APPENDIX C – ALTERNATIVES ANALYSIS REPORT

ALTERNATIVES ANALYSIS

CITY OF LAUREL

WATER TREATMENT PLANT INTAKE

Prepared for:

City of Laurel, Montana

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Prepared by: Jonathan Weaver, P.E.

Susan Hayes, P.E.

QA/QC: Jeremiah Theys, P.E.

Chad Hanson, P.E.

In association with:

Western Groundwater Services

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SECTION 1 - EXECUTIVE SUMMARY

As a result of the flooding that occurred on the Yellowstone River during the spring of 2011, the river channel migrated and scoured in the vicinity of the highway and railroad bridges and compromised the ability of the City of Laurel's water treatment plant raw water intake to draw water from the river on a consistent, year-round basis. During January of 2012, water over the submerged intake was at its lowest level since the installation of the new intake. This resulted in excessive ice buildup on top of the structure, slush ice developing on the intake screens, and a temporary shutdown of the raw water line from the intake to the CHS Oil Refinery because the City could not meet their own domestic demands. With the recent developments concerning water availability issues at the intake structure, these problems have escalated to a severe threat to public health and safety and must be corrected as soon as possible. Great West Engineering has been contracted by the City of Laurel to evaluate alternatives so that a long-term solution may be implemented which will provide a reliable municipal water supply to the residents and businesses of the City of Laurel.

Initially, a broad range of alternatives (24 in total) were considered and screened. Environmental agencies and other stakeholders were given numerous opportunities to participate in the alternatives analysis in the form of meetings and written correspondence. From the preliminary screening, three alternatives were identified and were evaluated more thoroughly, considering environmental impacts, practicability, and cost. The three alternatives considered are as follows:

- Alternative A: Remove existing pumps, replace with dry pit submersible pumps, remove sediment, replace existing screens with half-round screens, install hot water heater, construct a new intake adjacent to the existing intake
- Alternative B: Construct a new intake three miles upstream, adjacent to Canyon Creek Ditch, replace existing screens with half-round screens, install hot water heater
- Alternative C: Construct infiltration gallery using the trench method at Site 1, replace existing screens with half-round screens, install hot water heater

Based upon the alternatives analysis contained herein, it is the recommendation of Great West that the City of Laurel pursue Alternative B, which would construct a new surface water intake three miles upstream adjacent to the Canyon Creek Ditch diversion, and make modifications to the existing intake. This alternative provides the greatest redundancy in order to provide a sustainable and consistent water supply to the residents and businesses of the City and to ensure that the raw water intake capacity of 20 MGD is maintained. The total project cost of this alternative is $9.1M.

It is recognized that this recommendation will need to be validated by an Environmental Assessment (EA) in order to ensure that the Least Environmentally Damaging Practicable Alternative (LEDPA) is selected. Alternatives B and C will be evaluated in the EA along with a No Action alternative. Alternative A does not meet the stated Purpose and Need and will not be evaluated further.

SECTION 2 - INTRODUCTION

2.1 DESCRIPTION AND HISTORY OF THE PROJECT

The City of Laurel, Montana has drawn raw water from the Yellowstone since 1908 as its sole source for public water supply, providing water to the residents and businesses of Laurel as well as the Cenex Harvest States (CHS) refinery. Over the past 100 years, the river has undergone dramatic change in the vicinity of the highway and railroad bridges, mostly in response to large flood events. The tendency of the river to meander and migrate has made it difficult for the City to provide a reliable water supply. The current raw water intake, which was constructed in 2003, replaced an existing concrete intake (installed in the 1950s) that was left dry by river migration from the floods of 1996-1997. Both intakes were constructed immediately downstream of the highway 212/310 bridge.

During the spring of 2011, the entire State of Montana experienced severe flooding due to heavy rains and above average snowpack. Flooding on the Yellowstone, in the vicinity of the intake, caused the river to migrate yet again. The migration and corresponding scour has lowered the water surface at the intake, especially at low flows, and compromised the ability of the intake to draw water from the river on a consistent, year-round basis.

Additionally, a large volume of sediment was deposited upstream, downstream, and beneath the Highway 212/310 and railroad bridges located immediately upstream of the intake, particularly on the north side of the river. The bank erosion and sediment deposition indicated the river was migrating to the south. The intake structure had been located in the center of the main channel flow but was now on the north edge of the main channel flows.

During January 2012, water over the submerged intake was at its lowest levels since installation of the new intake. This resulted in excessive ice buildup on top of the structure, slush ice developing on the intake screens, and a temporary shutdown of the raw water line from the intake to the CHS Oil Refinery because the City could not meet their own domestic demands. With the recent developments concerning water availability issues at the intake structure, these problems have escalated to a severe threat to public health and safety and must be corrected as soon as possible.

The City of Laurel has secured funding from the Federal Emergency Management Agency (FEMA) Public Assistance Grant Program to construct improvements to protect the continued operation of the intake structure.

2.2 SITE INFORMATION

Site Description & Location

The current water treatment plant (WTP) intake is located approximately 1.4 miles south of Laurel, Montana in the Yellowstone River downstream of the highway bridge (see maps in Appendix A). It lies in the southwest quarter of Section 15, Township 2 South, Range 24 East, Yellowstone County, Montana at latitude 45.654121°N and longitude 108.759182°W.

The intake is located slightly downstream of the south center-span pier and is intended to remain submerged, even at low water. A raw water line runs from the intake to the WTP and is buried beneath the river bed. The intake is designed for future demand and has a capacity of 20 million gallons per day (MGD).

Figure 1: Existing (new) WTP intake structure, looking downstream from the highway bridge

Figure 2: Original intake structure and sediment deposition, looking upstream at highway bridge

Riverside Park, which is owned by the City, is adjacent to the intake on the south side of the river. It is accessed directly from U.S. Highway 212/310 which forms its western boundary. A Burlington Northern-Santa Fe railroad line parallels U.S. Highway 212/310 to the west of the highway. The topography of the park is generally flat with a manmade levee located along the river from the Highway 212/310 bridge to a point 2,500 feet downstream of the bridge. The levee consists of a standard trapezoidal cross section except west of the boat ramp where it was gently graded out on the landward side when the campground was developed. However, the top elevation of the levee was maintained all the way to the Highway 212/310 bridge abutment. Numerous cottonwood trees are found throughout the park and the area surrounding the levee is a dense upland riparian area.

The City of Laurel Water Treatment Plant sits on the north bank of the Yellowstone River opposite of Riverside Park. Also north of the river are the City of Laurel Wastewater Treatment Plant, a decommissioned landfill, the Cenex Harvest States (CHS) Oil Refinery, the CHS wastewater treatment plant, and the Billings Bench Water Association (BBWA) irrigation diversion structure. The CHS Oil Refinery has been in operation since the 1930s and produces 42,000 barrels per day of refined petroleum products including propane, gasoline, diesel, asphalt, and road oil. Residential and agricultural lands are the primary land use south of the river.

Utilities

There are a number of underground and overhead utility lines in the vicinity of the project (see Exhibit C in Appendix A). The Exxon-Mobil Silvertip crude oil pipeline lies 750 feet downstream of the highway bridge and was ruptured as a result of river bank erosion and bed scour at Riverside Park. A new pipeline was installed shortly after the failure, and the old, damaged pipeline has been being removed. Another crude oil pipeline and a 12-inch natural gas transmission main operated by Williston Basin Interstate Pipeline also cross beneath the river and run through the park.

Hydrology

The Yellowstone River drains approximately 8,200 square miles at Laurel and has the following peak flows, which were obtained from the Draft 2007 Flood Insurance Study (FIS) prepared by the U.S. Army Corps of Engineers (ACOE):

Table 1: Peak flows

Return Interval	Flow (cubic feet/second, cfs)
Bankfull (1.8 year)	28,000
10-year	43,200
50-year	52,900
100-year	56,700
500-year	65,100

It should be noted that the 100-year flow used in the FIS is lower than what has been predicted previously. The Montana Department of Transportation (MDT) used 69,900 cfs in their hydraulic analysis in 1995, and the ACOE predicted 65,000 cfs in their 2000 study (Appendix I). However, since the FIS is the most recent analysis completed, its flows will be used on this project.

The nearest stream gage to Laurel is at Billings (USGS gage no. 06214500). However, the data from the gage cannot be used directly since the Clarks Fork of the Yellowstone River drains into the Yellowstone approximately two miles downstream of Laurel. The 2007 FIS gives flows at Laurel and also just upstream of where Five Mile Creek drains into the Yellowstone in east Billings. The ratio of these flows was used to determine that flows at

Laurel are approximately 76% of those in Billings. This percentage can then be applied to the recorded flows at the Billings gage to give an estimate of the flows at Laurel.

The problems with the intake occur almost exclusively at low flows, and therefore, a thorough analysis of low flows was completed. In Appendix A of the 2000 ACOE study it states, "An annual seven day minimum low flow of about 800 cfs is reported in the USGS summary statistic for the Billings station. A similar value of about 100 cfs is reported for the Clarks Fork River. Thus, the intake should function with about 700 cfs to be reliable."

The Billings gage was analyzed, and the lowest mean daily flow for each year dating back to 1904 was used in a Log-Pearson regression. The gage flows were multiplied by 76% to make them accurate for Laurel. The results of the regression are shown in the table below.

Table 2: Low flow regression

Return Interval	P_{lower}	Flow (cfs)
100-year	1%	438
50-year	2%	450
25-year	4%	473
10-year	10%	555
5-year	20%	718
2-year	50%	951
1.25-year	80%	1259
1-year	99%	2065

The probability shown is not the *exceedance probability*, which is a typical output of these regressions; rather, it is the probability that the mean daily flow will drop below the corresponding flow in any given year (P_{lower}). For example, a P_{lower} of 4% means that there is a 4% chance that the mean daily flow will fall below 473 cfs in any given year. As is conventional, the Return Interval is the inverse of the probability (i.e. 25-year = 1 ÷ 4%). The table is reproduced in the graph below.

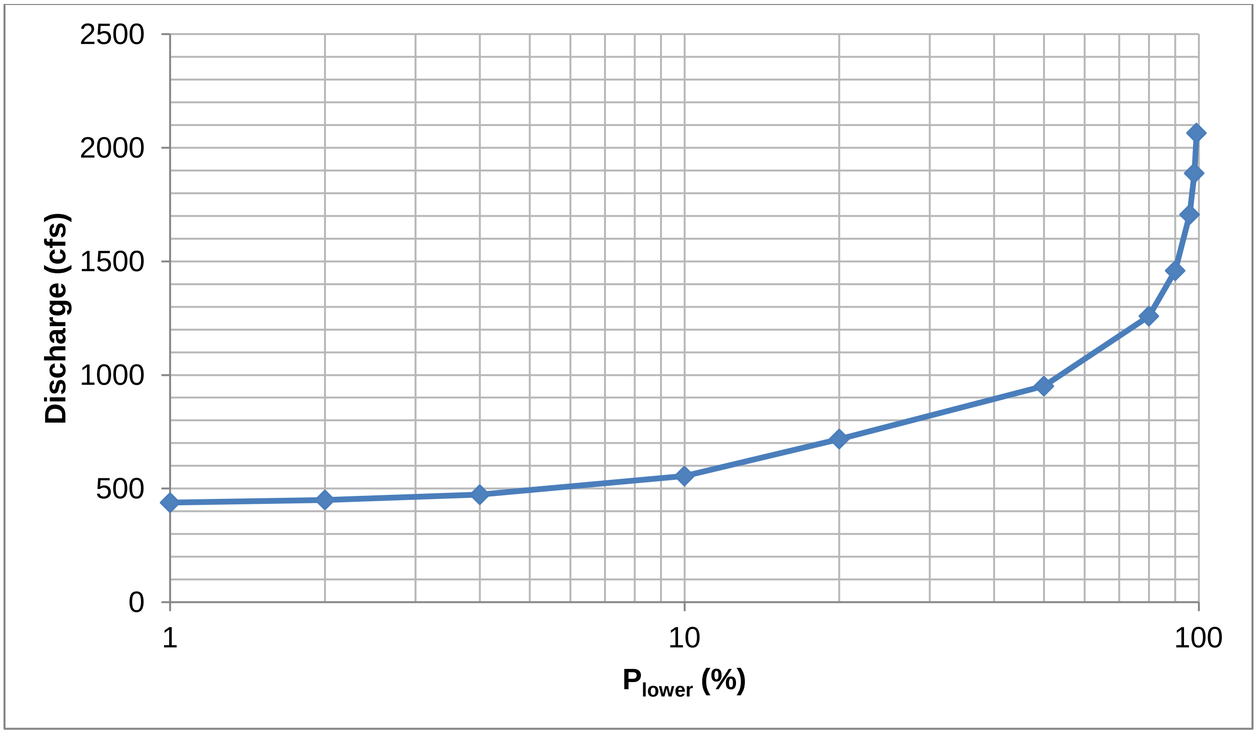


Figure 3: Graph of low flow regression

This analysis shows that the design low flow of 700 cfs, recommended by the ACOE in 2000, has an approximate 20% chance of occurring in any given year. Since the water treatment plant has on the order of one to two hours of storage capacity, this is not an acceptable risk to take. It is recommended that 450 cfs be used as the design low flow, which has an approximate 2% chance of occurring in any given year. See Appendix L for supporting hydrologic information.

Detailed Description of the Intake Problems

The existing intake, originally designed by HKM Engineering, Inc., consists of four “tee” screens, encased in a concrete protective structure (see Figure 4 below). As-Constructed plans of the existing intake, which are included in Appendix K, show that the intake was designed for a capacity of 20 MGD.

The intake is passive and does not “suck” water from the river. Water flows by gravity from the intake screens, through two 24” diameter pipes, and then enters a manifold in the pump building where it is then pumped by a series of vertical turbine pumps to the water treatment plant and the CHS refinery.

Figure 4: Photo of existing intake during construction, showing screens

In order for the pumps to operate at capacity and avoid cavitation, sufficient Net Positive Suction Head (NPSH) must be maintained and is directly related to the static water surface elevation at the pumps. Cavitation results in reduced operational capacity and even damage to the pumps.

The pumps were designed so that when the water surface elevation in the river is 3260.7 (NAVD88) or greater, there is sufficient NPSH and submergence over the suction bells for the pumps to operate efficiently. The elevation of the top of the concrete lid is 3261.0, so for reference, the design low water elevation is 0.3 feet below the top of the concrete lid. Hydraulic modeling of existing conditions, accounting for the permanent bank stabilization at Riverside Park, for a flow of 450 cfs (see Hydrology discussion above) shows the water surface elevation at the intake would be 3258.71; that is 2 feet below the design low water stage. The same model shows that a flow rate of approximately 1900 cfs is needed to maintain the design low water elevation of 3260.7. Based on the hydrologic analyses above, the river has a 99% chance of dropping below this flow in any given year.

Of equal concern is the probability of frazil ice clogging the screens and the pumps during the winter months when the water level is low. Frazil ice, also known as slush ice, sporadically forms in open, turbulent, super-cooled water and is a frequent occurrence on the Yellowstone River, see Figure 5 below. The screens are equipped with an air backwash system to keep them clear of seaweed, debris, and ice. During the winter months the backwash compressors are required to run nearly constantly in order to keep ice off the screens. According to WTP personnel, the intake and pumps begin to have problems with frazil ice when the water level drops to near the top of the lid (elev. 3260.7). The top of the lid is 1.5 feet above the top of the intake screens. Therefore, it is safely concluded that a depth of two feet of water is needed over the screens to prevent frazil ice to be drawn in and cause the pumps to cavitate.

