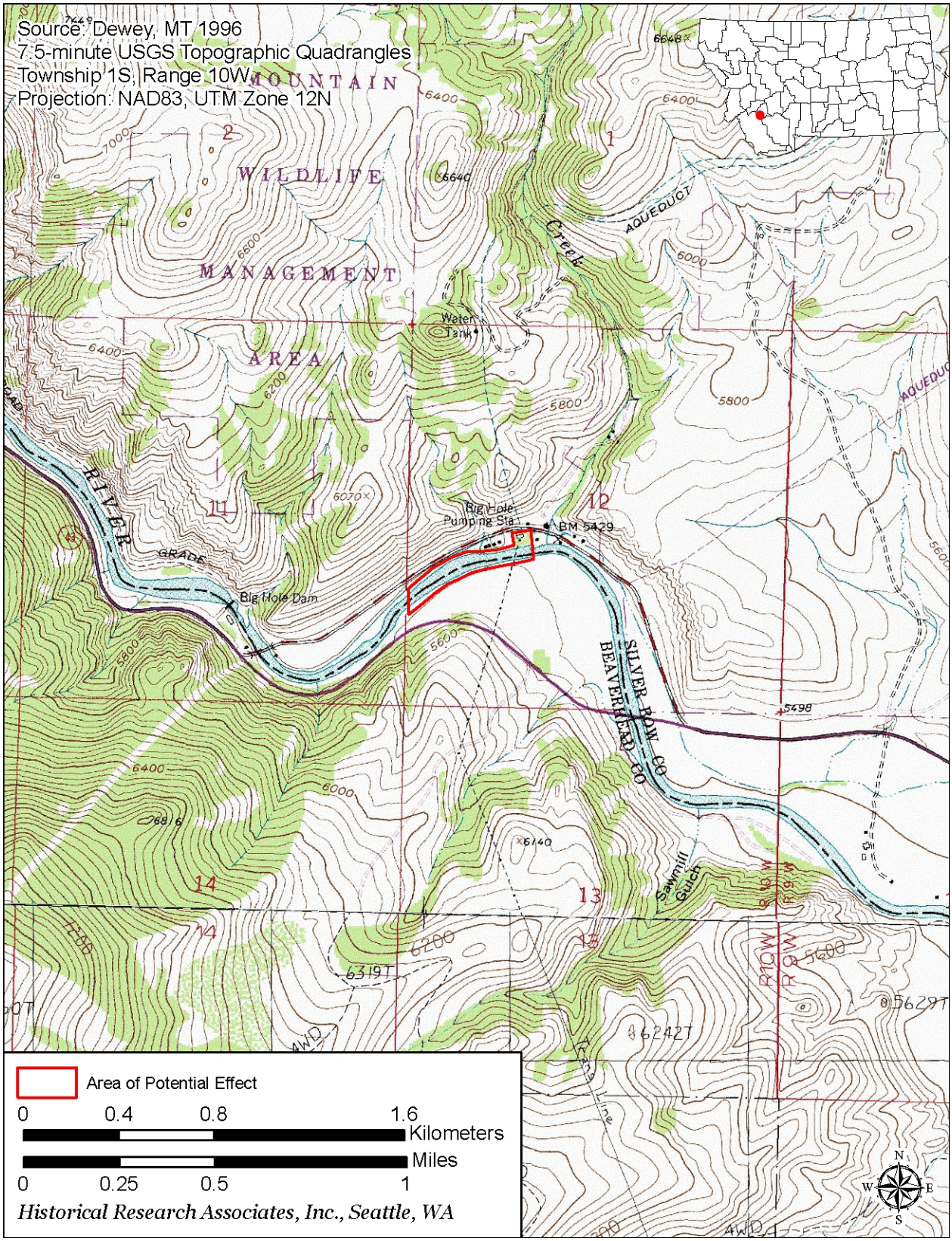
6.14 Photographs: see continuation pages

***6.15 Map: Attach a sketch map (if applicable) and photocopy of 7.5' Quad showing site location.**



After Smithsonian number received, submit completed form to the Archaeological Records Office.

MONTANA CULTURAL RESOURCES INFORMATION SYSTEM (CRIS) FORM



After Smithsonian number received, submit completed form to the Archaeological Records Office.

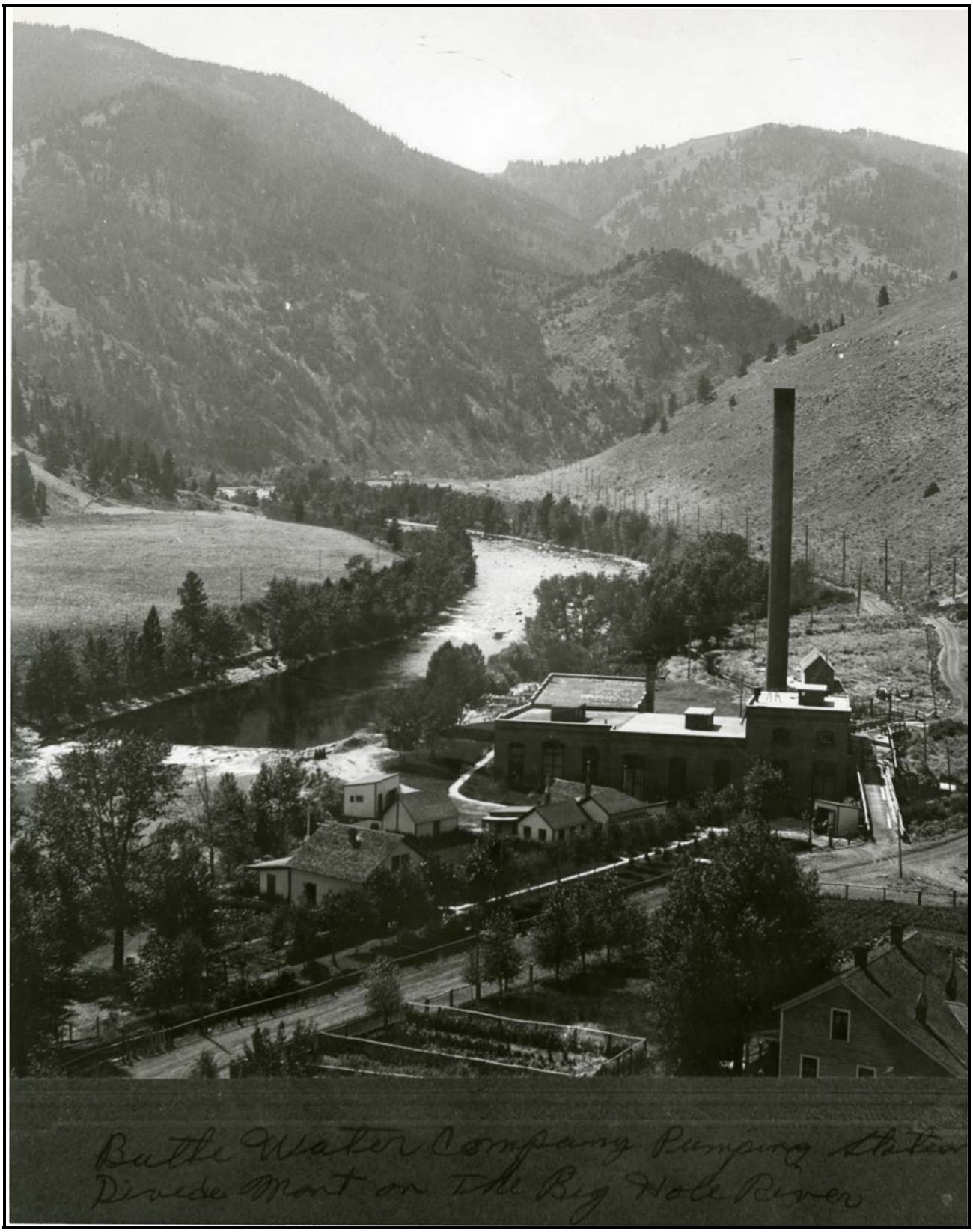


Photo 1: "Butte Water Company Pumping Station, Divide Mont. on the Big Hole River," c. 1920
Photo courtesy of the World Museum of Mining, Butte, Montana.

Photo 2: Big Hole pump station, settling basin, and diversion dam, viewing northeast from the south bank of the Big Hole River. Photo courtesy of HRA, 2009.

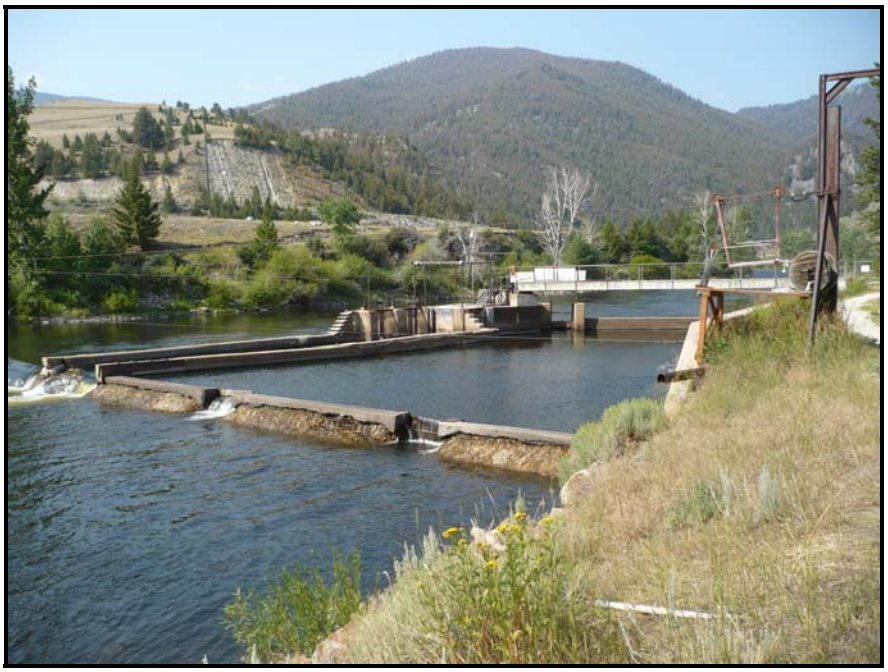


Photo 3: Big Hole settling basin and diversion dam, viewing southwest from the north bank of the Big Hole River. Photo courtesy of HRA, 2009.