Figure 5: Frazil ice beneath highway and railroad bridges, December 2012

In January 2012, the top of the intake, which is supposed to remain submerged in all flows, was exposed to air, and ice began to build up on the intake structure. Additionally, slush ice flows in the river, which have never affected the intake because they occur at the water surface, began clogging the intake screens. These occurrences culminated in the City having to temporarily shut off the raw water supply to the CHS Oil Refinery in order to meet domestic demands.

City of Laurel Public Works Director, Kurt Markegard, documented the recent intake problems in a letter to Great West Engineering dated February 16, 2012, and is quoted as follows:

> "The water supplied to the CHS Oil Refinery was disrupted on January 30, 2012, due to low river flows and a buildup of ice over the top of the intake structure…The river flow over the water intake on January 30th was the lowest that any City employee has seen it since the intake was installed in the river in 2003…I feel that it is imperative that the

river channel migration to the south be stopped and actually restored at the bridge structure in order to prevent the City of Laurel from running out of water for domestic, industrial, and fire suppression efforts."

In summary, the problems with the intake are twofold: 1) low water surface relative to the pumps, which causes cavitation and 2) low water surface relative to the screens, which clogs the screens and the pumps with frazil ice and causes cavitation. The low water surface at the intake is a direct result of the channel migration and scour that occurred during the flooding in 2011.

SECTION 3 - PURPOSE AND NEED

3.1 PROPOSED ACTION

The proposed action is to do one of two things: 1) keep the existing intake in service through modifications to the intake and pumping system and/or channel training, or 2) leave the existing intake as is and add another raw water supply, possibly by an alternate means at another location. In either case, the current intake or combination of raw water supplies must provide the City with 20 MGD (~14,000 gpm), reliably.

3.2 PURPOSE AND NEED

The purpose of this project is to provide a sustainable and consistent water supply through winter freezing, high runoff, and summer drought conditions. The need exists because the City of Laurel's raw water intake has experienced a loss of function and is in jeopardy of failing to provide a consistent water supply through winter freezing, high runoff, and summer drought conditions.

SECTION 4 - ALTERNATIVE FORMULATION

4.1 ALTERNATIVE SCREENING PROCESS

The City of Laurel has dealt with water supply problems for over the last 100 years. Due to the long history of problems and multiple attempts to provide a reliable water source for the City, it was imperative that a broad range of alternatives be considered. This was done in order to have the highest possibility of success in mitigating the City's water supply problems.

Great West, in coordination with the City, formed an internal group of engineers and scientists to brainstorm and develop alternatives. Multiple studies, reports, and analyses that have been previously conducted on the intake (see Appendices G-J) were also reviewed. Many alternatives which were considered previously were reevaluated in this analysis. A list of preliminary alternatives was created and was presented to interested parties at a coordination meeting held in Laurel on December 19, 2012 (see Appendix D for minutes from the meeting).

Following this meeting, the alternatives were further developed and compiled into an Alternatives Prescreening Analysis. This document was distributed for review and comment on February 25, 2013 (see distribution memorandum in Appendix D). Those parties in receipt of the analysis were asked to present any other alternatives or variations of alternatives that they wished to be considered. Two new alternatives were presented: 1) 'V'-deflector installed downstream of the intake (#9) and 2) install booster pumps in the WTP (#11). It was also suggested to consider the holding pond alternative (#18) without a W-weir. These comments and suggestions have been taken into consideration and are included in the alternatives analysis. The comments along with Great West's reply are included in Appendix D.

An onsite meeting was held on April 30, 2013 at the Riverside Park as a follow up to the Alternatives Prescreening Analysis. The meeting was well attended, and the list of possible alternatives was presented, allowing them to be viewed from and on-the-ground perspective. Minutes from the meeting are included in Appendix D.

Subsequent coordination meetings were held with representatives from Great West, the City of Laurel, and various regulatory agencies. The agencies involved and dates of the meetings are listed below:

- ACOE; June 17, 2013
- FWP and DEQ; July 19, 2013
- ACOE; December 5, 2013
- FWP and DEQ; December 5, 2013

The meeting on July 19, 2013 proved to be a turning point for the Alternatives Analysis. FWP and DEQ stated that the weir alternatives (numbers 2 and 3 below) would be extremely difficult, if not impossible, to permit. They stated that both from an environmental and technical standpoint, these alternatives are very undesirable. Up to that point, the W-weir had been identified as the only alternative which addressed both the lateral migration and degradation issues that plague the current intake. As a result of this meeting and correspondence with other regulatory agencies, the W-weir and straight weir alternatives will be ruled out in the preliminary screening process below.

Since the W-weir is no longer a viable alternative, it was necessary to evaluate in further detail other alternatives that were had previously been ruled out in the prescreening process. Western Groundwater Services was retained as a subconsultant to evaluate infiltration galleries, radial collector wells, and groundwater (alternatives #22 & #23). The report is summarized in the alternatives discussion below and is included in its entirety in Appendix F.

A comprehensive list of alternatives was developed from the alternative formulation process described above; the results are shown in the table below. The preliminary alternatives are generally separated into four categories: 1) channel training/alteration, 2) modify intake, 3) new intake, and 4) alternate source.

Table 3: List of Preliminary Alternatives

Category	Alt. #	Alternative Description
Channel training/ alteration	1	Construct bendway weirs/rock vane
	2	Construct W-weir
	3	Construct straight weir
	4	Removal the sediment beneath north side of bridges
	5	Raise the channel grade
Modify intake	6	Lower the existing intake screens
	7	Lower the existing intake screens with concrete modification
	8	Replace existing screens with half-round screens
	9	'V' deflector installed downstream of intake
	10	Install hot water heater and appurtenances to utilize hot water flush lines
	11A	Install inline booster pumps in WTP
	11B	Install booster pumps in a new wet well
	12	Remove existing pumps, replace with dry pit submersible pumps
New intake	13	Construct a new intake adjacent to the existing intake
	14	Construct intake 1600 feet downstream
	15	Construct new intake three miles upstream, adjacent to Canyon Creek Ditch
	16	Suspend pipe and intake from highway bridge
	17	Build new bridge to suspend intake and water line
Alternate source	18	Construct diversion to holding pond
	19	Divert water from the Canyon Creek Ditch Co. ditch
	20	Divert water from the Billings Bench Water Assn. ditch
	21	Divert water from both ditches
	22	Groundwater Alternatives – hydraulic connectivity to the Yellowstone River: infiltration galleries, radial collector wells
	23	Vertical groundwater wells

The following sections describe and analyze each of the aforementioned alternatives and consider advantages, disadvantages, design parameters, technical feasibility, environmental considerations, construction limitations, and whether the alternative meets the stated purpose and need of the project. This level of analysis will serve to identify alternatives that are clearly infeasible or are not stand-alone and need to be combined with other alternatives in order to be effective. Following this analysis, the list of alternatives will be reorganized and pared down, and then compared using several objective criteria.

4.2 ANALYSIS OF PRELIMINARY ALTERNATIVES

Alternative 1: Construct bendway weirs/rock vane

"Bendway weirs, also referred to as stream barbs, bank barbs, and reverse sills, are low elevation stone sills used to improve lateral stream stability and flow alignment problems at river bends and highway crossings" (FHWA 2009). For the purposes of this analysis the terms "bendway weirs" and "rock vanes" are considered to be synonymous. A variation of this alternative was originally proposed by the ACOE in their 2000 study. They proposed to utilize a series of four weirs that would be placed along the south bank of the anabranch upstream of the bridge and would be oriented with the objective of directing flow back to the north beneath the bridges (the ACOE study gives figures of their alternative and is included in Appendix I). This approach would likely have a negligible beneficial effect on flow patterns given that the main channel currently exists on the north and water only enters the anabranch during high flows. Bendway weirs could prove to be effective if they were installed beginning at the south bridge abutment and extending upstream in series along the south side of the main channel. The problem with this is that there is no stable bank to tie the weirs into in this area. Therefore, they would be inherently unstable and would have unpredictable effects on the flow patterns of the river.

As shown in Appendix B, over 160 feet of the north bank upstream of the bridges was lost during the 2011 floods. See Figure 6 below. The channel will likely continue to meander to the north (immediately upstream of the bridges) until it has added enough length to reach a stable gradient. That change in configuration has not only reinforced the change of flow to the right side of the channel beneath the bridges, but has also changed the angle at which the thalweg crosses beneath the structures. This change is likely responsible for the erosion right bank of the channel downstream of the bridge crossing.

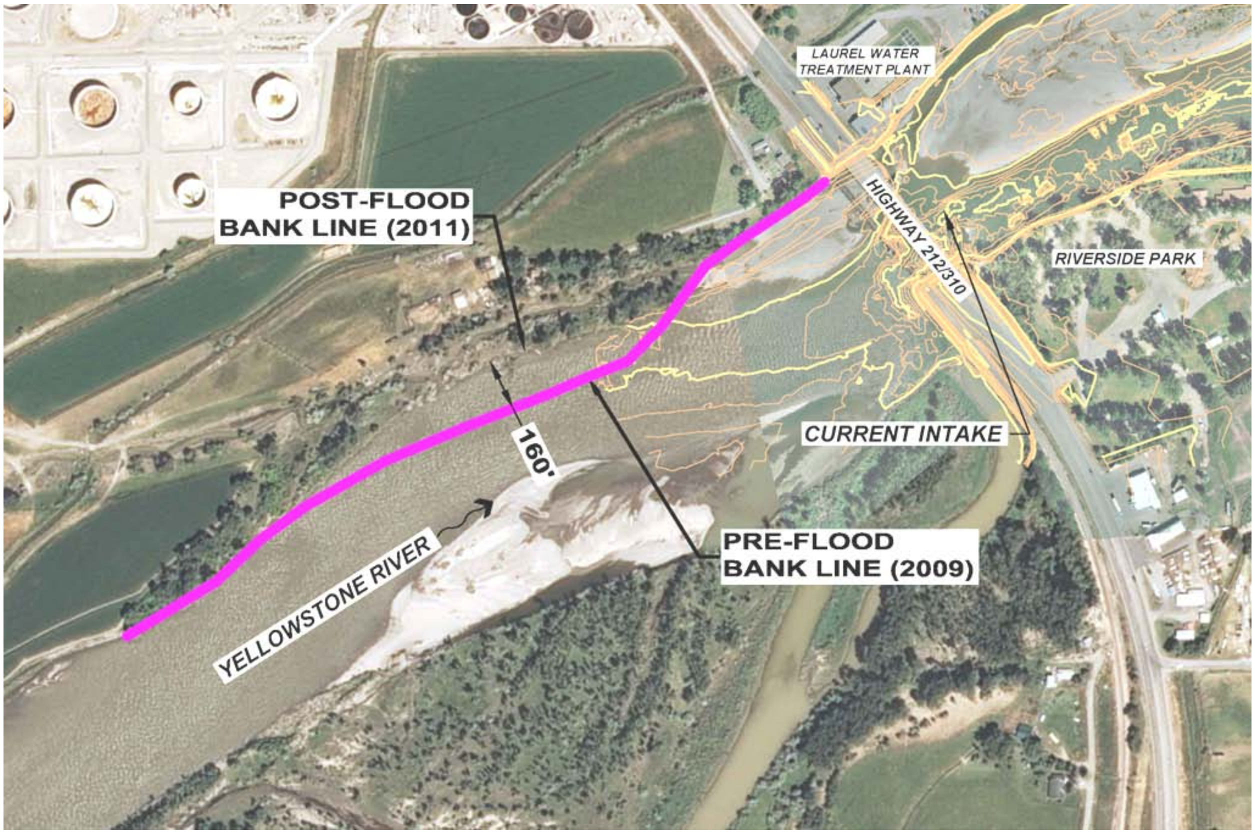


Figure 6 – Aerial photo showing bank loss from 2011 flooding

The weirs would be installed on the north bank, upstream of the bridges, and would also be installed extending upstream from the railroad bridge piers and south abutment. The exact placement would be determined during final design. The objective of using weirs would be twofold: 1) to direct shear stress away from the north bank upstream of the bridges and prevent further migration of the channel and 2) to help redirect flow beneath the bridges more toward the center of the channel. Figure 7 and Figure 8 below show typical drawings of bendway weirs/rock vanes.

This alternative, while it would provide tangible benefits with respect to preventing further bank loss, channel morphology, and river function, does not specifically address the problems associated with the loss of service at the intake. In addition, the likelihood of either MDT or BNSF allowing rock vanes to be placed upstream of the bridge piers and abutments is very low, considering the scour problems that currently exist at the bridges. Due to these stated reasons, this alternative will not be examined further.

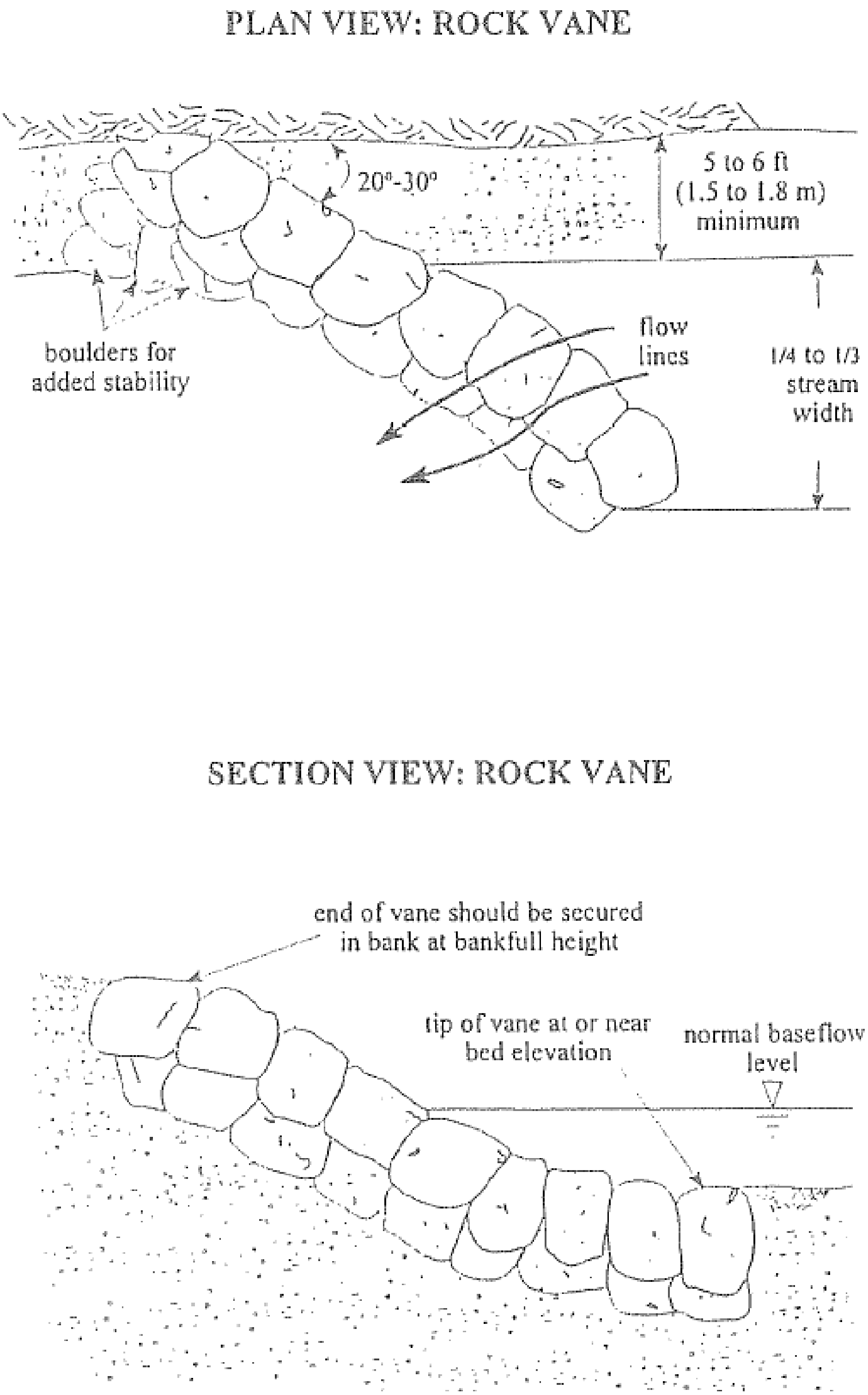


Figure 7: Plan and section view of rock vane/bendway weir (Johnson, et al. 2002)