Photo 4: The north abutment wall of the Big Hole diversion dam settling basin. Note the original (1899) rubble stone wall where it abuts the reconstructed (1927) concrete retaining wall. Photo courtesy of HRA, 2009.

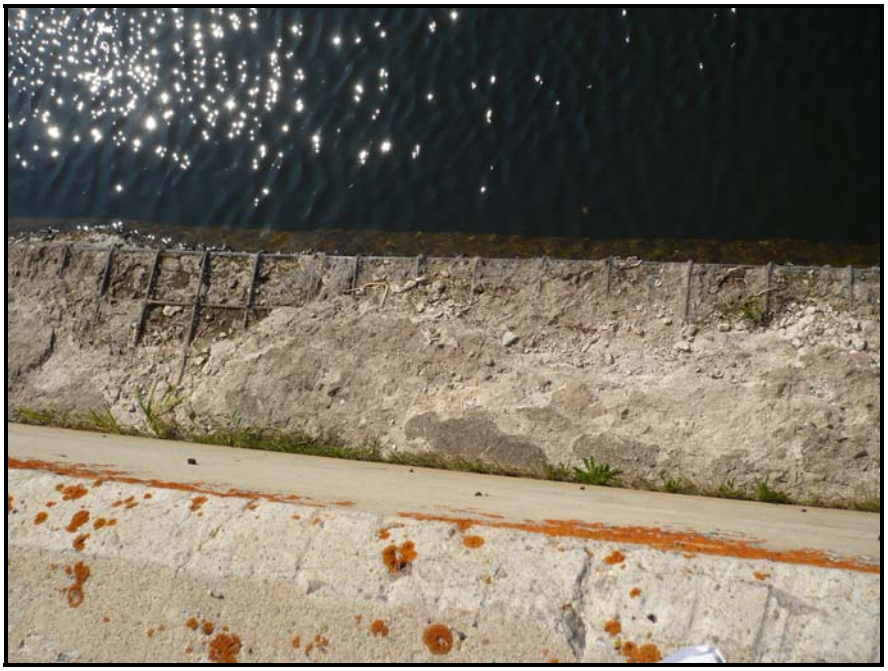
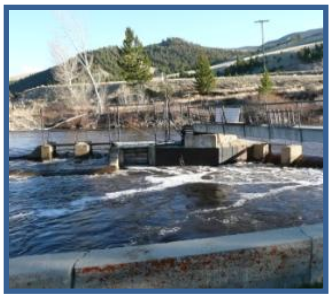


Photo 5: Viewing into the settling basin from the north bank. Note significant concrete deterioration and exposure of steel rebar. Photo courtesy of HRA, 2009.



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX H

SCOPING LETTERS

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Todd Tillinger
U.S. Army Corps of Engineers
10 West 15th Street, Suite 2200
Helena, Montana 59626

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Project Number: NWO-2008-1913-MTH

Dear Mr. Tillinger:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The U.S. Army Corps of Engineers (USACE) has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a Federal Clean Water Act Section 404 Permit. BSB anticipates that this will be the only federal permit required for the project.

With this letter, BSB requests comments and information from USACE relative to the permitting requirements for this project. BSB requests that USACE identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent USACE from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Bryan Miller
Bridge Bureau
Montana Department of Transportation
2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

MDT Structure #: P00046075+0061

Dear Mr. Miller:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Montana Department of Transportation (MDT) has been identified as an agency that may have an interest in the project because there is a bridge located near the project site (MDT Structure # P00046075+0061). The bridge is on State Highway 43 and crosses the Big Hole River approximately two miles west of the town of Divide, Montana. It is not clear at this time whether the proposed project will impact this bridge.

With this letter, BSB requests that MDT identify, as early as practicable, any issues of concern regarding the project's potential impacts that could substantially affect the project development process. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Bruce Rich, Fisheries Manager
Butte Area Resource Office
Montana Fish, Wildlife & Parks
1820 Meadowlark Lane
Butte, MT 59701

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Rich:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

Montana Fish, Wildlife & Parks (FWP) has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a Stream Protection Act (SPA) 124 Permit.

With this letter, BSB requests comments and information from FWP relative to the permitting requirements for this project. BSB requests that FWP identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent FWP from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

cc (w/ attachment): Jim Olsen, Fisheries Biologist - FWP

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

Steve Potts
U.S. Environmental Protection Agency
10 West 15th Street, Suite 3200
Helena, MT 59626

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Potts:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The U.S. Environmental Protection Agency (EPA) has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a Federal Clean Water Act Section 404 permit.

With this letter, BSB requests comments and information from EPA relative to the permitting requirements for this project. BSB requests that EPA identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent any EPA approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

cc (w/ attachment): Toney Ott - EPA

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Terry Eccles
Regional Manager
Water Resources Division - Helena Regional Office
Montana Department of Natural Resources and Conservation
1424 Ninth Avenue
P.O. Box 201601
Helena, Montana 59620-1601

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Eccles:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Montana Department of Natural Resources and Conservation (DNRC) has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a Montana Land-Use License or Easement on Navigable Waters and a Montana Dam Safety Act Hazard Classification and Construction Permit.

With this letter, BSB requests comments and information from DNRC relative to the permitting requirements for this project. BSB requests that DNRC identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent DNRC from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Tom Ellerhoff
Administrative Officer
Montana Department of Environmental Quality
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Ellerhoff:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Montana Department of Environmental Quality (DEQ) has been identified as an agency that may have an interest in the project due to potential permitting involvement. Specifically, BSB anticipates the need for a Federal Clean Water Act Section 401 Certification, Short-term Water Quality Standard for Turbidity (318 Authorization), and potentially a Montana Pollutant Discharge Elimination System (MPDES) General Permit for Storm Water Discharges Associated with Construction Activity.

With this letter, BSB requests comments and information from DEQ relative to the permitting requirements for this project. BSB requests that DEQ identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent DEQ from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

cc (w/attachment): Jeff Ryan - DEQ

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

pubworks@co.silverbow.mt.us

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Steve Hess
Butte - Silver Bow County Floodplain Administrator
155 W. Granite
Butte, MT 59701

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Hess:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

You have been identified as a party that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a County Floodplain Permit.

With this letter, BSB requests comments and information relative to the permitting requirements for this project. BSB requests that you identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent you from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

cc (w/attachment): Lori Casey - Silver Bow County

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Rick Hotaling
Field Manager
U.S. Bureau of Land Management
106 N. Parkmont
Butte, Montana 59701

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Hotaling:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The U.S. Bureau of Land Management (BLM) has been identified as an agency that may have an interest in the project because there is a tract of land under BLM ownership located near the project site. It is not clear at this time whether the proposed project will impact BLM land.

With this letter, BSB requests comments and information from BLM relative to the permitting requirements for this project. BSB requests that BLM identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could that could substantially affect the project development process. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

July 31, 2009

Mark Wilson
U.S. Fish and Wildlife Service
585 Shepard Way
Helena, MT 59601

Re: Request for Information and Solicitation of Comments

Project Name: Big Hole Diversion Dam

Dear Mr. Wilson:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The U.S. Fish and Wildlife Service (USFWS) has been identified as an agency that may have an interest in the project. Specifically, BSB anticipates the need to consult with USFWS in accordance with requirements under the Endangered Species Act (ESA).

With this letter, BSB requests that USFWS identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent any USFWS approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

We will be contacting you in the near future to schedule an agency coordination meeting to be held sometime in August or September 2009, at which time we will request your review of a proposed Purpose and Need statement, alternatives under consideration, and existing conditions information gathered to date. BSB will take any additional comments on the project at that time.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Assistant Public Works Director
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

October 6, 2009

Danette Watson
Beaverhead Conservation District
420 Barrett St.
Dillon, MT 59725

Re: Request for Information and Solicitation of Comments
Project Name: Big Hole Diversion Dam

Dear Ms. Watson:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Beaverhead Conservation District has been identified as an agency that may have an interest in the project due to the proposed work in the Big Hole River. It should be noted, however, that the project team anticipates needing a SPA 124 Permit as opposed to a 310 Permit; accordingly no permitting involvement is anticipated through the Beaverhead Conservation District.

With this letter, BSB requests that the Beaverhead Conservation District (BCD) identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent any BCD approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

October 6, 2009

Larry Laknar
Beaverhead County Floodplain Administrator
2 South Pacific St., STE #12
Dillon, MT 59725

Re: Request for Information and Solicitation of Comments
Project Name: Big Hole Diversion Dam

Dear Mr. Laknar:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

Beaverhead County has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a floodplain permit through Beaverhead County.

With this letter, BSB requests comments and information from Beaverhead County relative to the permitting requirements for this project. BSB requests that Beaverhead County identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent Beaverhead County from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

October 6, 2009

Dana Boruch
Right-of-Way Specialist
Southwestern Land Office
1401 27th Street
Missoula MT 59804

RECEIVED
OCT 13 2009
SOUTHWESTERN
LAND OFFICE

Re: Request for Information and Solicitation of Comments
Project Name: Big Hole Diversion Dam

Dear Ms. Boruch:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Montana Department of Natural Resources and Conservation (DNRC) has been identified as an agency that may have an interest in the project because of potential permitting involvement. Specifically, BSB anticipates the need for a Montana Land-Use License or Easement on Navigable Waters.

With this letter, BSB requests comments and information from DNRC relative to the permitting requirements for this project. BSB requests that DNRC identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent DNRC from granting a permit or other approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

October 6, 2009

Kris Hugulet
Mile High Conservation District
P.O. Box 890
Whitehall, MT 59759

Re: Request for Information and Solicitation of Comments
Project Name: Big Hole Diversion Dam

Dear Ms. Hugulet:

The City and County of Butte-Silver Bow (BSB) is initiating an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. The project is being funded through the Natural Resource Damage Program's (NRDP's) grant funds, with matching funds provided by BSB. No federal funds will be used for the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Mile High Conservation District has been identified as an agency that may have an interest in the project due to the proposed work in the Big Hole River. It should be noted, however, that the project team anticipates needing a SPA 124 Permit as opposed to a 310 Permit; accordingly no permitting involvement is anticipated through the Mile High Conservation District.

With this letter, BSB requests that the Mile High Conservation District (MHCD) identify, as early as practicable, any issues of concern regarding the project's potential environmental or socioeconomic impacts that could substantially delay or prevent any MHCD approval that is needed for the project. With this letter, BSB is also requesting any information you may have regarding the project area.

Please submit written comments to our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), or by e-mail (snicolai@hkminc.com). Please provide any initial written comments within thirty (30) calendar days from receipt of this letter.

If you have any questions regarding the project, you may contact Sarah Nicolai of DOWL HKM at 406-442-0370.

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Confederated Salish & Kootenai tribes
Marcia Pablo, Tribal Preservation Department
PO Box 278
Pablo, MT 59855

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Ms. Pablo:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

(4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Northern Cheyenne Tribe
Lynwood Tall Bull, Historic Preservation Officer
Northern Cheyenne Agency
P.O. Box 128
Lame Deer, MT 59043

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Tall Bull:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your

tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

> (4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Little Shell Tribe of Chippewa Indians
Tribal Historic Preservation Office
PO Box 1384
Great Falls, MT 59403

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

To Whom It May Concern:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

(4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Peter Bigstone
Fort Belknap Tribal Historic Preservation Officer
RR1 Box 66
Harlem, MT 59526

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Bigstone:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

(4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

The Crow Tribe of Indians
Dale Old Horn, Historic Preservation Officer
Baacheeitche Avenue
P.O. Box 159
Crow Agency, Montana 59022

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Old Horn:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your

tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

> (4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Chippewa Cree Tribe of the Rocky Boys
Alvin Windy Boy, Historic Preservation Officer
RR 1 P.O. Box 544
Box Elder, MT 59521

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Windy Boy:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

(4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operation Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
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EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Blackfeet Nation Tribe
John Murray, Historic Preservation Officer
P.O. Box 2809
Browning, MT 59417

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Murray:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

(4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 9, 2009

Assiniboine & Sioux Tribes
Darrell 'Curley' Youpee
Cultural Resources Department
P.O. Box 1027
Fort Peck Agency
Poplar, MT 59255-1027

SUBJECT: Request for knowledge of, or concerns with, Historic Properties in proximity to the proposed Big Hole River Diversion Dam Project

Dear Mr. Youpee:

The City and County of Butte-Silver Bow (BSB) plans to repair or replace the Big Hole River diversion dam and intake structure. The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the enclosed figure.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. The proposed project would involve full or partial removal of the existing diversion dam, and replacement with a new diversion structure and intake system located within 500 feet of the existing facility.

The U.S. Army Corps of Engineers (Corps) is serving as the lead federal agency for this project. As part of the planning process for this project, BSB and the Corps are assessing potential effects on cultural resources. To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's area of potential affect (APE). We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your

tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

> (4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that BSB will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact our consultant, DOWL HKM, at PO Box 1009, Helena, MT 59624 (Attn: Sarah Nicolai), by telephone at (406) 442-0370 extension 605, or by e-mail (snicolai@hkminc.com).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Enclosure

126 W. GRANITE
BUTTE, MT 59701

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 30, 2009

Montana Chapter of the Sierra Club
P.O. Box 1290
Bozeman, Montana 59771

Re: Notice of Availability and Solicitation of Comments
Project Name: Big Hole River Diversion Dam

To Whom It May Concern:

The City and County of Butte-Silver Bow (BSB) is preparing an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. Primary funding for this project is being provided through a grant from the Natural Resource Damage Program (NRDP), with matching funds provided by BSB. The U.S. Army Corps of Engineers (USACE) is also contributing federal funds for the design phase of the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section
1S	10W	12

The proposed project area is illustrated in the attached figure.

The Public and Agency Review Draft EA will soon be available for review and comment. The Preferred Alternative identified in the EA includes elements that best satisfy the need for the project while minimizing impacts. The proposed action is the replacement of the existing diversion dam structure and intake facility. The proposed project would provide a reliable source of water for Butte, safety improvements for maintenance personnel and recreational users, and improved fish and boat passage.

Beginning on December 10, 2009, the EA will be available for review at the following locations:

- Butte Public Library (226 W. Broadway)
- Butte-Silver Bow Public Works Office (126 W. Granite)
- Online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09)
- Email dick.talley@hkminc.com or call (406) 723-8213, ext. 409 for a copy

The formal comment period will extend from December 10, 2009 to January 15th, 2010. With this letter, BSB requests comments from the Montana Chapter of the Sierra Club relative to this project.

Please submit written comments to our consultant, DOWL HKM, at P.O. Box 3588, Butte, MT 59702 (Attn: Dick Talley), or by e-mail (dick.talley@hkminc.com), or online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09). Please provide written comments by the close of the comment period (January 15, 2010).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us
WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 30, 2009

Montana Environmental Information Center
107 West Lawrence St. #N-6
P.O. Box 1184
Helena, Montana 59624

Re: Notice of Availability and Solicitation of Comments
Project Name: Big Hole River Diversion Dam

To Whom It May Concern:

The City and County of Butte-Silver Bow (BSB) is preparing an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. Primary funding for this project is being provided through a grant from the Natural Resource Damage Program (NRDP), with matching funds provided by BSB. The U.S. Army Corps of Engineers (USACE) is also contributing federal funds for the design phase of the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section

1S 10W 12

The proposed project area is illustrated in the attached figure.

The Public and Agency Review Draft EA will soon be available for review and comment. The Preferred Alternative identified in the EA includes elements that best satisfy the need for the project while minimizing impacts. The proposed action is the replacement of the existing diversion dam structure and intake facility. The proposed project would provide a reliable source of water for Butte, safety improvements for maintenance personnel and recreational users, and improved fish and boat passage.

Beginning on December 10, 2009, the EA will be available for review at the following locations:

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- Email dick.talley@hkminc.com or call (406) 723-8213, ext. 409 for a copy

The formal comment period will extend from December 10, 2009 to January 15th, 2010. With this letter, BSB requests comments from the Montana Environmental Information Center (MEIC) relative to this project.

Please submit written comments to our consultant, DOWL HKM, at P.O. Box 3588, Butte, MT 59702 (Attn: Dick Talley), or by e-mail (dick.talley@hkminc.com), or online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09). Please provide written comments by the close of the comment period (January 15, 2010).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Attachment: Proposed Project Area

126 W. GRANITE
BUTTE, MT 59701

BSB
Butte-Silver Bow
PUBLIC WORKS DEPARTMENT
pubworks@co.silverbow.mt.us

WATER-ROADS-ANIMAL CONTROL-METRO SEWER-PARKS AND REC
EQUIPMENT MAINT.-TRAFFIC CONTROL-LANDFILL-TRANSIT

OFFICE: (406) 497-6515
FAX: (406) 497-6524

November 30, 2009

David Gaillard
Defenders of Wildlife Rocky Mountain Region Office
303 West Mendenhall, Suite 3
Bozeman, MT 59715

Re: Notice of Availability and Solicitation of Comments
Project Name: Big Hole River Diversion Dam

Dear Mr. Gaillard:

The City and County of Butte-Silver Bow (BSB) is preparing an Environmental Assessment (EA) for the proposed project to replace the Big Hole River diversion dam and intake structure. This project is subject to the provisions of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) because state and federal permits will be required. Primary funding for this project is being provided through a grant from the Natural Resource Damage Program (NRDP), with matching funds provided by BSB. The U.S. Army Corps of Engineers (USACE) is also contributing federal funds for the design phase of the project.

The facility is owned and managed by BSB and is used to divert water from the Big Hole River to storage and distribution systems in Butte, providing Butte's primary source of potable water. The existing diversion dam and associated intake structure is approximately 80 years old and has outlived its useful life. Due to its age, the facility is in poor condition and poses an imminent threat of failure or malfunction, which would deprive the citizens of Butte of potable water. Additionally, there are two main safety issues associated with maintenance and recreation at the site. First, the facility experiences icing problems in winter months. In order to remove the ice, BSB personnel often must venture onto the ice, placing themselves at risk of injury or drowning. Secondly, the current configuration of the dam results in a turbulent area immediately downstream that is a life-threatening danger to boaters or recreationalists who might deliberately or inadvertently float or be swept over the dam.

Accordingly, the purpose of the proposed project is to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists.

The proposed project is located in Silver Bow County near the community of Divide, Montana within the following legal description:

Township	Range	Section

1S 10W 12

The proposed project area is illustrated in the attached figure.

The Public and Agency Review Draft EA will soon be available for review and comment. The Preferred Alternative identified in the EA includes elements that best satisfy the need for the project while minimizing impacts. The proposed action is the replacement of the existing diversion dam structure and intake facility. The proposed project would provide a reliable source of water for Butte, safety improvements for maintenance personnel and recreational users, and improved fish and boat passage.

Beginning on December 10, 2009, the EA will be available for review at the following locations:

- Butte Public Library (226 W. Broadway)
- Butte-Silver Bow Public Works Office (126 W. Granite)
- Online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09)
- Email dick.talley@hkminc.com or call (406) 723-8213, ext. 409 for a copy

The formal comment period will extend from December 10, 2009 to January 15th, 2010. With this letter, BSB requests comments from the Defenders of Wildlife relative to this project.