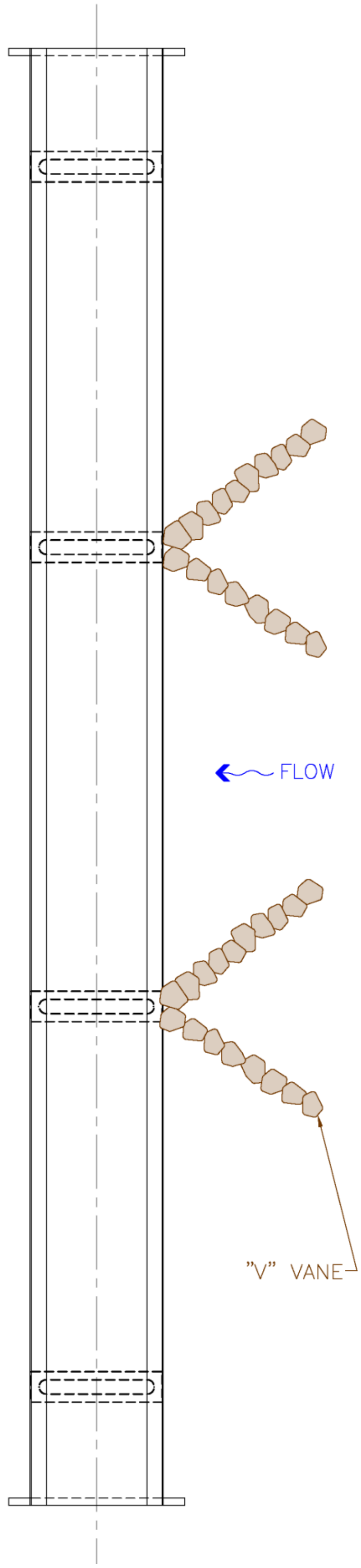


Figure 8: Example of rock vane at bridge pier

Alternative 2: Construct W-weir

A W-weir was proposed by R. Mark Wilson of USFWS in a letter included in the HKM, Inc. 2002 feasibility study and is included in Appendix D (HKM, Inc. 2002).

> "[A W-Weir] is a grade control structure that decreases near-bank shear stress, velocity and stream power, but increases the energy in the center of the channel. The structure will establish grade control, reduce bank erosion, create a stable width/depth ratio, maintain channel capacity, while maintaining sediment transport capacity, and sediment competence…Various rock weirs installed across larger rivers for fish habitat, grade control, and bank protection often create an unnatural and uniform 'line of rocks' that detracts from visual values. [W-weirs have two sides which are] vanes directed from the bankfull bank upstream toward the bed with similar departure angles. From the bed at ¼ and ¾ channel width, the crest of the weir rises in the downstream direction to the center of the bankfull channel creating two thalwegs" (Rosgen 2006).

A schematic of a W-weir is shown in Figure 9 below.

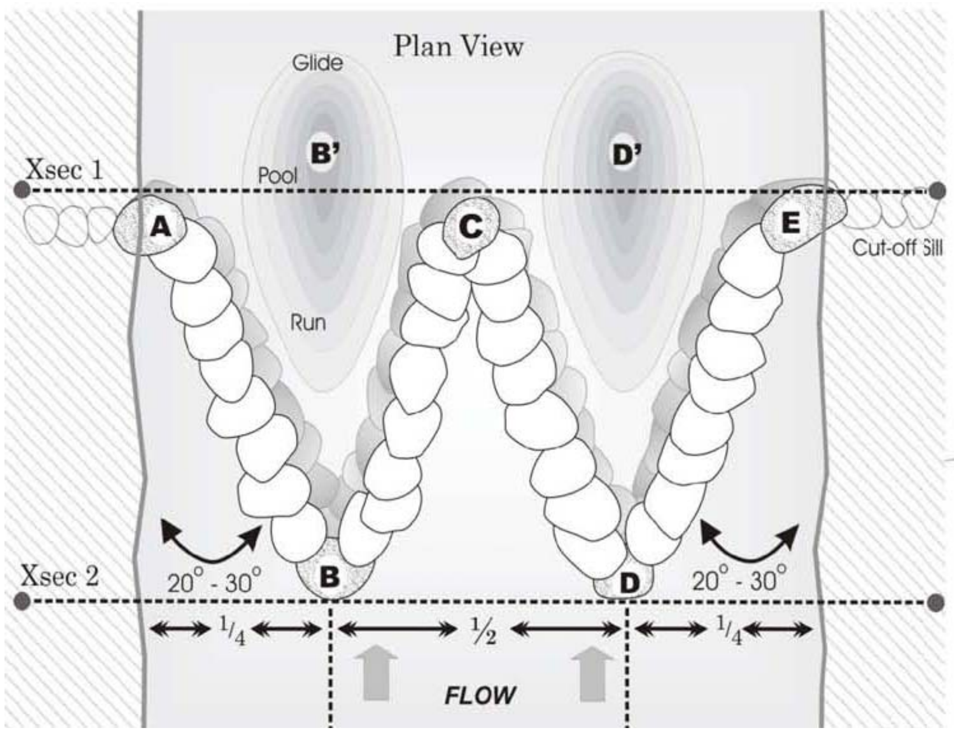


Figure 9: Schematic of W-weir (Rosgen 2006)

Two alternatives were investigated for the construction of a W-weir: a rock alternative and a grouted rock alternative. The primary concerns with the rock alternative are long-term stability, scour, ice jams, and ease of construction. A grouted rock weir alternative will be more durable, will ensure a longer term of stability, and will have a more predicable hydraulic response since it would be effectively impervious.

The use of grouted rock in weirs has become a common way to provide a durable structure. Numerous grouted rock weir structures have been installed across the county for use in irrigation diversion, creation of fish habitat, and recreation for kayakers and other boaters.

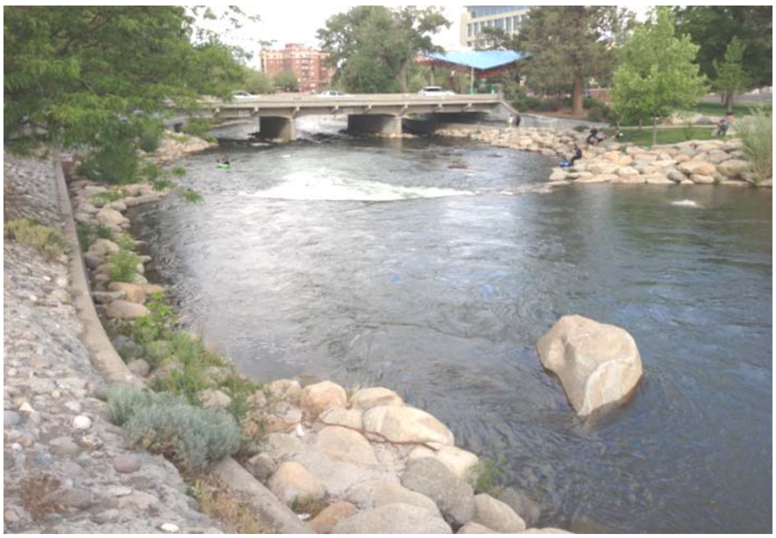


Figure 10: Reno Whitewater Park on the Truckee River, Reno, NV

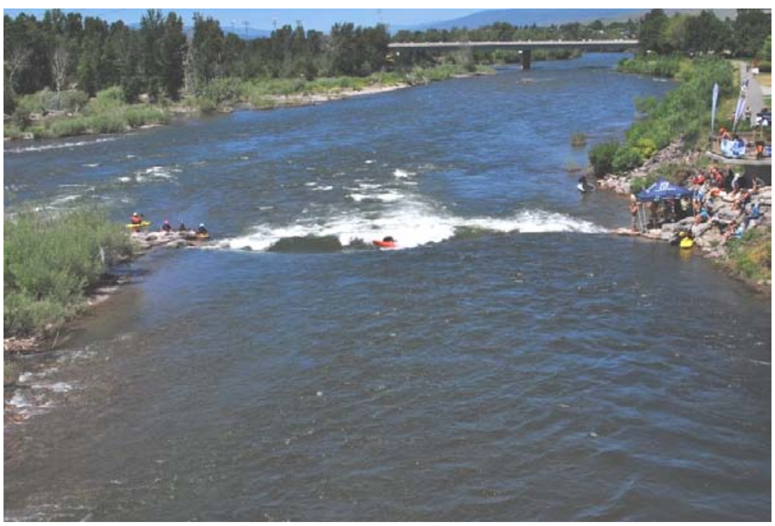


Figure 11: Brennan's Wave on the Clark Fork, Missoula, MT

The purpose of the W-weir installation at this site is to provide adequate water surface elevation over the existing WTP intake at the design low flow of 450 cfs as well as to direct the thalweg of the channel. This will require setting the elevation of the controlling rocks (see points B and D, Figure 9 above) to an elevation in which the water surface at low flow still provides adequate water depth to the intake. The proposed weir location is shown below in Figure 12 and is located immediately downstream of the existing intake.

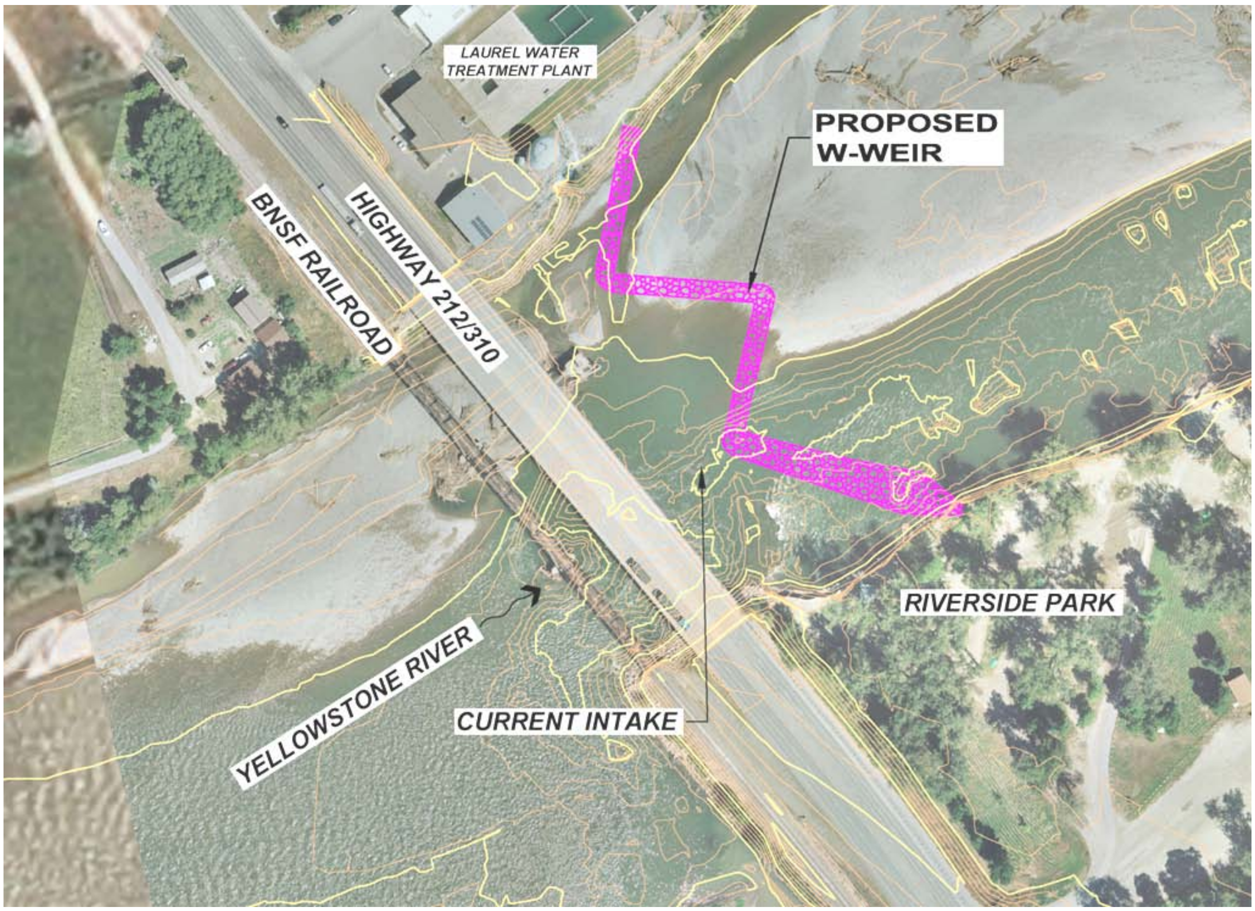


Figure 12: Proposed W-weir, plan view

The construction of the weir would vary depending upon the materials utilized. If the grouted rock system is utilized, proper dewatering is integral to installation. This would likely require staged construction. Due to the installation of the footer rocks and the necessity to be at or below bedrock depths, dewatering will be necessary in some locations to install the grout properly and ensure a quality product. It is anticipated the north section of the W-weir will be constructed first. During this construction, the bulk of the flow will be concentrated to the

Figure 13: Proposed W-weir, perspective view

south. Some dewatering work will be required, but as the flow is already concentrated to the south, this will likely consist of earthen berms to redirect flows rather than a cofferdam. Once the north section of the W-weir is installed, the south section will need to be dewatered due to deep flow depths. Dewatering methods can vary, but may incorporate a cofferdam or similar system. This cofferdam may be located either directly upstream of the diversion or above the railroad bridge. To properly install this cofferdam and due to the size of the operation, it is anticipated that a work bridge will be necessary for installation. Some stream work will be necessary to then direct flows to the north. Once construction of the south portion of the W-weir is complete, the cofferdam will be removed.

For the rock weir with no grout, no cofferdams are assumed to be needed. It is anticipated that the rock structure can be built in ‘wet conditions’. Some channel work and temporary modifications will be likely necessary to aid in construction.

Recreational use will also be incorporated into the design of the structure, with allowable passage for boating traffic. A ‘notch’ or similar system in the weir will be constructed in the weir to allow safe travel.

As this reach of the Yellowstone River is in a detailed flood study, floodplain impacts must be considered. Any change to the BFE and/or floodway will require the issuance of a CLOMR and eventually a LOMR from FEMA. This is a substantial effort and could add up to six months to the schedule.

Ice jamming and sedimentation are also significant considerations. The W-weir is designed so that sediment transport capacity is maintained (see the quote above from Rosgen). However, there are a few cases in Montana (as noted in correspondence from Jeff Ryan of DEQ, see Appendix D) where the installation of a rock weir has caused sedimentation problems upstream.

The W-weir, although it serves to allow the current take to remain in service by controlling the river laterally and vertically, would face insurmountable permitting issues, as indicated in the Alternatives Formulation discussion. Therefore, this alternative will not be examined further.

Alternative 3: Construct straight weir

Several rock weirs or ‘dams’ have been used on the Yellowstone River, primarily for the purpose of irrigation. “Between Billings and Sydney, a total of six irrigation diversion dams cross the Yellowstone River. These dams include Huntley, Waco-Custer, Rancher’s Ditch, Yellowstone, Cartersville, and Intake” (Applied Geomorphology, Inc. & DTM Consulting, Inc. 2008). A weir would serve to elevate the water surface over the intake to provide sufficient head at low flows.