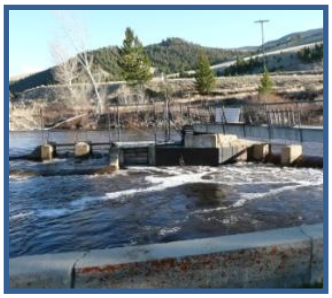
Please submit written comments to our consultant, DOWL HKM, at P.O. Box 3588, Butte, MT 59702 (Attn: Dick Talley), or by e-mail (dick.talley@hkminc.com), or online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09). Please provide written comments by the close of the comment period (January 15, 2010).

Sincerely,

Rick Larson

Rick Larson
Operations Manager-Utilities Division
City and County of Butte-Silver Bow

Attachment: Proposed Project Area



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX I

AGENCY RESPONSE LETTERS

From: Ryan, Jeff [jeryan@mt.gov]
Sent: Wednesday, August 05, 2009 3:16 PM
To: Nicolai, Sarah
Cc: Ellerhoff, Thomas; Chambers, Jenny; Ryan, Jeff; Romankiewicz, Christopher
Subject: Big Hole Diversion Dam - Comments

Sarah, DEQ received a July 31/2009 letter from Rick Larson, Assistant Public Works Director - City/County Butte-Silver Bow requesting preliminary agency scoping comments on the draft EA that is being completed for the proposed project to replace the Big Hole River diversion dam and intake structure.

We have been involved in a couple previous on-site and office meetings on this project and fully understand the need to provide a newer more efficient means of providing Butte-Silver Bow it's drinking water supply. As noted in the Montana Water Quality Act, 75-5-101 "Policy" (1) "conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses". While the main emphasis of this proposed project involves the beneficial uses of drinking water, the need to support the other beneficial uses, such as fish and aquatic life and recreation, is of equal importance. The EA should consider a design alternative that not only satisfies the water supply needs, but also provides for efficient fish and safe boater passage. Hopefully, a design that accomplishes these goals, without an actual dam at the site, can be considered.

As stated in the previously noted Butte-Silver Bow letter, DEQ will be involved in this project through several of it's permitting responsibilities. We also look forward to participating in the up-coming multi-agency meeting to review the purpose and need statement for the project EA that is being developed.

serving you with pride

Montana Department of Transportation
2701 Prospect Avenue
PO Box 201001
Helena MT 59620-1001

Jim Lynch, Director
Brian Schweitzer, Governor

August 11, 2009

Sarah Nicolai
PO Box 1009
Helena, MT 59624

Subject: Butte-Silver Bow Big Hole Diversion Dam

This letter is in response to a request for comments from the Butte-Silver Bow Public Works Department (BSB) dated July 31, 2009. BSB is proposing to replace the existing diversion dam and intake structure in order to provide a reliable source of drinking water for the Butte service area and to improve safety at the site for maintenance personnel and recreationalists. MDT has the following comments:

MDT is concerned for the potential of a head cut to develop at the dam site and travel upstream. What are the plans for monitoring and mitigating the potential head cut? MDT issues associated with a head cut include the roadway embankment adjacent to the Big Hole River of State Highway 43.

Structure P00046075+0061 as referenced in the letter from BSB is located approximately 1 mile downstream of the diversion dam. MDT currently does not see any issues associated with the proposed project with this structure. If project issues associated with this bridge surface, please keep MDT informed.

Structure L47017000+01001 is owned by BSB and is approximately 1 mile upstream. MDT is unaware of the foundation type for this bridge and has not evaluated the bridge for scour. The bridge is included in the State Wide scour evaluation program. The USGS will visit the site in the future to complete an initial scour review. If the bridge is determined to be scour critical, MDT will inform BSB.

Bryan Miller, P.E.
Bridge Area Engineer

copies: Mark Goodman – Hydraulics Engineer
Mike Murphy – Bridge Management Engineer

BUTTE-SILVER BOW
HISTORIC PRESERVATION OFFICE
PLANNING DEPARTMENT
155 W. Granite Street Butte, MT 59701
406-497-6258

October 19, 2009

Dick Talley
DOWL HKM
P.O. Box 3588
Butte, MT 58702

Re: Comments on Proposed Demolition – Big Hole River Diversion Dam

Dear Dick:

As a follow-up to the September 6, 2009 Historic Preservation Commission meeting, I have summarized the comments and concerns expressed by the Commission relating to removal of the Big Hole River Diversion Dam.

Main Points of Commission Discussion

1. The Big Hole River Pump Station is listed on the National Register of Historic Places. The Dam is a contributing element of the historic pump station facility.
2. When historic resources in Silver Bow County are threatened, the local Historic Preservation Commission is responsible for reviewing the project, exploring opportunities to prevent or mitigate loss of such resources, and recommending approval, approval with conditions, or denial of the demolition request.
3. The existing dam is failing, resulting in potential health and safety concerns.
4. Several possible design alternatives for the new dam are being considered.
5. In this case, the Commission stated they were unable to effectively evaluate the impacts of the proposed demolition, or issue a recommendation, without a better understanding of the final dam design.
6. In the absence of a final proposal, the Commission offered the following general suggestions intended to mitigate possible impacts to historic resources, and facilitate design of the dam.
    a. Only remove those elements of the existing dam necessary to accomplish the goals of the project, e.g. retain historic stonework along riverbank.

b. New dam design should have minimal visual impact to the overall pump station setting, e.g. low height, natural colors and materials.
c. Existing dam design should be professional documented according National Park Services HABS/HAER standards.
d. Install interpretative panel at the site to describe the original design and workings of the dam.
e. Impacts to existing pump station buildings and archaeological resources are avoided, or minimized, during dam construction.
f. Any new buildings or structures erected at the site should be submitted to the Historic Preservation Commission for design review.

Thank you for this opportunity to comment on this important project. If you require any additional information please contact me. As your plans unfold, the Commission is ready to re-evaluate this demolition request.

Sincerely,

Jim Jarvis
BSB Historic Preservation Officer

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

BRIAN SCHWEITZER, GOVERNOR

STATE OF MONTANA

Telephone: (406) 542-4200
FAX: (406) 542-4285

SOUTHWESTERN LAND OFFICE
1401 27th Avenue
Missoula, Montana 59804-3199

November 2, 2009

DOWL HKM
Attn: Sarah Nicolai
PO Box 1009
Helena MT 59624

RE: Butte-Silver Bow replacement of the Big Hole dam water diversion structure

Dear Ms. Nicolai:

Thank you for the opportunity to provide initial comment regarding the proposal to replace the Bug Hole River diversion dam and intake structure.

As you are aware, the Department of Natural Resources & Conservation (DNRC) Trust Lands Management Division (TLMD) is one of several permitting agencies that will oversee the proposed project. The DNRC TLMD regulatory authority is over the streambed of the Big Hole River, the portions in which the project is located being considered a navigable waterway and owned by the State of Montana in trust for the common schools.

Most – if not all – of our concerns are likely similar to those that have already been considered. DNRC believes that the following should be analyzed:

- Passive public portage for the project should be included to maintain the intended navigability of the Big Hole River
- Alternatives should focus on the safety concerns for both the service personnel and the public uses of the Big Hole River
- A fishery assessment should be completed, and all alternatives should ensure connectivity of fish habitat based on the fishery assessment
- Design alternatives should be considered to prevent fish from entering the treatment system
- Which alternative provides for the best long term channel stability and protection of the streambed and banks of the river?

One significant concern that we have at this time is the lack of coordination with the applicant among the permitting agencies with regards to the environmental review that is required of most (if not all) of the permitting agencies, whether that be under the National Environmental Protection Act (NEPA) or the Montana Environmental Protection Act (MEPA). Multiple environmental reviews compound the potential for dueling opinions regarding many factors

and they also open the door for multiple mitigations, resulting in further complexity for addressing issues when factoring in other agencies.

We believe that the best approach to this task is to complete an agreement with all of the permitting agencies prior to undertaking the environmental review. This would ensure that all issues are analyzed such that each agency is able to use one singular environmental document for permitting. Typically these joint documents result in the permitting agencies signing the completed document as the decision maker.

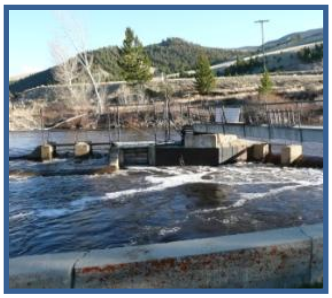
The Southwestern Land Office looks forward to assisting and moving Butte-Silver Bow's project forward. Clean water is important to Butte, just as a multi-functioning navigable water system is important to Montana. We believe both can be accomplished in a timely and cost-effective manner.

I am available for any questions or consult that you might need. I can be reached at 542-4286 or by email at dboruch@mt.gov.

Sincerely,

Dana M. Boruch
Right-of-Way Specialist

CC: BSB Public Works Attn: Rick Larson 126 W Granite Butte MT 59701



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX J

SUMMARY OF AGENCY COORDINATION MEETINGS

DOWL HKM

Physical Address:
104 East Broadway, Suite G-1
Helena, MT 59601

Mailing Address:
PO Box 1009
Helena, MT 59624

Phone: (406) 442-0370

Fax: (406) 442-0377

MEMORANDUM

To: Rick Larson
Butte-Silver Bow

From: Sarah Nicolai
DOWL HKM

Date: September 17, 2009

Subject: Big Hole River Diversion Dam
Summary of Agency Coordination Meeting on September 1, 2009

An Agency Coordination Meeting was held on September 1, 2009. The following were in attendance:

Project Team:

Rick Larson	Butte-Silver Bow (BSB)
Marty Hovan	Butte-Silver Bow (BSB)
Dick Talley	DOWL HKM
Sarah Nicolai	DOWL HKM
Kristen Hansen	DOWL HKM

Agency Representatives:

Steve Hess	Butte-Silver Bow (BSB)
Jeff Ryan	MT Dept. of Environmental Quality (DEQ)
Terry Eccles	MT Dept. of Natural Resources & Conservation (DNRC)
Bruce Rich	MT Fish, Wildlife & Parks (MFWP)
Jim Olsen	MT Fish, Wildlife & Parks (MFWP)
Pat Cunneen	Natural Resource Damage Program (NRDP)
Vicki Sullivan	U.S. Army Corps of Engineers (USACE)
Steve Potts	U.S. Environmental Protection Agency (EPA)
Doug Peterson	U.S. Fish and Wildlife Service (USFWS)

The meeting began at approximately 1:00 p.m. and ended at approximately 4:15 p.m.

Introduction
The meeting started with an introduction of the project team, followed by an introduction of agency representatives.

Project Location, History, and Funding
The project team provided a brief introduction to the project, including a description of the project area and the history of the Butte water system. It was noted that no federal funding will be involved in this project. Primary funding is being provided through NRDP, with matching funds provided by BSB.

Draft Purpose and Need Statement
As described during the meeting, the Purpose of the project is twofold: to provide a reliable source of water for the Butte service area and to improve safety at the site. There is a strong Need for the project due to the risk of dam failure or malfunction and due to unsafe conditions at the site for maintenance personnel and recreational users. No agency comments were received on the proposed Purpose and Need statement.

Project Goals
The project team presented the preliminary list of goals. Apart from elements covered under the Purpose and Need statement, additional goals include improved fish passage, minimization of impacts to environmental resources, and minimization of project costs. No agency comments were received on the proposed Purpose and Need statement.

Environmental Assessment Process
It was noted that the team is currently in the scoping phase of the project, which involves gathering baseline data and requesting information from members of the public and regulatory agencies. The project team held a public meeting on Thursday, August 27, 2009. USACE asked whether members of the public had voiced any opposition to the project. In response, the project team noted that the public was largely in support of the project, although there were a number of questions regarding the technical design of the alternatives and anticipated project impacts.

Following scoping activities, the design team will further develop and analyze a set of project alternatives and ultimately choose a Preferred Alternative. Members of the public and regulatory agencies will have an opportunity to review and comment on the draft Environmental Assessment (EA) document during a public review period; the project team will also hold a formal public hearing. If supported by the analysis and documentation, the team will prepare a Finding of No Significant Impact (FONSI).

As required under the National and Montana Environmental Policy Acts (NEPA/MEPA), the EA document will consider project impacts to a number of resource areas. While no concerns are anticipated in relation to some resource areas, the team will pay special attention to water quality, fisheries, wetlands, floodplains, and wildlife and habitat issues. The existing Pumphouse is listed on the National Register of Historic Places; accordingly, the team will also pay close attention to historic and cultural resource issues.

Preliminary Alternatives

Meeting attendees discussed the five alternatives under consideration for the project. There were a number of questions and comments on this topic, which are presented in bullet format below.

- Regulatory agencies asked if Silver Lake, the Georgetown system, or groundwater had been considered as an alternative source of water either to supplement or replace the Big Hole water source. In response, Dick Talley and BSB noted that new or additional water rights would be very difficult to obtain in a timely manner; time is of the essence due to the near-term risk of dam failure at the Big Hole site. BSB's existing Silver Lake water right would not be sufficient to supply both domestic and industrial uses currently supplied by the combined Silver Lake and Big Hole River sources. Groundwater in the Butte vicinity is contaminated; there is some question whether existing technology could treat contaminated groundwater to drinking water standards. Further, Butte is located in a controlled groundwater area and a closed basin; it likely would not be possible to obtain new water rights before the existing Big Hole River Diversion Dam fails. Regulatory agencies requested documentation of these considerations in the EA in order to justify why the list of alternatives exclusively considers the Big Hole River as a source of water for this project and why other surface water and groundwater sources would not be feasible. Dick noted that BSB previously prepared a Master Plan, which discussed these issues in detail.
- With regard to rip-rap, there was some discussion regarding whether it will actually be needed on both the north and south banks, and over what distance from the new facility. USACE noted that any rip-rap included in the final project design must be justified.
- DNRC noted that if the existing point of diversion is moved, the project team will need to file a notice for change for the point of diversion, which can be a very lengthy process. Additionally, in doing so, this will trigger a review of the water right itself. The new water right would likely be determined based on actual historic usage as opposed to the water right provided on paper. The date used for this new water right assessment would be 1973. There was some discussion regarding leaks associated with BSB's 100-year old distribution system, and BSB's efforts to replace aging infrastructure and to conserve water in recent years. The project team will take this issue under advisement and may make adjustments to the design in order to avoid a lengthy review process and potential loss of BSB's original 1901 water right. Rick Larson stated that there will be no change to BSB's water right as a result of this project. Any planned upgrades or modifications to the existing diversion dam, intake, or pump station will not impact BSB's existing water rights.
- DEQ and MFWP asked whether an additional alternative could be considered upstream near an abandoned irrigation weir on the south side of the river below Silver Bridge. The thought was that since it would be located at a higher elevation, this alternative could provide sufficient head without the two to four additional weirs presented in Alternatives 4A and 4B. Dick Talley noted the suggested alternative would not be located on BSB-owned land, and would therefore involve right-of-way negotiations not contemplated with the other alternatives. Further, by providing a single drop, this alternative would result in the same "keeper wave" and associated safety concerns as the existing dam. The single suggested drop would still need to meet a minimum elevation in order to ensure water entry into the intake pipe. Agencies requested documentation of this issue in the EA in order to justify why such an alternative would not be feasible.

- USACE noted that removal of the abandoned irrigation weir could be considered a mitigation technique for the project as a whole. Dick noted that nature has already removed most of the abandoned structure.
- MFWP asked if there would be any advantage from an engineering standpoint to going upriver to a riffle section, since such an area would have a lower fisheries habitat value. As noted previously, an upriver alternative would gain elevation and could provide additional head. It was noted that there is currently a pool that attracts grayling near the existing dam structure. There was some discussion regarding whether the existing diversion dam created the pool in question. Dick believes that by removing the existing dam facility as is contemplated under several of the alternatives, the river may naturally wash away the current bed and form a long stretch of riffles at the existing dam site. Dick also noted that the step pools in Alternatives 4A and 4B would likely form high-quality fish habitat.
- USACE noted that it would be beneficial from an environmental standpoint to remove the existing diversion dam. The historic significance of the existing structure was discussed. It may be possible to preserve the site through documentation and thereby sufficiently meet SHPO's mitigation requirements. The project team will engage in consultation with SHPO to determine appropriate mitigation strategies.
- Regulatory agencies agreed that it would be preferred to minimize the in-stream footprint of any new structure.
- USACE requested consideration of alternative bank stabilization measures in addition to or in place of traditional rip-rap. Such measures could include dense, horizontal soil layers lined with dormant willow whips. This method has provided dense, stable vegetation in a relatively short time period on previous projects. Discarded Christmas trees can also be used for armoring. Although such a method would be labor intensive, it is often possible to find volunteers.
- There was discussion of whether fish could become trapped in the rest pools in Alternatives 4A and 4B. Dick noted that the design team will carefully consider this issue. There was also discussion of the size and type of fish screens on the intake structure.
- USACE reiterated that each design element must be justified and the project team must demonstrate need. USACE is required to identify the least damaging practicable alternative; the project team must ultimately demonstrate that the Preferred Alternative meets this definition.
- Regulatory agencies requested documentation of the modeling efforts in the EA.

Preliminary Research Results

The project team briefly discussed the preliminary research results. Analyses are ongoing; sub-consultants will be completing biological and cultural resource reports in the coming weeks.

Next Steps

Sarah noted that she will be in contact with agency representatives in the coming weeks and may request individual appointments to discuss the permit application process and ensure that the project team addresses regulatory agency concerns in the EA document. Dick also noted that there will likely be another agency meeting before the final EA has been completed.

cc: Meeting attendees
file

DOWL HKM

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MEMORANDUM

To: Rick Larson
Butte-Silver Bow

From: Sarah Nicolai
DOWL HKM

Date: November 16, 2009

Subject: Big Hole River Diversion Dam
Summary of Second Agency Coordination Meeting on November 3, 2009

A second Agency Coordination Meeting was held on November 3, 2009. The following were in attendance either in person or by telephone:

Project Team:

Rick Larson	Butte-Silver Bow (BSB)
Marty Hovan	Butte-Silver Bow (BSB)
Dick Talley	DOWL HKM
Sarah Nicolai	DOWL HKM

Agency Representatives:

Steve Hess	Butte-Silver Bow (BSB) Planning Department
Jim Jarvis	Butte-Silver Bow (BSB) Historic Preservation Commission (HPC)
Jeff Ryan	MT Dept. of Environmental Quality (DEQ)
Terry Eccles	MT Dept. of Natural Resources & Conservation (DNRC) Water Resources
Dana Boruch	MT Dept. of Natural Resources & Conservation (DNRC) Trust Lands
Fred Staedler	MT Dept. of Natural Resources & Conservation (DNRC) Trust Lands
Jim Olsen	MT Fish, Wildlife & Parks (FWP)
Vicki Sullivan	U.S. Army Corps of Engineers (USACE)
Steve Potts	U.S. Environmental Protection Agency (EPA)
Doug Peterson	U.S. Fish and Wildlife Service (USFWS)

The meeting began at approximately 9:00 a.m. and ended at approximately 12:30 p.m.

Introduction
The meeting started with an introduction of meeting attendees.

Project Location and Funding
The project team provided a brief overview of the project area and an update on project funding. In addition to funding provided through the Natural Resource Damage Program (NRDP), USACE has committed to provide funds for the environmental and design phases of the project.

Purpose and Need Statement
The project team briefly provided an overview of the Purpose and Need for the project. It was stressed that although this project will provide benefits to fisheries and recreational users, the primary purpose of the project is to provide a reliable source of water for Butte. It was also stressed that the project team considers this an emergency project, which is being fast-tracked because the existing diversion dam could fail at any time.

Agency Roles and Responsibilities
There was a lengthy discussion on agency roles and responsibilities. DNRC Trust Lands proposed the idea of having all involved state and federal agencies develop a formal written agreement before moving forward with the environmental compliance effort. The agreement would specify that the agencies would play the role of decision maker. The EA document would contain appropriate signature blocks, and each agency would have veto power over this document and the manner of its development. The intent of this agreement would be to develop consensus on one single environmental document that would satisfy all state and federal requirements.