An alternatives analysis has been underway for the Intake Diversion Dam since the late 1990’s, as it has been recognized as a barrier to upstream and downstream passage of pallid sturgeon and other species. This project culminated in the development and release of a Final EA in April of 2010. The preferred alternative from the EA consists of a concrete weir and rock ramp with new canal headworks. A schematic of the proposal is shown in Figure 16 below.

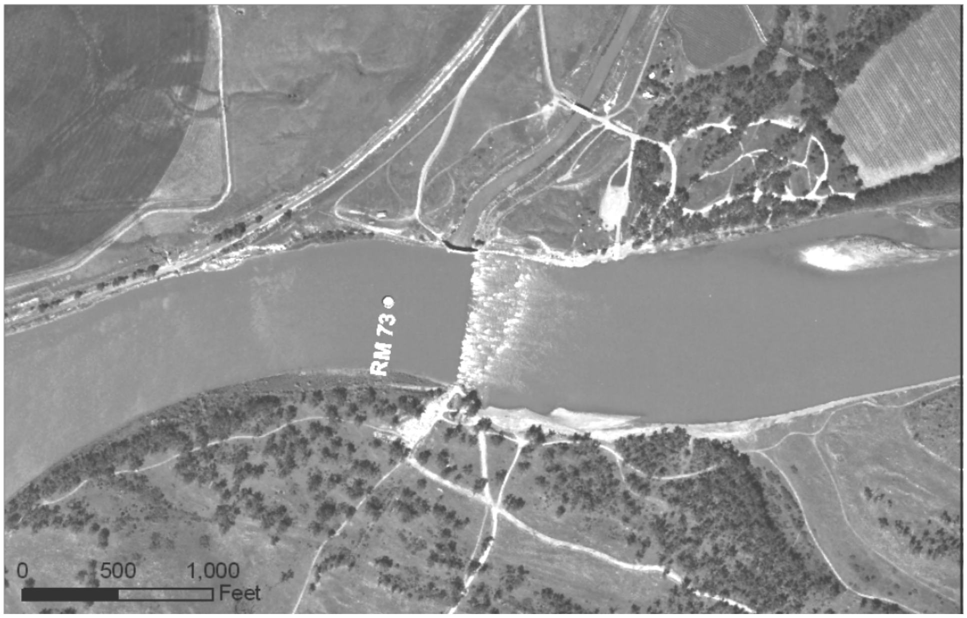


Figure 14: 2005 image of Intake Diversion Dam on the Yellowstone River (Applied Geomorphology, Inc. & DTM Consulting, Inc. 2008)

Figure 15: Photo of Intake Diversion Dam on the Yellowstone River (courtesy of USFWS)

Figure 16: Schematic of preferred alternative for the Intake Diversion Dam. Concrete weir with rock ramp

As mentioned above, construction of the weir may consist either of rock or grouted rock. A grouted rock weir alternative will be more durable and will help to ensure long term stability.

The design and installation will be very similar to the W-weir mentioned above, though the structure length is shorter. The weir will have a low point that will likely align with the intake. It has a few disadvantages when compared to the W-weir. First, because of the single weir configuration, flow is more or less concentrated at one location. Secondly, sediment transport would less efficient, when compared with the W-weir. This is a significant disadvantage considering the volume of sediment that is moved by the river. Ice jamming problems would also be amplified with a straight configuration. Construction would be very similar to the previously discussed W-weir. The proposed weir location is shown in Figure 17 below and is located immediately downstream of the existing intake.

The straight weir, although it serves to allow the current take to remain in service by controlling the river laterally and vertically, would face insurmountable permitting issues, as indicated in the Alternatives Formulation discussion. Therefore, this alternative will not be examined further.

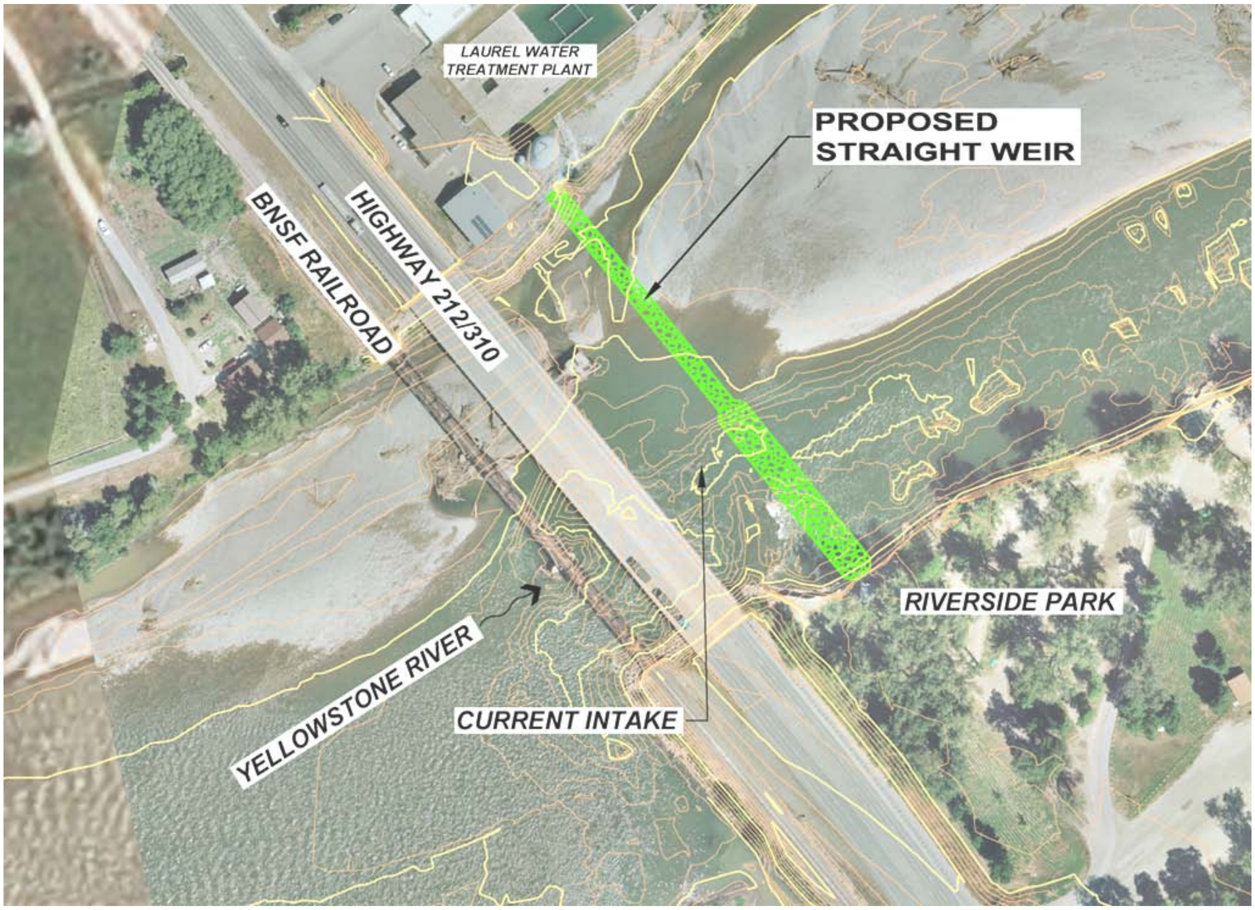


Figure 17: Proposed straight weir

Alternative 4: Remove the sediment beneath north side of bridges

Significant changes to the river occurred during the flooding in spring and summer of 2011. A large volume of sediment was deposited upstream and beneath the highway and railroad bridges. City personnel report that as much as eight feet of additional sediment was deposited beneath the bridges as a result of the flooding. This reduced the hydraulic capacity of the bridges and created a backwater effect which caused increased velocities and scour through the southern halves of the two bridges. The increased velocities combined with the expanding flow

Figure 18: Sediment deposition beneath railroad and highway bridges. Looking upstream.

patterns as water flowed out from the bridges caused severe erosion to the south river bank immediately downstream of the highway bridge.

Sediment removal, as a stand-alone measure, will not solve the channel migration and sedimentation problems that exist in the vicinity of the intake. However, when combined with other river training measures, it would be an effective and beneficial measure. Removal of the sediment will help to restore the hydraulic capacity of the bridges. This will likely be necessary if the W-weir or straight weir option is chosen. The installation of the weir will increase the water surface at all flows and may reduce the freeboard at the 100-year flow to an unacceptable level. Removal of the sediment will increase the available freeboard beneath the bridges.

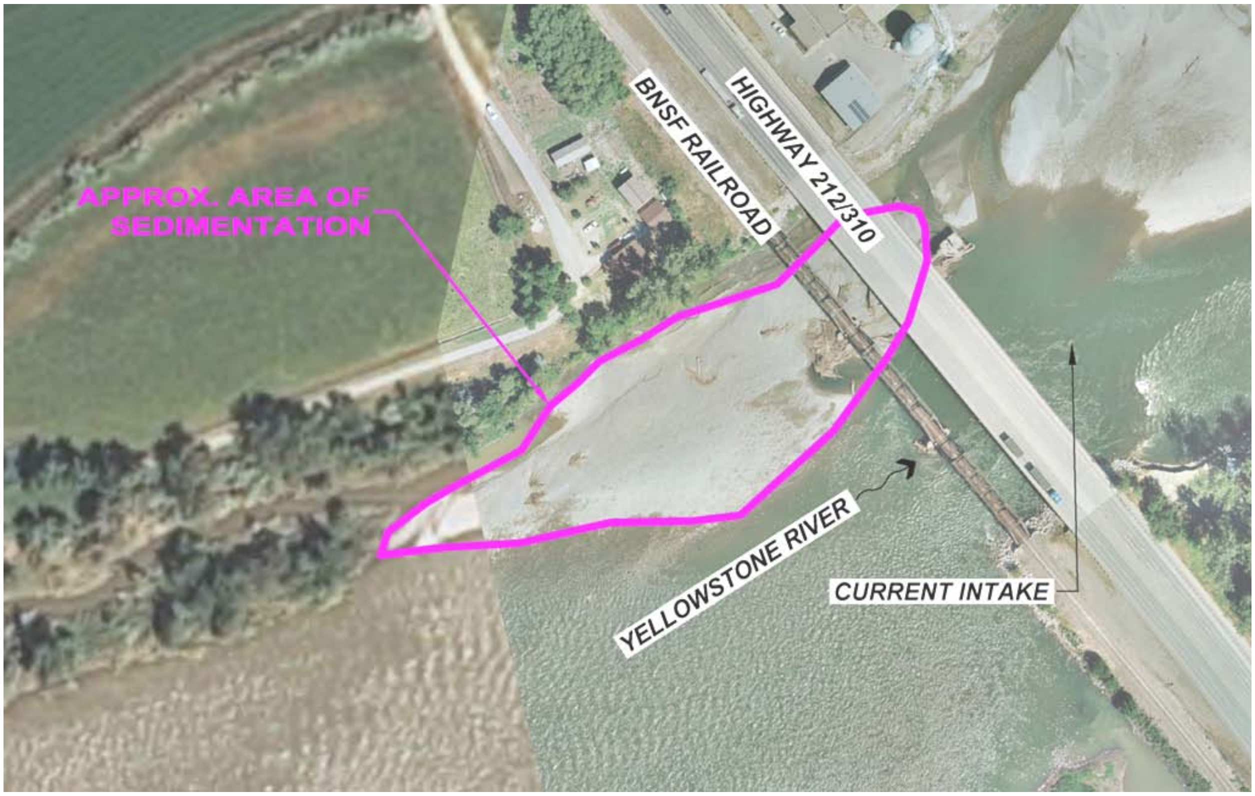


Figure 19: Aerial photo exhibit of existing sedimentation beneath bridges (photo date = 2011)

Sediment removal will help to slow the velocity of the water as it moves through the bridges during high flow events and reduce sheer stress and scour along the channel bed and banks, thereby also reducing degradation and erosion. When combined with other river training measures, the sedimentation could potentially be eliminated in the long-term. It will also provide room for ice to spread out laterally in the event of an ice jam. Figure 19 shows the approximate extent of the sediment deposition. Approximately 6,000 cubic yards of the sediment was removed during March and April of 2013 as part of an effort to restore the function of the historic intake. It is estimated that an additional 10,000 cubic yards of sediment would need to be removed. This volume would depend largely on the water level at the time of construction. Sediment would only be removed to within 12 – 24 inches of the water surface.

Alternative 5: Raise the channel grade

Substantial scour developed beneath the south spans of the railroad and highway bridges during the flooding of 2011 and spring runoff in 2012. Not only did the channel experience localized scour, but the entire reach degraded. This degradation caused a drop in the water surface during low flows and further complicated the ability of the City to draw water from the intake. This alternative would propose to raise the channel gradient throughout the reach. In order to prevent further scour and degradation, the fill would be capped with riprap, a-jacks, or cabled-articulated blocks and in filled with native cobbles and gravel.

Hydraulic modeling was used to determine the amount of fill that would be required to raise the water surface to the minimum design elevation of the existing intake during the design flow event. A design low flow of 450 cfs was used to ensure maximum reliability, even during times of very low water. The minimum design water surface elevation of the intake is approximately 0.3 feet below the top of the structure according the intake construction plans (see Appendix K).

The hydraulic model was adjusted to simulate raising the channel thalweg and narrowing the low flow portion of the channel until the desired water surface at the intake was achieved. Fill would be placed to raise the entire channel invert to a maximum elevation of at least 3 inches below the bottom of the openings along the sides of the intake which matches the original intent of the intake design. The low flow portion of the channel would be narrowed considerably by constructing a large bench along the south riverbank. The fill for the thalweg and south bench would extend from 25 feet upstream of the intake to 225 feet downstream of the intake, and would involve placing approximately 7,000 cubic yards of a combination of any or all of the following: riprap, native cobbles, a-jacks, and cabled-articulated blocks. The base width of the proposed low flow channel would be 50 feet with an average depth of 4.5

feet. Figure 20, below, shows the limits of the fill and the scour holes that were identified in a recent topographic survey.