EPA suggested that perhaps a formal agreement would not be necessary since the EA currently being developed by DOWL HKM on behalf of BSB would address NEPA and MEPA concerns.

USACE provided a brief overview of the 404 permit process, noting that it would prepare its own environmental document in support of the 404 process. USACE cannot begin to act until the Preferred Alternative is selected. Generally, the Individual Permit (IP) process requires 120 days, while the Nationwide Permit (NP) process requires 45 days. The funding arm of USACE would follow a separate process to satisfy its environmental requirements.

For clarification, agencies requested an overview of the proposed project timeline. DOWL HKM noted that a final EA/FONSI was intended for the December 2009 / January 2010 timeframe in order to allow time for permitting and bidding prior to the intended construction season beginning in June 2010. This timeframe was developed in order to ensure in-stream work would be conducted during periods of low flow with completion by December 2010.

Returning to the issue of agency roles and responsibilities, DNRC Water Resources noted that agencies cannot tell the project team how to move forward, but can only provide guidance regarding agency requirements.

FWP noted that it is generally their position to accept the environmental document prepared by the project sponsor and that a formal agreement wouldn't be necessary for FWP.

DEQ also agreed that it would not be necessary to have a formal agreement between agencies, nor would DEQ need to sign the EA currently being prepared.

DNRC Trust Lands raised the issue of whether an EIS should be prepared, noting that this would be the safest approach. DOWL HKM responded that an EIS would be pursued only if impacts to one or more resources in the project area were identified as being significant. To date, no significant impacts have been identified. The issue of significance was discussed briefly. EPA noted that controversy is one of the factors that is used to determine if a project has potentially significant impacts. If there is a high degree of controversy associated with the Big Hole Diversion Dam project, this could make if difficult to make a Finding of No Significant Impact (FONSI). An EIS should be conducted for projects with potentially significant impacts. The factors used to determine significance in regard to NEPA can be found at 40 CFR 1508.27.

It is also important to note that if a proposed project has opponents who are willing to litigate in regard to project implementation, it is often easier to legally defend a project for which an EIS has been prepared, since the EIS acknowledges that the project has potentially significant environmental impacts and discloses those impacts along with measures proposed to mitigate the impacts. When an agency makes a FONSI, the burden of proof is on the agency making such finding to prove that there are no significant impacts.

At the end of this discussion, it was agreed that the project team would continue to work informally with most agencies, but would develop a more formal arrangement with DNRC. DNRC will continue to play the lead state agency role, and will ultimately sign the EA prepared by DOWL HKM on behalf of BSB. The project team considers this issue fully resolved at this time.

Environmental Assessment and Permitting Phases

Meeting attendees discussed a number of topics relating to the environmental compliance and permitting efforts.

DEQ noted that permitting for this project would likely proceed smoothly as long as the Preferred Alternative provides boat and fish passage and minimizes construction impacts. The EA document should mention efforts to minimize construction impacts.

BSB Planning asked if the proposed project timeframe was achievable. DNRC Trust Lands noted that it seemed aggressive. DOWL HKM responded that there is sense of urgency because the Big Hole River provides over 60 percent of Butte's water supply and is necessary for the continued health and safety for the population of Butte. In addition to potable water, the Big Hole River also provides essential fire protection for the city and outlying areas.

DNRC Water Resources asked if there are a different set of NEPA/MEPA requirements for an emergency situation, especially one that could threaten human health and property. USACE responded that it doesn't issue emergency permits. In emergency situations, an NP Category 3 (Maintenance) could be issued following emergency repairs, although USACE prefers not to advertise this possibility.

FWP noted that there is no such thing as a planned emergency. FWP does not foresee any problems with the proposed schedule from its perspective.

BSB noted that the dam has already failed by its estimation. There are already large holes in the dam which BSB has filled with boulders on two occasions in recent years. BSB stated that the city would be negatively affected by failure of the dam.

USACE agreed that BSB has been applying bandaids to the problem, and needs a permanent solution. The goal would be to replace the structure such that continual maintenance and repairs are not required. USACE would see this as a long-term benefit because BSB wouldn't need to be working in the river time and time again to conduct repairs.

DNRC Trust Lands noted that although BSB has a sense of urgency, this project has already been sitting for a year and a half. BSB responded that this perceived delay has been due in part to BSB's attempts to identify funding for the project. The project team is now moving forward in a more visible way because funding has been secured.

DNRC Trust Lands noted a lack of comfort with the environmental compliance effort and the process used to date. DNRC Trust Lands would like to study the notes from public involvement activities to ensure that sufficient outreach has been conducted. Conducting proper outreach efforts is essential to avoiding conflicts later in the process.

DOWL HKM noted that a public meeting has been held, newsletters have been widely distributed, and the project team has engaged a group of stakeholders regarding the project. BSB noted a general consensus that no one likes the structure that currently exists, and that any new structure would be an improvement in the public's view.

DNRC Trust Lands will need to reach a comfort level with the public process, but will make it a priority to work with the team on this project. Again, it was noted that this process has already extended a number of years. The project team noted that although meetings have not been recorded to date, there are brief summaries of the discussion items and public comments received.

DNRC Trust Lands again brought up the issue of whether an EA or an EIS would be needed for this project. The issue of Threatened and Endangered Species was discussed. USFWS noted that although the arctic grayling is not listed today, USFWS is currently conducting a 12-month finding to be completed in August 2010. Based on the finding, a listing may be appropriate. Projects fully completed before a proposed listing would not require consultation, whereas ongoing projects may require consultation.

DNRC Trust Lands recommended attempting to complete the project by the summer or fall of 2010.. DNRC Water Resources noted that there are no shortcuts to the environmental compliance process. DNRC Trust Lands advised the project team should acquiesce to complete an EIS in order to avoid any future issues.

DOWL HKM reiterated that an EA is required to identify important resources, resultant impacts, and mitigation strategies for a project. Should significant impacts be encountered that are not or cannot be mitigated, then an EIS is required to be finalized through a Record of Decision. To

date, no significant impacts have been identified and mitigation strategies are being developed for the other minor impacts that have been determined.

The issue of alternative sources of water was discussed. DNRC Water Resources noted that this should be discussed in the EA. DOWL HKM provided a summary of the project team's assessment of this issue. BSB has been aggressively replacing leaking system components and implementing water usage metering over the past five to ten years. These efforts have had a positive effect on the amount of water required from the Big Hole River source, however, these improvements are not sufficient to supplant the Big Hole source.

With regard to groundwater, it is believed that sufficient volumes of groundwater are not available to supplant the Big Hole River source. Furthermore, Butte is located in a "closed" basin and any resultant new groundwater sources would require mitigation or replacement prior to acquiring a permitted and approved status. Lastly, there are known groundwater contamination issues in and around the Berkley Pit and the Upper Clark Fork Basin resulting from years of mining.

The Silver Lake water system is a highly adjudicated surface water source and the timing to re-adjudicate this water from industrial customers and uses to public water supply is unknown, but could take years. Moreover, the amount of unclaimed water is not of sufficient volume to supplant the Big Hole source.

For these reasons, BSB has focused on preserving its water right on the Big Hole River, which has served as a source of water for Butte for over 100 years.

Returning to the issue of public input, USACE noted that it will be important to document feedback from recreationalists, who may not live in Butte. They will likely have more concern regarding fishing and recreation, and less concern for the Butte water supply. DNRC Trust lands requested a list of issues that the project team has developed in order to gain a greater level of comfort with the scoping process conducted to date.

Project Alternatives

DOWL HKM presented the five alternatives under consideration for this project and discussed the various design components relating to each of the alternatives. There were a number of questions and comments on this topic, which are presented below.

Alternative 1: No Build

- The issue of floodplains was discussed. DOWL HKM noted that there is an inundation map for Silver Bow County, but it does not provide for 100-year flood elevations or cross sections. There is no floodplain mapping for Beaverhead County. In order to assess impacts, the project team has modeled water surface elevations for various flood events at various cross-sections of the river both up and down stream of the dam for both existing conditions and proposed conditions as anticipated under each of the alternatives. The agencies agreed with this approach and confirmed that if there are not significant changes in water surface elevations at these sections, then it is correct to assume that there will not be significant changes in areas of inundation.

Alternative 2: Reconstruct Existing

- DOWL HKM noted that Alternative 2 would involve reconstructing the existing diversion dam slightly upstream of the current location. The dam would be constructed of concrete and function in the same manner as the existing structure.
- The existing point of diversion was discussed. DNRC Water Resources noted that in order for the system to work, it pulls water from several different places depending on flows. This is a different situation than a point of diversion consisting of a single headgate. Accordingly, DNRC Water Resources agrees that the point of diversion is not actually a single point, but the existing footprint of the area enclosed by the system defined as the diversion dam face on the east, the south wall of the concrete race way, the west wall of the upstream weir and the north river bank. The DNRC legal department agrees with this assessment. As long as the new intake is located within that same footprint, there would be no need for a point of diversion change. If the intake were to move one foot up or downstream, however, a change would be required. The EA should specifically define the footprint of the existing system. Since the intake position would change under Alternative 2, a point of diversion permit would be required.
- Agencies noted that Alternative 2 would not be preferred due to a lack of boater and fish passage.
- USACE noted that Alternative 2 would not fall under an NP Category 3 (Maintenance) because it would involve construction of an entirely new structure; further the location of the new structure would not be identical to the footprint of the existing diversion dam. Although this alternative may not require extensive fill material in the river, USACE would consider it to have large impacts because it would block boat and fish passage. Some mitigation would be achieved by removing the existing diversion dam. This alternative would likely require an IP.
- DEQ concurred that permitting for this alternative would be more difficult due to lack of fish and boater passage.
- With regard to USACE permitting, DOWL HKM noted that the existing diversion dam must continue to function during construction of the new structure in order to maintain service to Butte. This precludes construction within the same footprint. DOWL HKM requested clarification regarding whether an NP Category 3 (Maintenance) would be appropriate under any circumstance, given that the existing structure must remain functional during replacement or construction of a new structure. USACE responded that the Category 3 permit is only for maintenance of existing structures, not construction of an entirely new structure. A Category 3 permit would only be appropriate if the project team were exploring ways to repair and retrofit the existing structure. USACE advised that the team shouldn't be afraid of the IP process. Ultimately, a new structure would likely be the least environmentally damaging.
- DNRC Trust Lands noted that fish and boater passage is critical. In order to move forward with Alternative 2, the project team would have to demonstrate that it is the only reasonable alternative, which is unlikely.
- With regard to the point of diversion issue, BSB asked if the footprint could include the entire area where the existing diversion dam affects the river flow. DNRC Water Resources responded that this is too broad an interpretation; the footprint includes only the area defined by the location of the system components.