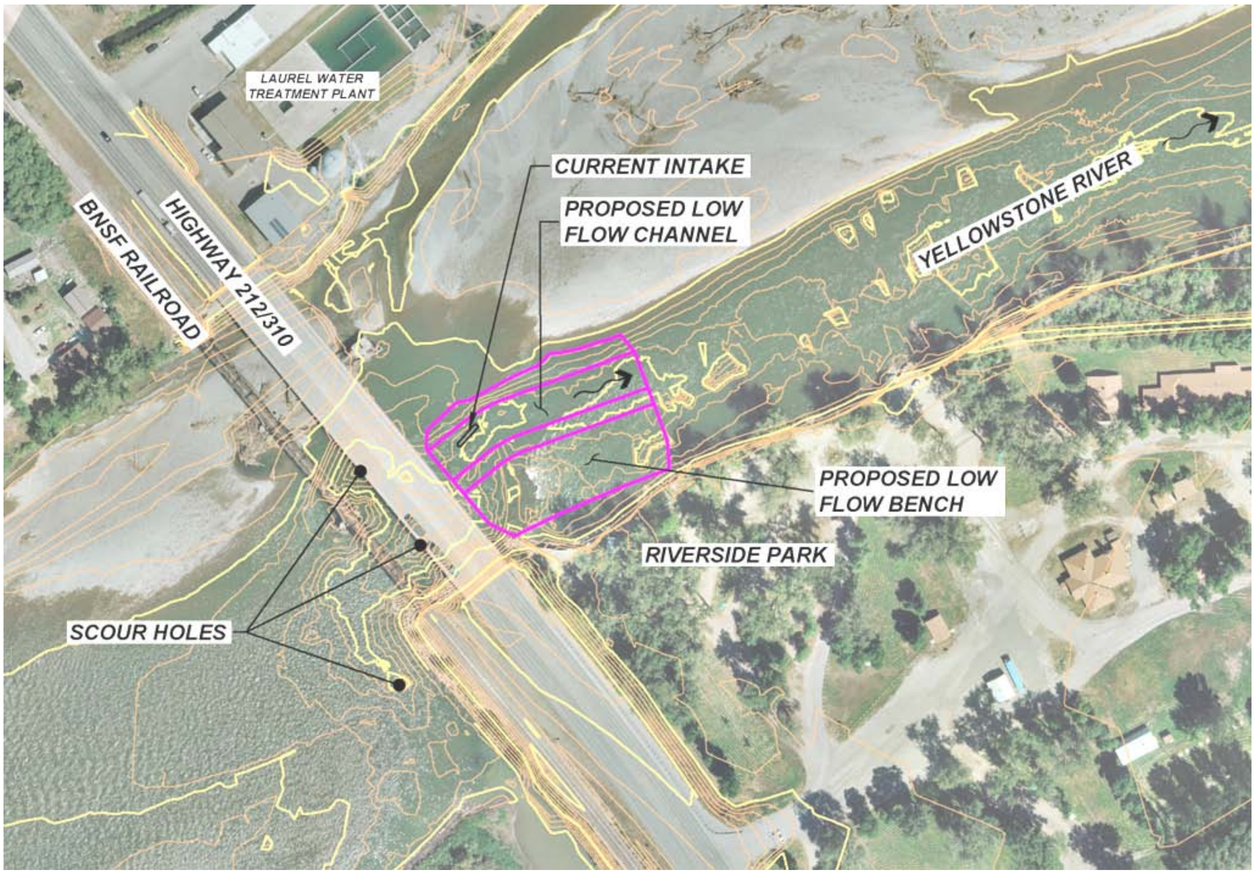


Figure 20: Proposed channel fill limits and scour holes beneath bridges as documented in September 2012 survey

Although numerous iterations were conducted, no practical amount of fill was found to raise the water surface at the intake high enough to meet the design criteria of 0.3 feet below the top of the intake. Since the channel invert cannot be raised above the openings on the intake, some other measure of grade control would be necessary for this alternative to meet the design criteria. Additional hydraulic modeling was performed to evaluate whether filling in the scour holes would have an effect on the water surface at the intake. Filling the scour holes beneath the bridges would cause only a negligible rise at the intake; however, some amount of filling may reduce the likelihood of scour proceeding downstream and compromising the proposed channel fill. This alternative may also have other unpredicted, adverse consequences. In order to effectively raise the water surface, placing fill would have to be combined with weirs or other river training to prevent the flow from eroding the sediment island to the north to bypass the raised channel.

This alternative will not be considered further since it is unable to raise the water surface at the intake enough to satisfy the design criteria and does not meet the stated purpose and need.

Alternative 6: Lower the existing intake screens

According to the screen manufacturer, Johnson Screens, the intake screens require that free space around the screens be equal to ½ the screen diameter for proper function and velocity distribution. Four 24” diameter “tee” screens were installed in the current intake. According to the design plans (see Appendix K), there is 12” of space on the top and on each side of the screens, which is equal to ½ of the screen diameter. However, according to the plans, there is 24” of space from the bottom of the screens to the bottom of concrete. Therefore, the screens themselves could be lowered by 12” without affecting the concrete structure, while still providing adequate free space around the screens. The concrete lid then could also be lowered by 1’-0”. This would effectively increase the depth of water over the screens and would make them less susceptible to clogging by frazil (slush) ice.

It should be noted that in the intake design, HKM established a design low water surface elevation of 3260.7 (NAVD88) that needs to be maintained in order for the intake to function at its design capacity. For reference, this elevation corresponds to approximately four inches below the top of the intake lid. The establishment of the design low water surface elevation is a function of the depth of water required over the screens, but more importantly, it is a function of the hydrostatic head required at the pumps in the WTP in order for them to maintain suction without cavitating. This is pointed out to show that lowering the screens does not, in and of itself, restore complete function to the intake because it does nothing to raise the water surface relative to the pumps. Therefore, lowering the screens should be combined with other alternatives which act to maintain the required water surface elevation at the intake.

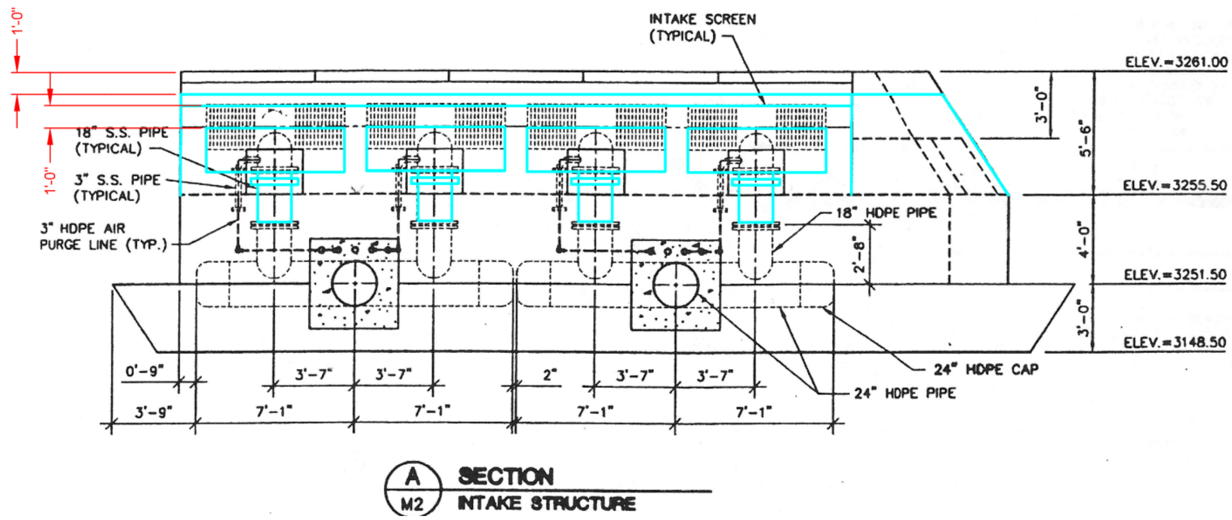


Figure 21: Showing the lowering of the intake screens and concrete lid

The construction of this alternative would entail dewatering and temporarily disabling the current intake. A short work bridge would be constructed from the sediment island to the north that would allow the intake to be dewatered. The stem of the tee screen and the pipe coming up from the concrete would have to be cut and shortened by 6” each; the flanges would have to be welded back on in order to make the connection.

Dewatering, likely by means of a cofferdam, will be necessary. If the contractor is able to perform the required work without dewatering with a sheet pile cofferdam, then the project cost could be reduced significantly.

Alternative 7: Lower the existing intake screens with concrete modification

Another more intensive option would be to dewater and temporary disable the intake and remove all the concrete above the footing. The concrete demolition would pose difficulties for preserving the plumbing inside of the structure. However, concrete cutting technologies are such that the feasibility of this alternative should not be ruled out.

If the concrete were removed above the footing, as shown below in Figure 22, it is estimated that the concrete encasement could be modified to lower the screens an additional 1’-6”. Therefore, with this option, the screens could be lowered a total of 2’-6”. The top of the concrete could also be lowered 2’-6”. This would help to significantly increase the depth of water over the screens and would further reduce problems with the icing of intake.

Similar to Alternative 6, lowering the screens does not, in and of itself, restore complete function to the intake because it does nothing to raise the water surface relative to the pumps in the WTP. Therefore, lowering the screens should be combined with other alternatives which act to maintain the required water surface elevation at the intake.

Construction of this alternative would be very similar to Alternative 6, but it would also involve casting a new concrete encasement on the existing footing. It will also involve reconnecting all of the plumbing which was cut during the removal of the concrete. This may prove to be problematic as the concrete will have to be chiseled out around the remaining plumbing in order to provide a connection

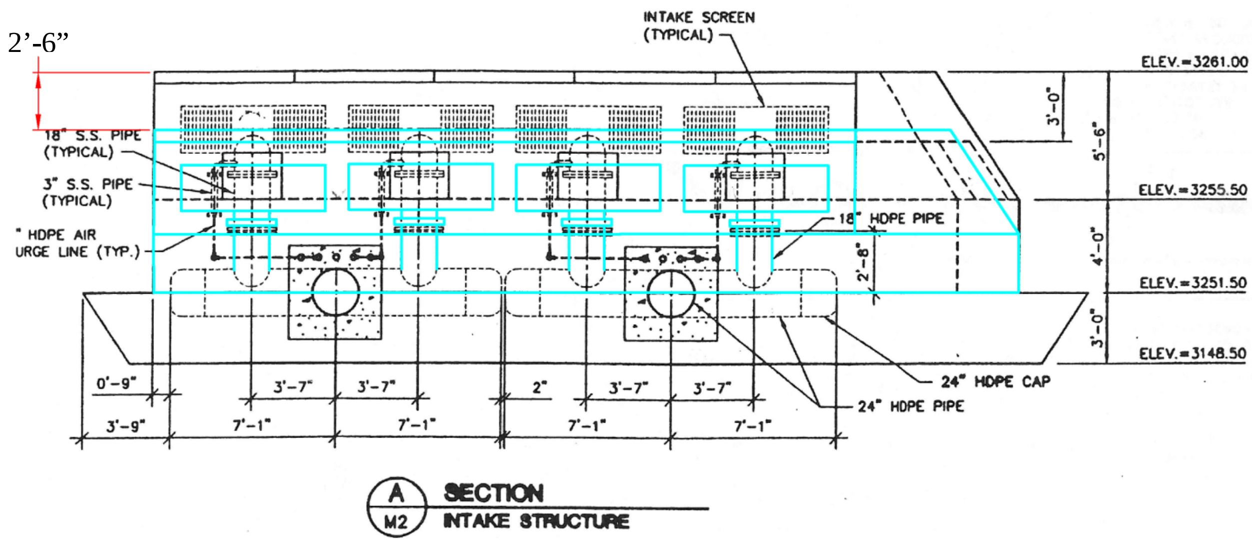


Figure 22: Showing the reconstruction of the intake above the footing

Alternative 8: Replace the existing screens with half-round screens

The manufacturer of the existing screens, Johnson Screens, was contacted to determine if other screen configurations are available that would allow the screens to be lowered. Johnson Screens has recently started manufacturing a “half screen” which is shown in the photos below.

Figure 23: Johnson Screens®: Half Intake Screen System

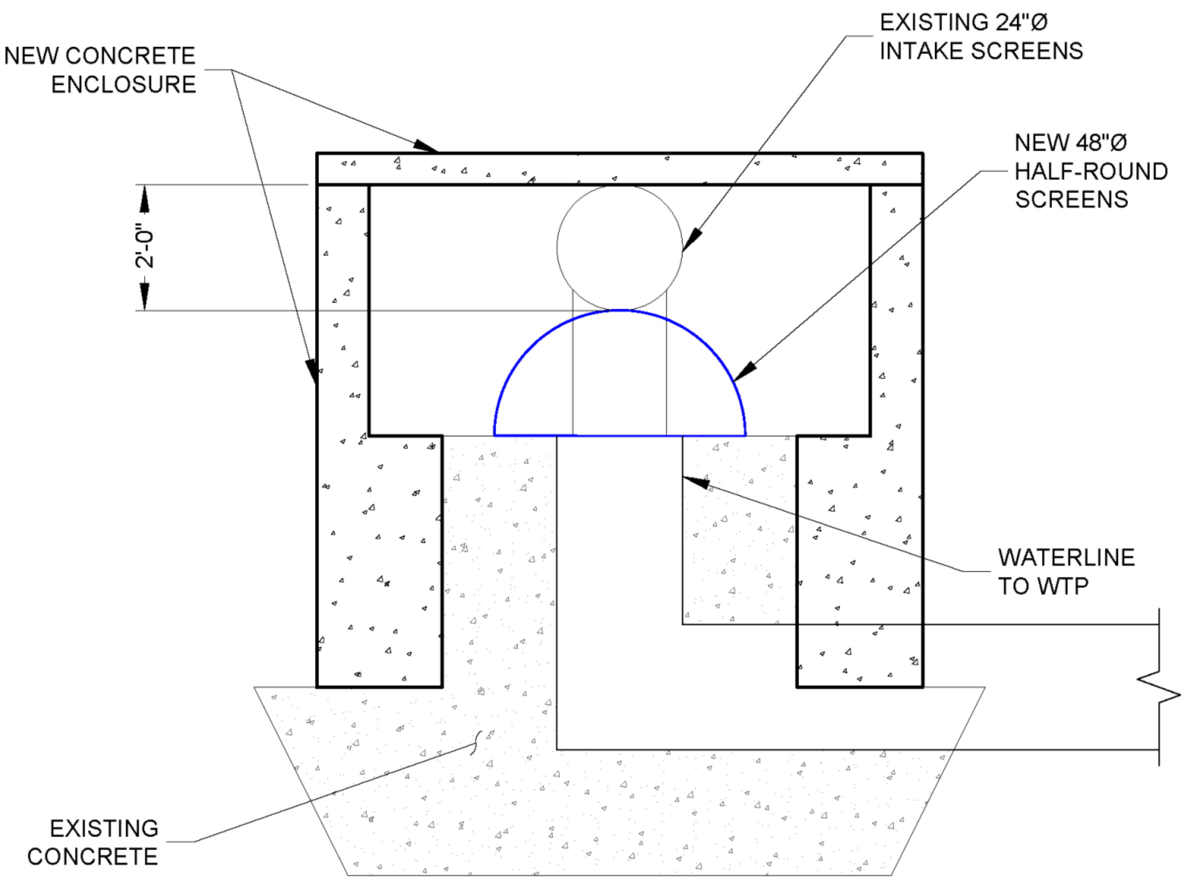


Figure 24: Install half screens in intake

In order to provide the same screen area as the existing 24" diameter round screens, 48" diameter half screens would be needed. A possible configuration is shown in Figure 24 below. The top of the screens would be lowered by two feet compared to the existing. The concrete encasement would have to be expanded in order to provide adequate free space around the screen. In addition, the deck air purge lines and the screen air purge lines would have to be adjusted to accommodate the screen.

Similar to Alternatives 6 and 7, the lowering the screens does not, in and of itself, restore complete function to the intake because it does nothing to raise the water surface relative to the pumps in the WTP. Therefore, lowering the screens should be combined with other alternatives which act to maintain the required water surface elevation at the intake.

Construction of this alternative would be very similar to Alternative 7, but it would pose far less danger to the plumbing that is encased in concrete. Whereas in Alternative 7, the entire mid-section of the intake would be cut through and the plumbing would be reconnected, Alternative 8 involves minimal concrete demolition and only minor rerouting of the plumbing. In comparing Alternatives 6, 7, and 8, Alternative 8 is the preferred approach to lower the screens. It provides an additional one-foot of cover compared to Alternative 6 and poses significantly less risk to the plumbing as Alternative 7. Therefore, Alternatives 6 and 7 will not be considered further in this analysis.

Alternative 9: 'V' deflector installed downstream of intake

In theory, this alternative would serve to funnel/pile up water over the intake. One deflector could be set at the downstream end of the structure as shown in Figure 25, or a series could be installed along the length of the intake. This alternative is attractive because it would be low cost and a relatively simple concept.

However, upon further investigation, this alternative presents several difficulties. As stated in the introduction, at the proposed design low flow of 450 cfs, the water surface elevation at the intake will be approximately 2.6 feet below the design low water stage. While there is no doubt that the deflector(s) will serve to raise the water surface elevation to some extent, it is very unlikely that it would be able to provide the required 2.6 feet over the entire structure length. Additionally, it is even more unlikely that it would be able to raise the water surface in the pumping chamber. The shape of the deflector would be prone to collect ice and debris and would be problematic for that reason. This alternative does not meet the stated purpose and need of the project and will not be considered further.