- The issue of passage was discussed. DNRC Trust Lands noted that ideally, the project should allow boaters to float past the structure without having to portage or get out and assess how to maneuver the stretch. DNRC Trust Lands has jurisdiction over this project because the Big Hole River is defined as a navigable waterway by DNRC based on historic commerce. It was also noted that passage has a positive economic value, as recreation is a growing sector for the state. BSB asked how this issue is addressed during low flows when boat passage is not possible. DNRC Trust Lands responded that the alternative must be reasonable and low flows are taken into consideration. It was agreed that the design should attempt to provide fish and boat passage during normal water flow conditions, as opposed to extreme high or low water flows. FWP asked if the project team had heard from boaters during the public involvement process regarding what flows would be prohibitive. BSB has heard boaters will not attempt to float in conditions less than 300 cfs. FWP noted that these minimum design criteria should be defined in the EA document in coordination with recreational users.
- Intake screen size was discussed. The current designs include 100 micron screens (i.e. screens with 0.10 inch openings). FWP may consider increased screen size beyond the 0.10-inch screen openings should the final design determine that increased screen opening size is necessary to facilitate intake operations.
- FWP asked about icing issues. DOWL HKM responded that the screens would be submerged to avoid icing and the design would maintain minimum velocities to keep water moving past the system.
- FWP asked about the settling basin design. DOWL HKM responded that the current diversion and sedimentation removal system is complicated, but it performs well in maintaining low amounts of debris and sediment entering the pump station. The proposed designs would not be as complicated and they are reviewing the impacts that additional debris and sediment loading may have on the pumps and downstream water treatment facilities.

Alternative 3: Rock Weir with New Pump House

- DOWL HKM noted that Alternative 3 would involve a rock weir instead of a concrete dam, and would not move the point of diversion. A two-drop channel would be constructed down the center to provide fish and boat passage. A new pump house would be constructed such that the new pumps could be located at a lower elevation to gain the sufficient head afforded by the dam. Given that the proposed dam would be located in the same locaton as the existing and that the crest is set so as to not increase the upstream water surface elevation unduly at flood stages, the available head remains similar to existing conditions; hence, there is a need to relocate the pumps to a lower elevation to alleviate cavitation potential. It was noted that boater passage was designed to provide calm floating instead of whitewater conditions, as requested by members of the public.
- This alternative would not require a point of diversion application as the new intake would be located within the existing intake system footprint.
- Velocities were discussed. FWP noted that fish can migrate through water traveling at 5 to 6 fps.
- DNRC Trust Lands asked if additional grants would be available to fund the pump house. FWP noted that there is a funding program for projects providing fish passage. USACE noted that it would not consider cost in its assessment, as they are required to identify the least damaging practicable alternative. USACE also noted that although

Alternative 3 would require more fill material it would be preferred over Alternative 2 because it provides fish and boat passage. USACE noted that this alternative would likely require an IP.

- FWP asked about fish passage during low flows. DOWL HKM responded that at 200 cfs, water would still flow through the middle chute as evidenced in the 200 cfs upstream water profle elevation of 5420.8 feet and the weir elevation of 5418 feet. The amount or depth of water over the weir is controlled by the position of the butterfly gate valve in the intake structure. FWP noted that no matter how much or how little water is in the river, fish will still want to move. Grayling will be looking for slow, cold water (thermal refuge). FWP asked if the velocities in the chute would be impassable (considered 6 fps or greater). DOWL HKM confirmed that the velocities would be 6 fps or lower, and the design could potentially open the chute slightly to lower velocities even further. FWP noted that the chute downstream of the intake structure could be re-designed to provide a fish ladder using rock instead of concrete. DOWL HKM noted that the chute only drops about a foot, and that the exit channel is currently planned to be constructed of rock instead of concrete. EPA noted that all fish passage issues, including life stage considerations, water flows, and velocities should be defined in the EA document.
- DOWL HKM requested clarification regarding the new pump house and asked if a discharge permit would be required if the pump station was operated in a continuous flow through of the wet well. DEQ responded that it would have to look into this issue further. USACE would regulate the structure only if fill were placed below the high water mark. USACE would be concerned with fill discharge, while DEQ would be concerned with water quality of the discharge volume.

Alternative 4: Rock Weir with Floating Intake

- DOWL HKM noted that Alternative 4 would look just like Alternative 3, except the point of diversion would be located upstream about 400 feet, hence requiring a point of diversion change. It would provide similar boat and fish passage as Alternative 3, would reduce ice problems, and would provide a reliable system. The intake would consist of a series of T-screens attached to sleds that would be located in the bottom of the river in the deeper upstream pool. These intake screens would convey water to the north bank via two pipes and would continue into the existing pump station and connect to the existing header. The location of the T-screens is such that sufficient head would be afforded to the existing pumps.
- The point of diversion change was discussed. FWP noted that members of the public likely wouldn't care that the point of diversion was moving slightly. DNRC Trust Lands noted that DNRC is trying to avoid lawsuits. There are laws that need to be followed. USACE will not take the point of diversion issue into consideration; from their perspective, the Preferred Alternative must be the least environmentally damaging alternative. DOWL HKM noted that the 2009 legislature enacted new point of diversion legislation. DNRC Trust Lands noted that rules will likely be written with regard to this new legislation. In response to a question by BSB Planning, DOWL HKM confirmed that the concern regarding a point of diversion change relates to potential adjudication of BSB's water right, in addition to the time required to move through the process (approximately 16 months). DOWL HKM noted that the project has moved in a positive direction in that DNRC Water Resources had previously defined the point of diversion as a specific latitude and longitude, whereas it is now defined as a footprint. The legal

determination as to what constitutes a change in point of diversion in light of the new legislation is needed prior to selection of the preferred alternative as it weighs heavily on the development of alternatives.

- It was noted that Alternative 4 would maintain an existing pool located upstream of the current diversion dam structure. Per FWP, this pool is of excellent habitat value. FWP also noted that in addition to preserving the existing pool, this alternative would create new pools downstream of the dam.

Alternative 5: Upstream Rock Weir and New Diversion Structure

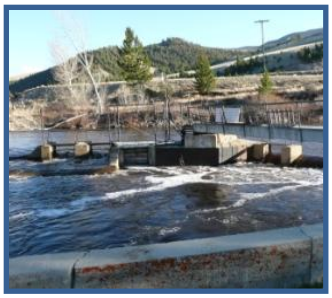
- DOWL HKM noted that Alternative 5 would also involve construction of a rock weir approximately 700 feet upstream to take advantage of a natural pocket in the north bank of the river for placement of a concrete diversion structure similar to the one proposed in Alternative 3. Under this alternative, a two drop chute would be constructed in the thalwag of the river providing fish and boat passage similar to Alternatives 3 and 4. More piping from the intake to the existing pump station would be required for this alternative. A new point of diversion would be required for this alternative.
- It was noted that Alternative 5 would directly impact the pool upstream of the existing dam. If this alternative were selected, USACE would require that the project team demonstrate why it was chosen, given this impact.

Comparison of Alternatives and Further Discussion

- As a means of summarizing and comparing the alternatives, it was noted that Alternatives 2, 4, and 5 would require a change in the point of diversion. Alternatives 3, 4 and 5 were generally perceived to provide the adequate fish passage, with Alternative 4 being the most friendly for fish and boater passage. Alternatives 2, 4, and 5 would be the most cost effective in the $4 to $5 million range, while Alternative 3 may be prohibitively costly at over $8 million. Alternatives 2, 3, 4, and 5 would provide mitigation by removing the existing diversion dam.
- The issue of mitigation was discussed. USACE noted that wetland mitigation can be provided off-site, but it is not possible to mitigate for lack of passage. Under the IP process, both temporary and permanent impacts would be assessed.
- Jurisdictional wetlands were discussed. USACE noted that wetlands are defined by three criteria (hydric soils, hydrophytic vegetation, and wetland hydrology). Areas located within the high water mark should not automatically be considered wetlands. USACE offered to verify the wetland delineation conducted for this project.
- A poll was conducted of meeting attendees regarding their Preferred Alternative, with results as follows:
    - DEQ prefers Alternative 4
    - USACE prefers any alternative that provides boat and fish passage (Alternatives 3, 4, and 5), although Alternative 4 appears to have the least impacts by maintaining the existing pool upstream of the existing dam
    - FWP prefers Alternative 4, as is appear to be the most fish-friendly
    - EPA prefers Alternative 4
    - DNRC Trust Lands prefers any alternative that provides boat and fish passage (Alternatives 3, 4, and 5)

- There was a discussion of priorities. DOWL HKM again noted that over 30,000 people depend on this water source, and further, that the Preferred Alternative must be within range of the budgetary constraints of BSB.
- USACE and DNRC Trust Lands noted that regulations must be followed.
- FWP noted that it would not consider cost or schedule as a factor. An alternative should not be eliminated due to the point of diversion issue, which would only require approximately 16 months to address. The new structure could be in place for 100 years. Environmental impacts must be weighted heavily.
- DOWL HKM noted that it may not be possible to get through another spring runoff. This is an important issue for the residents of Butte who depend on the Big Hole River as a source of water. DNRC Trust Lands noted that unless the dam fails tomorrow, there are laws and processes that must be followed.
- The process for selection of the Preferred Alternative was discussed. DNRC Trust lands stated that BSB and DOWL HKM will select their Preferred Alternative, but that DNRC, as decision maker, will ultimately select the single alternative that moves forward. EPA noted that the funding agencies (NRDP, BSB, USACE) should agree on the Preferred Alternative. DOWL HKM noted that it will be imperative to close the public review period before the end of the year, or we will miss our window of opportunity for construction next summer.

cc: Meeting attendees
file



ENVIRONMENTAL ASSESSMENT

for the

Big Hole River Diversion Dam

in

Silver Bow and Beaverhead Counties, Montana

APPENDIX K

NEWSPAPER ADVERTISEMENTS AND SUMMARY OF PUBLIC MEETINGS

Public Meeting

Proposed Replacement of Big Hole River Diversion Dam

The City and County of Butte-Silver Bow (BSB) invites you to attend a public meeting regarding the proposal to replace the existing Big Hole Diversion Dam. The meeting is scheduled for **Wednesday, August 26th, 2009 at 6:00 p.m. in the Council Chambers located in the Courthouse in Butte, Montana.**

The proposed project is located in Silver Bow County near Divide, Montana. The existing diversion dam and intake structure is owned and managed by BSB and is used to divert water from the Big Hole River, which is then treated and pumped to storage and distribution systems in Butte, Montana. BSB has initiated an Environmental Assessment (EA) to study potential impacts that may result from the proposed project.

The purpose of the meeting is to present the proposed Purpose and Need, Project Goals, and Preliminary Alternatives to the public and gather public input. Community participation is a very important part of the process and the public is encouraged to attend. Comments may be submitted in writing at the meeting or by mail to project consultant Dick Talley of DOWL HKM at P.O. Box 3588, Butte, MT 59702 or by email at dick.talley@hkminc.com. Please indicate comments are for the Big Hole River Diversion Dam project and submit comments by **September 28th, 2009.**

6:00 p.m.
August 26th, 2009
Council Chambers
Courthouse
Butte, Montana

Summary of Public Meeting #1
August 27, 2009

An initial public information meeting was conducted for the proposed Big Hole River Diversion Dam project on August 27, 2009. The meeting was held in the Silver Bow County Courthouse Council Chambers and took place from 6:00 p.m. to 8:00 p.m. Approximately 20 people attended the meeting. The meeting format included a formal presentation followed by a question and answer period. The purpose of the meeting was to discuss the Purpose and Need and goals of the project as well as preliminary project alternatives. Following the formal presentation, members of the public commented on a number of aspects of the project including habitat impacts and mitigation; regulatory agency involvement; icing, sediment and debris problems; project costs; vandalism and safety concerns; historic preservation; permitting concerns; and technical questions regarding design of each of the alternatives. Comments and responses are summarized below. It should be noted that the meeting was not recorded. This summary is intended only to capture the general content of meeting discussions and is not a transcript of the meeting.

Q: Will there be mitigation for habitat impacts?

A: A Biological Resource Report is being prepared for this project, which will identify anticipated project impacts under each of the proposed alternatives. Project impacts will be minimized to the extent possible; unavoidable impacts will be mitigated as appropriate in coordination with appropriate regulatory agencies.

Q: Has the project team engaged FWP in this process?

A: A formal scoping letter was sent to FWP in July 2009 requesting their involvement in this project. Additionally, the project team has scheduled an Agency Coordination Meeting on September 1, 2009. FWP and other agencies with potential interest in this project have been invited to attend this meeting. The project team is actively engaging regulatory agencies early in the process in order to identify and address agency concerns before the permitting phase.

Q: The project team should consider the alternatives on an equal basis.

A: A number of factors will be considered in the alternatives screening process, including the function and reliability of the system, boat and fish passage opportunities, anticipated impacts to the natural and built environment, safety at the site, maintenance requirements, and estimated cost. All of the project alternatives will be assessed based on these screening criteria. The Preferred Alternative will be selected based on its ability to best meet the goals and objectives for the project.

Q: Would there be icing problems with Alternative 5?

A: The design of the existing diversion dam essentially stops water from moving as it reaches the dam crest; ice naturally forms at this point during winter months. Proposed project alternatives are designed to reduce icing problems at the site by keeping water moving during the coldest months of the year.

Q: How are sediment problems being addressed?
A: Proposed project alternatives are designed to allow sediment flushing and reduce sediment buildup behind the dam structure.

Q: How are trees/debris addressed in the design of preliminary alternatives?
A: Under each of the proposed alternatives, a debris boom will collect surface debris. Additionally, during periods of high flow, Alternatives 3, 4, and 5 are designed such that large debris would overtop the rock weir structures.

Q: How will cost factor into this project?
A: The project team is developing cost estimates for each of the proposed alternatives. Cost-effectiveness will be one of the factors used to screen alternatives.

Q: Under Alternative 4A, why is there a need for the rock drops?
A: Currently, there is a sharp vertical drop immediately downstream of the existing diversion dam crest, which results in a safety hazard for recreational users. The rock drop structures are intended to gradually lose elevation downstream, providing safe boater passage through this stretch. The gradual drops would also improve fish passage by providing rest pools and gradual elevation changes.

Q: Under Alternative 4A, how will the secondary intake operate?
A: The secondary intake serves as an emergency backup in case of failure or if the primary intake needs to be taken offline for repairs or maintenance. The secondary intake is normally valved out and only would be valved into the system when the primary intake is nonoperational.

Q: Is it possible to design a hybrid option of 4A and 4B?
A: The project alternatives presented this evening are preliminary in nature. The project team will continue to refine the design of these alternatives in order to best meet the project objectives. As part of continued design efforts, the project team may consider a hybrid alternative.

Q: Why is it necessary to move upriver?
A: Bedrock conditions were encountered during original pump installation, preventing the pumps from being installed at the proper elevations. As a result, pump cavitation currently occurs more frequently than desired. By moving upriver, the design would take advantage of the natural gradient of the river and would gain elevation needed to prevent pump cavitation.

Q: Under Alternative 4B, would the nearby house be impacted?
A: No, none of the alternatives would impact any of the buildings near the project site, with the exception of the pump house.

Q: FWP should be involved early in the process.
A: The project team agrees with this recommended approach; we will continue to engage FWP and other regulatory agencies throughout the process.

Q: Will the new facility require additional personnel?

A: Butte-Silver Bow has requested a new facility that would involve reduced maintenance requirements. Additional personnel are not anticipated.

Q: How is the project team addressing the issue of vandalism?

A: The project team has attempted to minimize the use of features or elements that could be easily vandalized.

Q: How do the project alternatives affect safety at the site?

A: The design of the current facility is unsafe for maintenance personnel and for boaters. Under Alternatives 3, 4, and 5, it is anticipated that icing problems would be alleviated. Accordingly, maintenance personnel would no longer need to venture onto the ice to maintain system function in the winter. Additionally, the proposed rock drop structures would provide a gentle decrease in elevation thereby removing the "keeper" wave that exists immediately downstream of the current dam. By eliminating this keeper wave, safety for boaters will be improved as compared to the existing sharp vertical drop that currently exists.

Q: Do the Project Alternatives consider preservation?

A: The pump house is listed on the National Register of Historic Places and the existing diversion dam is considered a contributing element. A Historic Resources Report is being prepared for this project to identify all historic, cultural and archaeological features at the site and to assess potential project impacts. Project impacts will be minimized to the extent possible; unavoidable impacts will be mitigated as appropriate in coordination with the Montana State Historic Preservation Office (SHPO).

Q: What construction impacts will result from the project? Will boat passage be maintained during construction?

A: In order to minimize water quality impacts during construction, temporary bypass channels will be used to divert water around the construction area. During this period, boat passage will be temporarily interrupted.

Q: Will the project team conduct fish counts before and after construction activities?

A: No, fish counts will not be conducted for this project. Butte-Silver Bow has retained a team of professionals, including wildlife and fisheries biologists, to aid in project design, assess impacts to fisheries, and identify appropriate mitigation strategies.

Q: Will habitat degradation result from the project?

A: There will be some permanent impacts to riparian vegetation where new facilities are tied into the streambanks. Impacts to riparian vegetation will be mitigated to the extent practicable through re-seeding efforts. The project team anticipates that fisheries habitat will actually be enhanced as a result of the project due to improved access to spawning and rearing habitats.

Q: What is the permitting timeframe for this project?

A: A number of permits will be required from various state, federal, and local agencies. The project team anticipates that it will take approximately four to six months to obtain the appropriate permits.

Notice of Availability & Public Hearing

Environmental Assessment for Big Hole River Diversion Dam

The Environmental Assessment (EA) for the Big Hole River Diversion Dam project will soon be available for public review and comment. The Preferred Alternative identified in the EA includes elements that best satisfy the need for the project while minimizing impacts. The proposed action is the replacement of the existing diversion dam structure and intake facility. The proposed project would provide a reliable source of water for Butte, safety improvements for maintenance personnel and recreational users, and improved fish and boat passage.

Beginning on December 10, 2009, review the EA at:

- Butte Public Library (226 W. Broadway)
- Butte-Silver Bow Public Works Office (126 W. Granite)
- Online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09)
- Email dick.talley@hkminc.com or call (406) 723-8213, ext. 409 for a copy

Comment Period: December 10, 2009 to January 15th, 2010

- Provide oral or written comments at the public hearing
- Submit written comments to Dick Talley, DOWL HKM, P.O. Box 3588, Butte, MT 59702
- Online at http://www.hkminc.com/big_hole_river/index.htm (site active on 12/10/09)

For More Information:

- Dick Talley, DOWL HKM, (406) 723-8213

PUBLIC HEARINGS

December 15, 2009, 6:00 - 9:00 p.m.
Silver Bow County Courthouse, 155 W. Granite, Commission Room, 3rd Floor

December 16, 2009, 6:00 - 9:00 p.m.
Grange Hall in Divide, Montana

Same presentation will be given on both evenings.