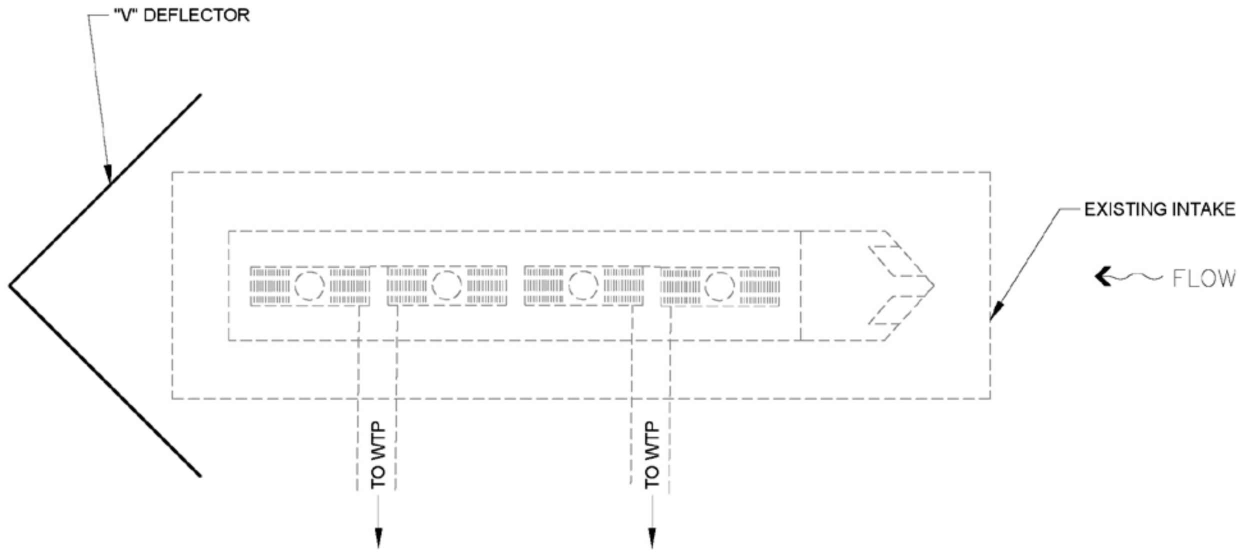


Figure 25: Schematic of 'V' deflector

Alternative 10: Install hot water heater and appurtenances to utilize hot water flush lines

One of issues with the current intake, aside from channel migration and low water surface elevation, is the buildup of frazil (slush) ice on the intake screens. This was recognized during the design and construction of the current intake, and with good foresight, hot water flush lines were installed. However, they were never connected due to cost concerns. It is understood that the plumbing is in place, but it would also be necessary to install a commercial hot water heater, pump, new building, piping, and electronic controls in order to utilize the existing hot water flush lines.

In any of the alternatives where the existing intake is left in service, it is recommended that the hot water flush lines be put into service. However, it should be noted, that this is not a stand-alone alternative. Further investigation needs to be completed in order to determine specific design requirements for this alternative.

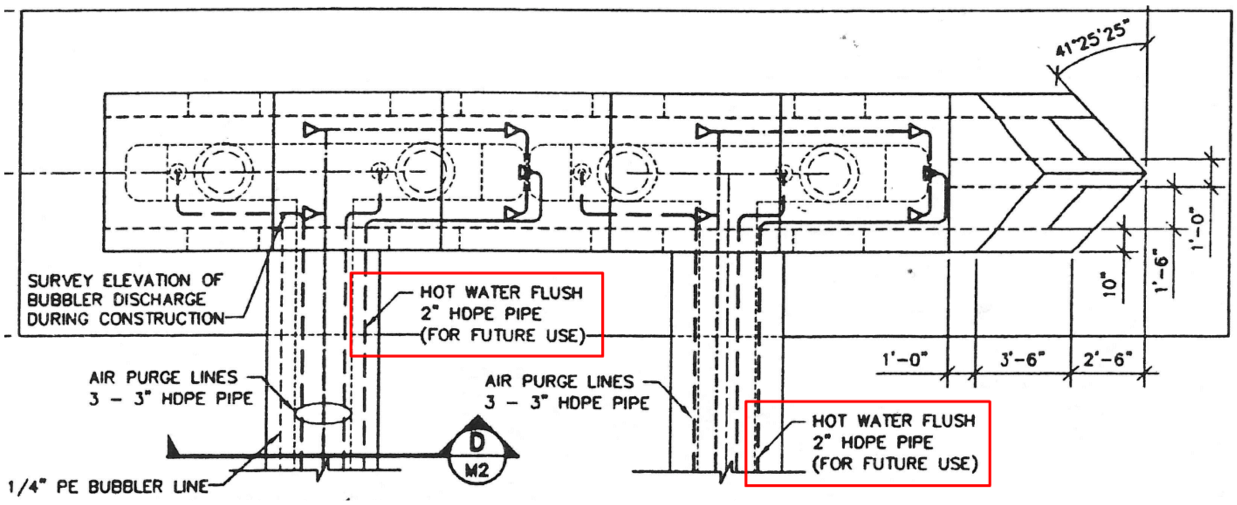


Figure 26: Excerpt from design plans showing hot water flush lines

Figure 27: Picture of existing intake during construction showing hot water flush line

Alternative 11A: Install inline booster pumps in WTP

This alternative considers adding inline booster pumps in the WTP pump building as a way to increase the NPSH-available to the existing vertical turbine pumps, which then pump the raw water to the rest of the WTP. A general schematic of this is shown in the figures below and assumes the use of three dry pit submersible pumps. This alternative would require no manipulation to the river and would be attractive from that standpoint. The figures below show generally where the booster pumps could be installed. The booster pumps would only be used at times when the level in the river fell below the 2003 intake design low water stage of 3260.7 feet in order to limit the operating costs of the pumps.

It should also be noted that due to space constraints only three of the proposed pumps could be installed. This configuration will limit the flexibility of the booster pumps and therefore the raw water capacity related to flow variations. It is recommended that 1 smaller pump (1,000 to 1,500 gpm) and 2 larger pumps (2,000 to 2,500gpm) be installed. This would ensure the estimated average day demand of 1,775 gpm could always be provided even if one of the pumps was out of service; however it would not be possible to guarantee that the estimated maximum day demand of just over 4,500 gpm would always be provided.

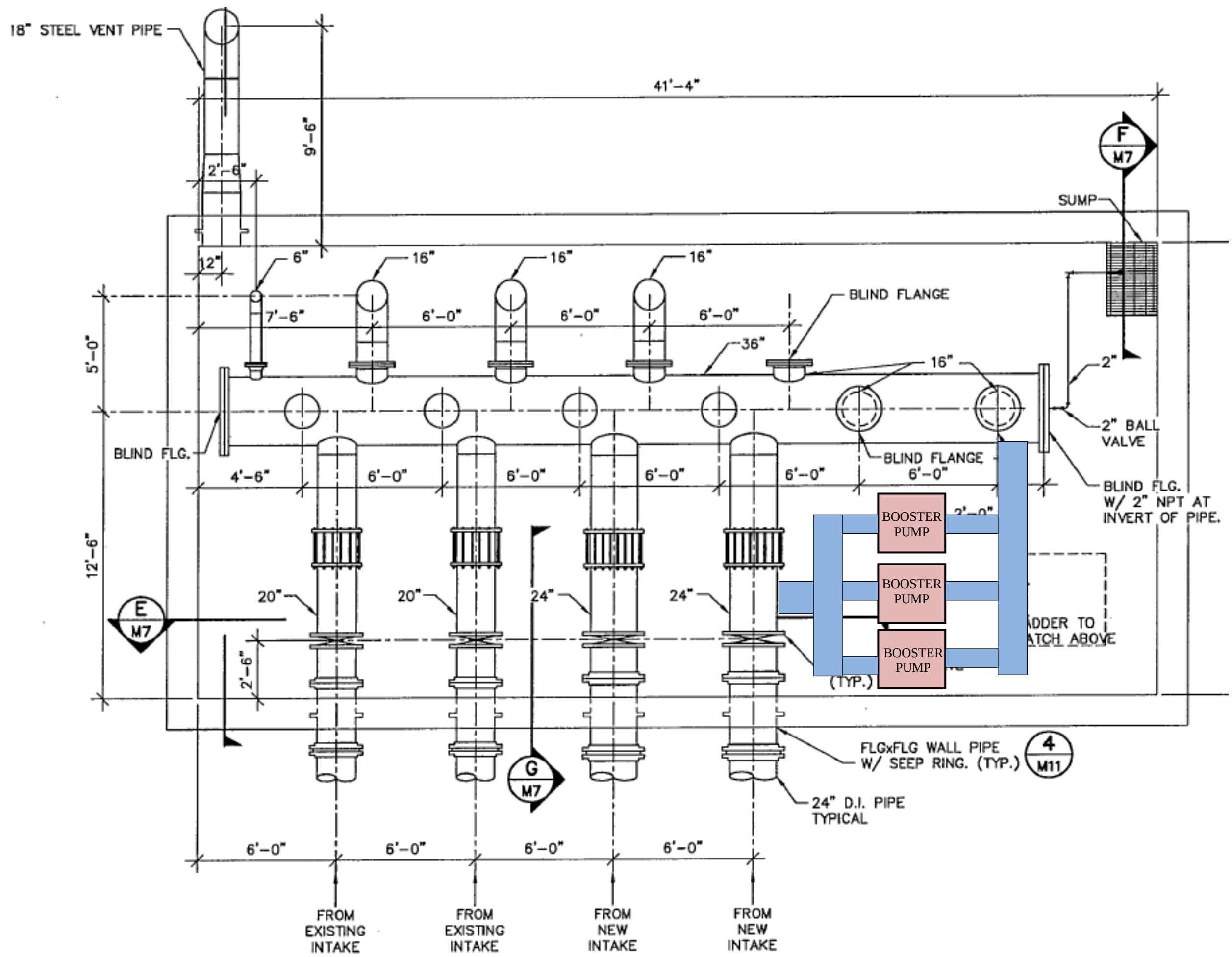


Figure 28: Plan view – lower level of WTP pump building

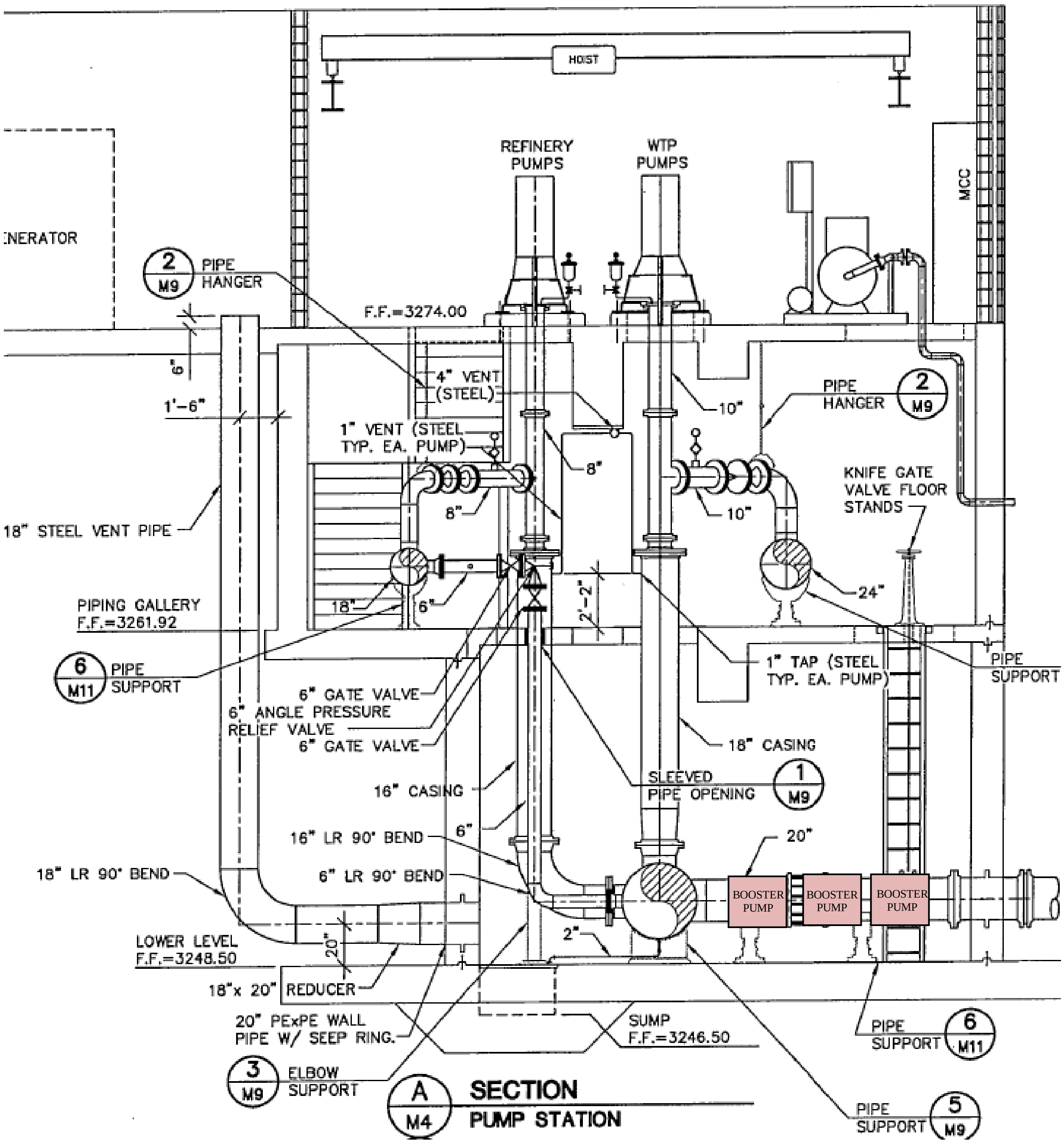


Figure 29: Section view – WTP pump building

Several other issues with this alternative have been identified:

- The booster pumps and vertical turbine pumps would have to work simultaneously and flawlessly to prevent any cavitation and/or pressure surges. The controls for this could be extremely difficult to coordinate and the use of variable frequency drives

(VFDs) would be desirable and/or necessary for all of the pumps. Programming for the controls would require very specific set points, alarms, and range of operations.

- There is a very large range in demand depending upon the season and if the refinery is drawing raw water. As stated previously, the three proposed booster pumps would not have sufficient range to meet all demand scenarios. It would also be necessary to install control valves or check valves on each of the intake lines to avoid pumping water back towards the river. Because check valves typically induce the most head loss, it would be recommended to use gate valves or butterfly valves.
- If the river levels get low enough that the intakes begin drawing in air, the plant could potentially have two sets of cavitating pumps instead of just one.
- The additional pumps would add substantial O&M costs.
- As stated previously, at the proposed design low flow of 450 cfs, the water surface elevation at the intake will be approximately 2 feet below the design low water stage. If the intake screens were left at their current elevation, they would be half exposed and would definitely draw in frazil ice. Even if the intake screens were lowered two feet, as proposed in Alternative 8, the top of the screens would only be approximately 14 inches below the water surface and would still be prone to drawing in slush ice. It is assumed that the screens require a minimum of two feet of water over them in order to prevent frazil ice concerns. The booster pumps would do nothing to address this issue.
- One of the primary concerns with this alternative is that it would do nothing to address the lateral instability of the river.

Even considering the stated issues, this alterative is attractive, given its extremely low environmental impact. However, it is documented below that Alternative 11B provides a more reliable and flexible means of utilizing the current intake and pumping system. Therefore, Alternative 11A will be ruled out from further consideration.

Alternative 11B: Install booster pumps in a new wet well

This alternative considers constructing a wet well and adding booster pumps to provide the necessary head conditions to the vertical turbine pumps in the WTP pump building, which then pump the raw water to the rest of the WTP. This alternative would require limited manipulation to the river related to piping modifications. However, it would require the construction of relatively large wet well adjacent to the existing pump building. The figures below show generally where the wet well is proposed to be located.

Assuming that the existing intake remains submerged with a minimum of 12 inches of water above the screens to maintain the design flow of up to 14,000 gpm into the dual 24" raw water lines which feed the WTP, this alternative would provide a structure and pumps capable of maintaining the necessary head conditions for the vertical turbine pumps any time the river elevation were to fall below 3260.7 feet. However, the capacity of the intake screens themselves would limit the reliability of the wet well and booster pumps; should the water level in the river fall to a point that the screens are not adequately submerged and not able to provide the design flow.

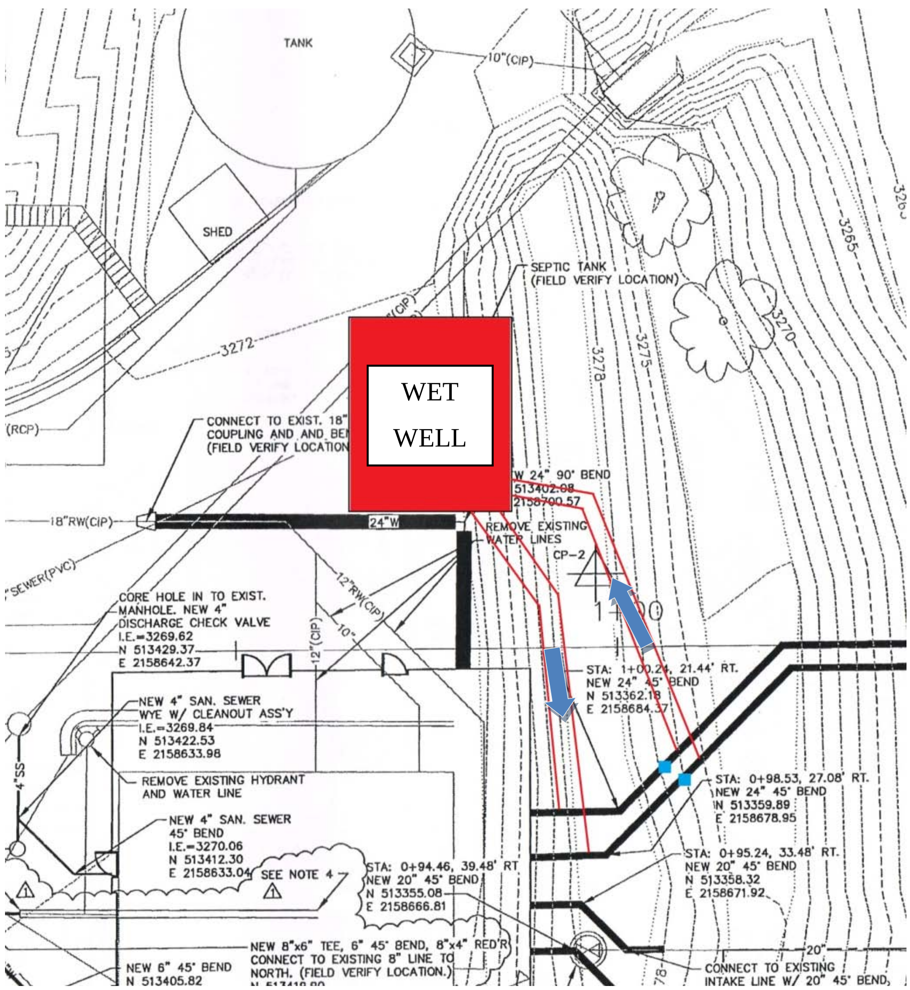


Figure 30: Proposed Wet Well Location and Connective Piping

Construction for this alternative would involve a wet well, suction and discharge piping connected to the raw water lines in the river, and the addition of booster pumps to feed the vertical turbine pumps. Valving and piping modifications would be necessary to divert water to the wet well when low flows are present. The wet well would need to be of sufficient depth and size to provide the design flows to the existing pumps through the use of new booster pumps. There are a number of possible options for booster pumps including submersible, suction lift or flooded suction depending on how the wet well is constructed. It is assumed that all pumps would be equipped with variable frequency drives to aid in the proper function of the pumps.

There are similar concerns associated with this alternative as with the previous booster pump alternative:

- The booster pumps and vertical turbine pumps would have to work simultaneously and flawlessly to prevent any cavitation and/or pressure surges. The controls for this would require specific programming, and all pumps should be equipped with variable frequency drives to fine tune the coordination of the pumping set points.
- There is a very large range in demand depending upon the season and if the refinery is drawing raw water. Multiple pumps and variable frequency drives would be necessary to meet all demand scenarios, requiring several booster pumps to be installed.
- Cavitation would not be an issue for booster pumps located in a wet well adjacent to the plant as long as the intake was continually drawing water. There would also be low water level alarms in the wet well so the pumps would automatically shut off if the water level were to fall below a certain point. Therefore, while cavitation could be avoided through the use of a wet well it cannot guarantee that the plant could always be provided adequate flow as that is dependent on the level of the river and screen submergence.
- The additional pumps would add substantial O&M costs, as would maintenance of the wet well.
- As with the previous booster pump alternative, this alternative does nothing to address the issue of frazil ice formation. However, it is possible the wet well would stop frazil ice from continuing on to the vertical turbine pumps as well as the WTP itself. The booster pumps in the wet well would be located at such a depth that they may not draw in frazil ice. Additionally, the wet well would be connected to a hot

water line to prevent the formation of ice at the water surface of the wet well and eliminate any need to remove ice buildup in the wet well.

- Construction of the wet well would require substantial excavation into bedrock, which is costly.
- Available space at the WTP site is very limited. It is questionable whether or not it is even feasible to install a wet well at the current site.
- One of the primary concerns with this alternative is that it would do nothing to address the lateral instability of the river.

This alternative in conjunction with one of the alternatives addressing the level of the screens, addresses not only the available head problems and possible cavitation faced by the existing vertical turbine pumps, but also the frazil ice problem which can disrupt the treatment process and possibly cause pump cavitation. Also of concern is the fact that there is not an abundance of available space at the WTP site; however, due to the fact that this would be strictly a wet well utilized for lifting water and not for storage, limited space will be necessary. See Figure 30 for preliminary size and siting. This alternative provides greater reliability and flexibility compared to Alternative 11A; however, considering the stated limitations and cost, Alternative 12 below will prove to be the preferred way of making pumping modifications.

Alternative 12: Remove existing pumps, replace with dry pit submersible pumps

This alternative proposes removing the existing vertical turbine pumps, reconfiguring all of the piping in the lower level of the pump building, and installing new dry pit submersible pumps capable of pumping water to the WTP or to the refinery. Based on the dimensions of the lower level, by relocating the main manifold slightly to the south it will be possible to install the same pumping capacity that currently exists using the vertical turbines as well as leave room for the future pumps.

Advantages of this alternative include;

- No work would be done in the river related to the pumps themselves, as the construction specific to the pumps would be related to pump replacement and piping reconfiguration.
- Assuming the intake screens are always submerged, there is no concern for cavitation of the proposed pumps.

- The proposed pumps are designed for solids handling, frazil ice and grit would not be an issue
- The proposed pumps run at low speeds (rpms) which consumes less energy
- The proposed pumps are submersible pumps, flooding is not a concern
- This option uses only <u>one</u> set of pumps, as compared to the previous options utilizing boosters in conjunction with the existing vertical turbine pumps. The controls will be simpler.

While there are many advantages associated with this alternative, there are disadvantages and limitations as well; those include the following;

- Space constraints – based on the dimensions of the building and that of the pumps, it is possible to arrange the pumps in a manner such that there is room for all of them; however, it will be challenging to install and extract the pumps should maintenance be necessary. The hatch to the lower level is small and a lifting/moving mechanism of some sort will be necessary. It is possible that structural modifications to the ceiling of the lower level will be necessary to install an additional hatch for pump installation and removal.
- An alternative method of pumping water during construction would be necessary (bypass pumping) as this alternative will require that the existing manifold and pumps be taken out of service during construction.
- This alternative does nothing to address frazil ice concerns for the WTP process.
- The lateral instability of the river is still an issue.

This alternative in conjunction with one of the alternatives lowering the level of the screens and adding a new intake, would successfully address the available head problems and possible cavitation faced by the existing vertical turbine pumps. This alternative also the limits the number of pumps that would be used compared with either of the booster pump alternatives, and therefore has less of an effect on overall O&M costs. Alternative 12 is the preferred way to make pumping modifications and will be considered further, in conjunction with other secondary alternatives. It is pointed out again that the lateral instability of the river would still be of concern.

Alternative 13: Construct a new intake adjacent to the existing intake

This alternative would involve leaving the current intake in place and constructing another approximately 20'-40' to the south, to capture the main flow, where it currently exists. Plumbing for this new intake would be spliced into the existing lines.

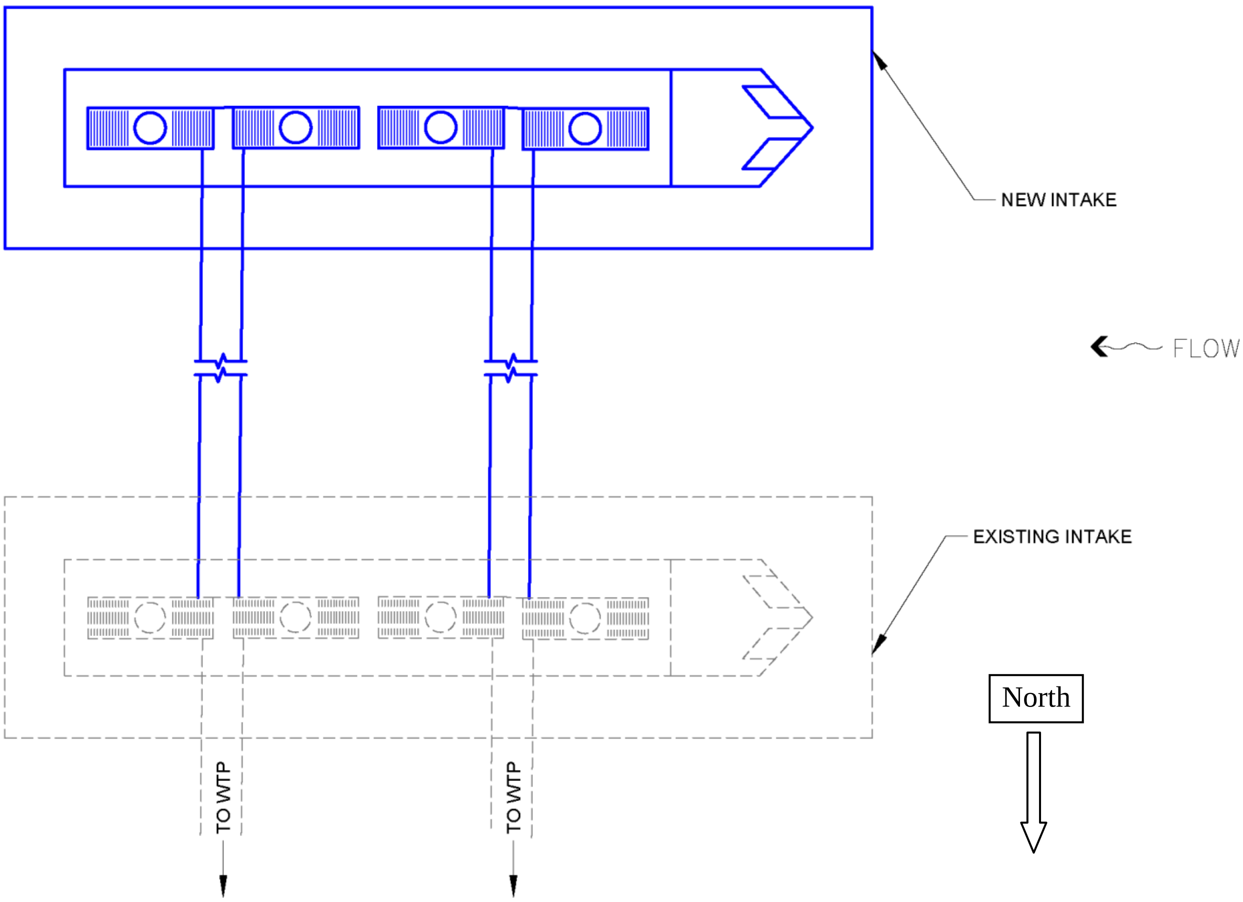


Figure 31: Schematic showing construction of new intake adjacent to existing intake

The problem with this option is that there is still instability of the river, and the long-term reliability would be questionable. It would also do nothing to address the static head issues that occur during low water. Although, having another intake would add some measure of reliability to the current system. This option would need to be done in conjunction with either the inline booster pumps or wet well alternatives.

Alternative 14: Relocate intake 1600 feet downstream

This site was identified in the 2000 ACOE study and is approximately 1600 feet downstream of the current intake. Appendix B also identifies this site as one of three locations which, for six miles upstream and downstream of Laurel, has remained stable for over 60 years.

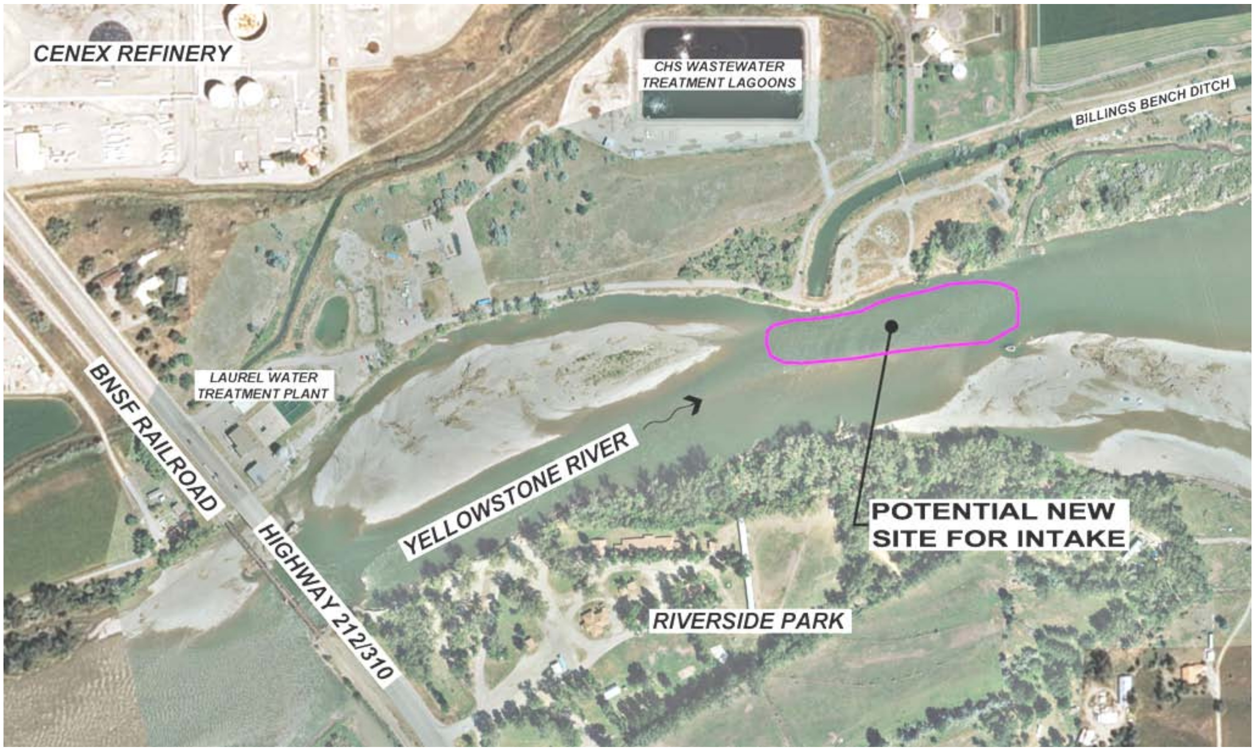


Figure 32: Aerial exhibit of possible site for new intake

In the Geomorphic Reconnaissance and GIS Development, Yellowstone River, Montana report (Applied Geomorphology 2004), the river reach through Laurel (designated A17 in the report) is classified as “unconfined anabranching”. Unconfined anabranching is further defined by the following characteristics: low natural confinement, moderate gravel bar frequency, high side channel frequency, and a high relative rate of change. These broad, large-scale predictions can be seen at this site with the annual change in the large upstream sediment island and the development of the transverse bar in the middle of the channel. There has also been substantial erosion of the channel banks in this vicinity (see Figure 33 below). Therefore, it should be safely concluded that the channel near the BBWA diversion, although it appears stable now, will experience unpredictable changes if only given the time. This was documented further in correspondence included in Appendix D.

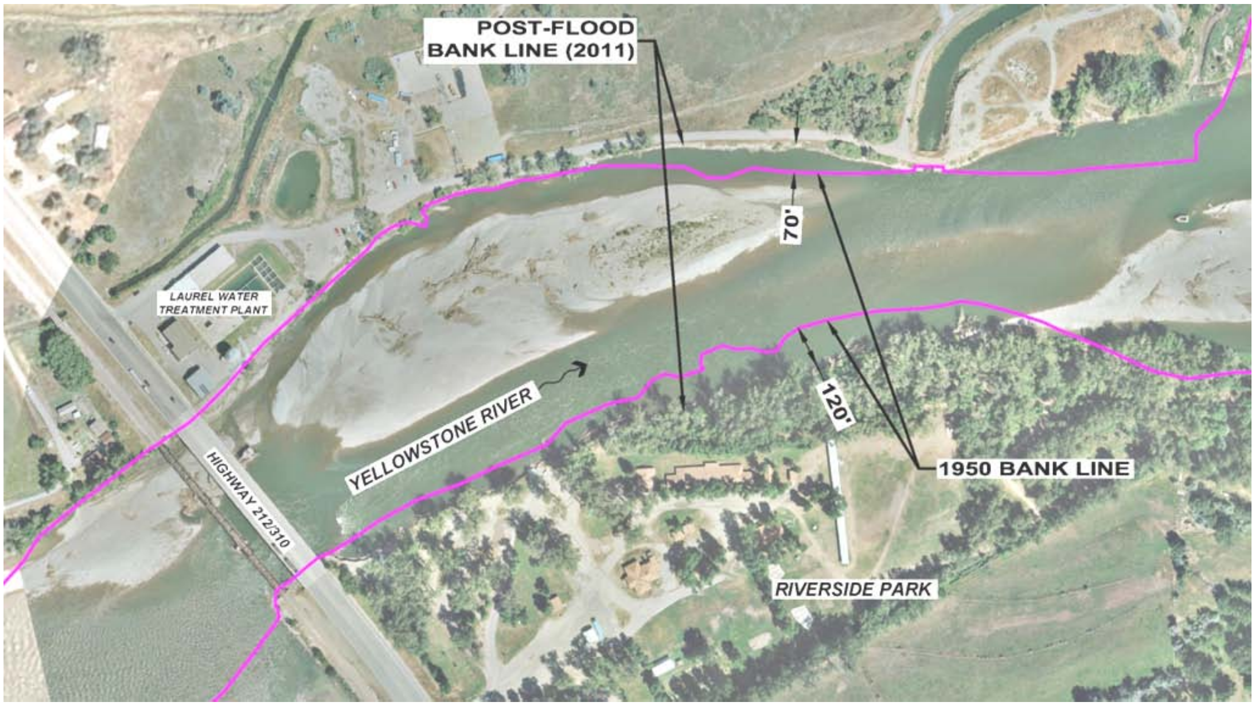


Figure 33: Channel migration adjacent to the BBWA diversion

Another difficulty with this alternative would be that it is lower in elevation than the existing intake. This means that a wet well and booster pumps would need to be utilized in order to transmit the raw water to the WTP. If a new intake is to be constructed, this is not the preferred location.

Alternative 15: Construct new intake 3 miles upstream, adjacent to Canyon Creek Ditch

The City of Billings WTP has had very few problems over the years drawing water from the river. This is largely due to the fact that the river has little to no room to migrate. It is constrained on the northeast side by a steep hillside and on the southwest side by an armored bank. The river channel in Laurel, on the other hand, has seen substantial lateral migration over the last 60 years. Refer to the Geomorphological Analysis in Appendix B.

This site, shown in the figures below, was chosen because it is on the outside bend of a meander and is constrained on the southeast (right) bank by a high bank, comprised of Belle Fourche shale (see Figure A-19 in Appendix A). As discussed in Appendix B, this is one of three sites within 6 miles upstream and 6 miles downstream of Laurel that has remained stable for the last 60 years. These characteristics make it a good candidate to site a new intake. Because the site is up-gradient, raw water could flow by gravity through a pipeline from the intake to the WTP. It would also present the opportunity to install an inline sediment settling basin, which could potentially aid in the water treatment process.

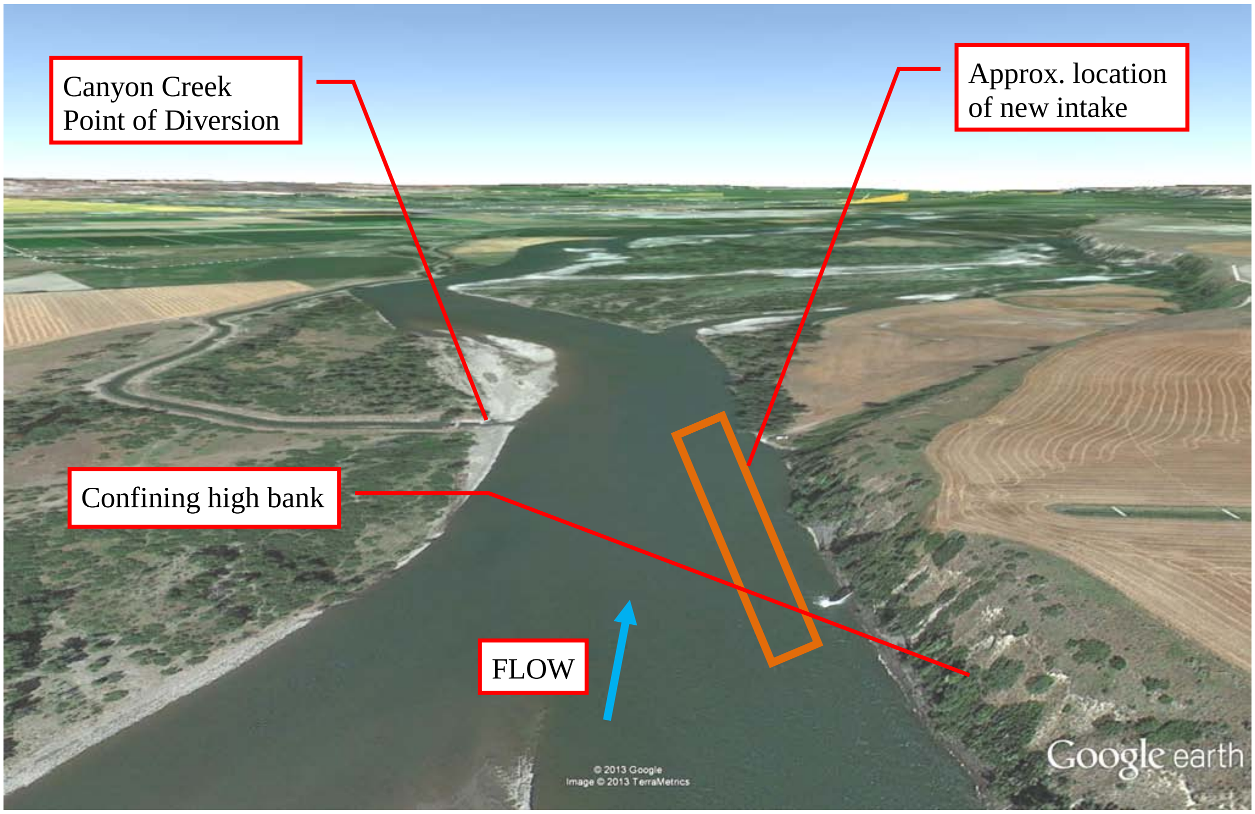


Figure 34: Perspective view of new intake location

The Canyon Creek ditch, which can be seen in the left bank in the figure, has had significant problems drawing water on a consistent basis and has had to dredge annually. However, since the ditch is located on the inside of a bend, sedimentation is to be expected. The proposed site, being located on the outside of a bend, should not experience the same sedimentation problems.

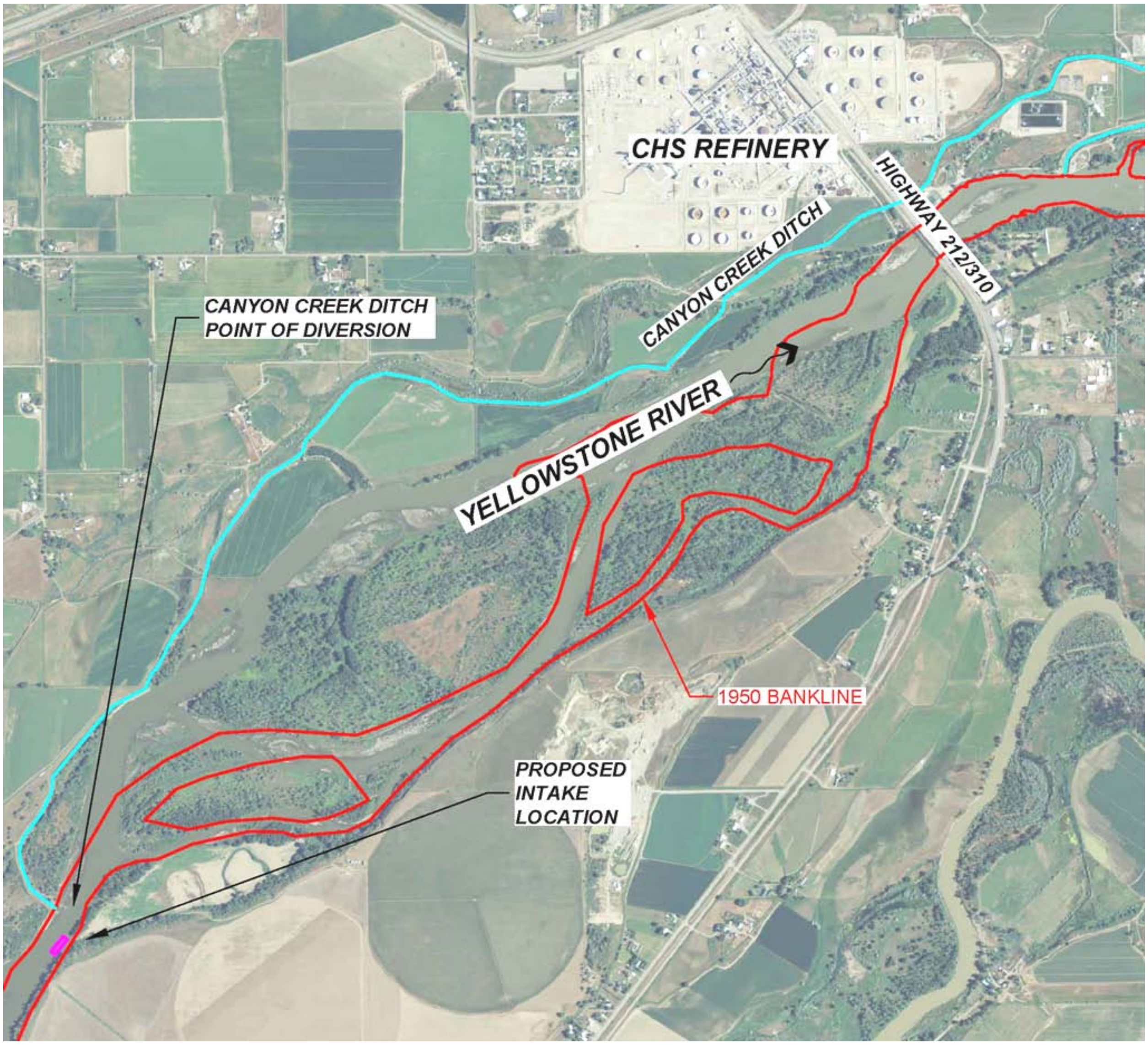


Figure 35: Location of proposed intake, adjacent to the Canyon Creek Ditch

Upon further investigation of this alternative, several difficulties have been identified, including: land acquisition, water rights, bedrock limitations for excavation, cost, and inherent channel instability. Each of these limitations is discussed in more detail in the following paragraphs.

- **Land Acquisition/Easement**

  The pipeline for the intake would be aligned closely with the existing Canyon Creek Ditch. Following the ditch alignment may make adjacent landowners more amenable to allowing the pipeline since there would be very little additional disturbance. The pipeline would cross through several privately owned parcels and easements or right-of-way would have to be acquired.

- **Water rights**
  There are still issues to be resolved with respect to the water rights implications of this alternative. See the Water Rights discussion in Alternative 18 below. However, Majel Russell with the Elk River Law Office in Billings, who is acting as the Attorney for the City of Laurel and is also a water rights attorney, has stated that moving the intake 3 miles upstream would not impact the amount of water that the City is entitled to under its water right and reservation. Further coordination with a water rights attorney and the DNRC will be necessary if this alternative moves forward.

Even in light of the stated complications with this alternative, it remains a viable alternative.

Alternative 16: Suspend pipe and intake from highway bridge

The 2000 ACOE study proposed to hang a 36-inch water line from the highway bridge. The 2002 HKM study noted this, but states that "MDT has told the City of Laurel that the highway 212/310 bridge cannot support the load of a 36-inch water line." However, in light of the recent intake problems it is recommended that this option should be reconsidered.

The existing highway bridge was constructed in 1997 with five spans for a total length of 513 feet. The superstructure is comprised of steel plate girders with a monolithic concrete deck. The substructure consists of 7-foot-diameter drilled concrete shafts which are socketed into the existing bedrock. Based on the existing bridge plans, the existing bridge was designed to handle HS20-44 vehicular loads.

The intake could be hung from the bridge in one of two ways: 1) anchor the intake on the downstream side of one of the piers (Figure 36) or 2) hang the intake from the downstream face of the bridge and brace it against the upstream face (Figure 37). Either of these options could potentially be designed to alleviate the need for a foundation for the intake, depending on its weight. This would allow the downpipe and screens to be moved horizontally and vertically, should the alignment/depth of the river change, without rebuilding a foundation. The intake, water supply line, and pumping system would essentially act as a siphon. This would need to be considered further, and the capacity of the pumps would need to be verified, since the water would be pumped up to the elevation of the bridge and down to the WTP. Priming the pumps may be an issue due to the height from the bridge to the intake. However, the versatility of this option, albeit with some complications, is very attractive.

If it is determined that the bridge cannot, in fact, support the additional water line (a waterline is already hung from the bridge which serves Riverside Park), a possible solution would be to add another steel girder that would only serve to carry the water line. This would alleviate concerns with the overloading of the superstructure and would become only a question of the bearing and moment capacity of the piers.

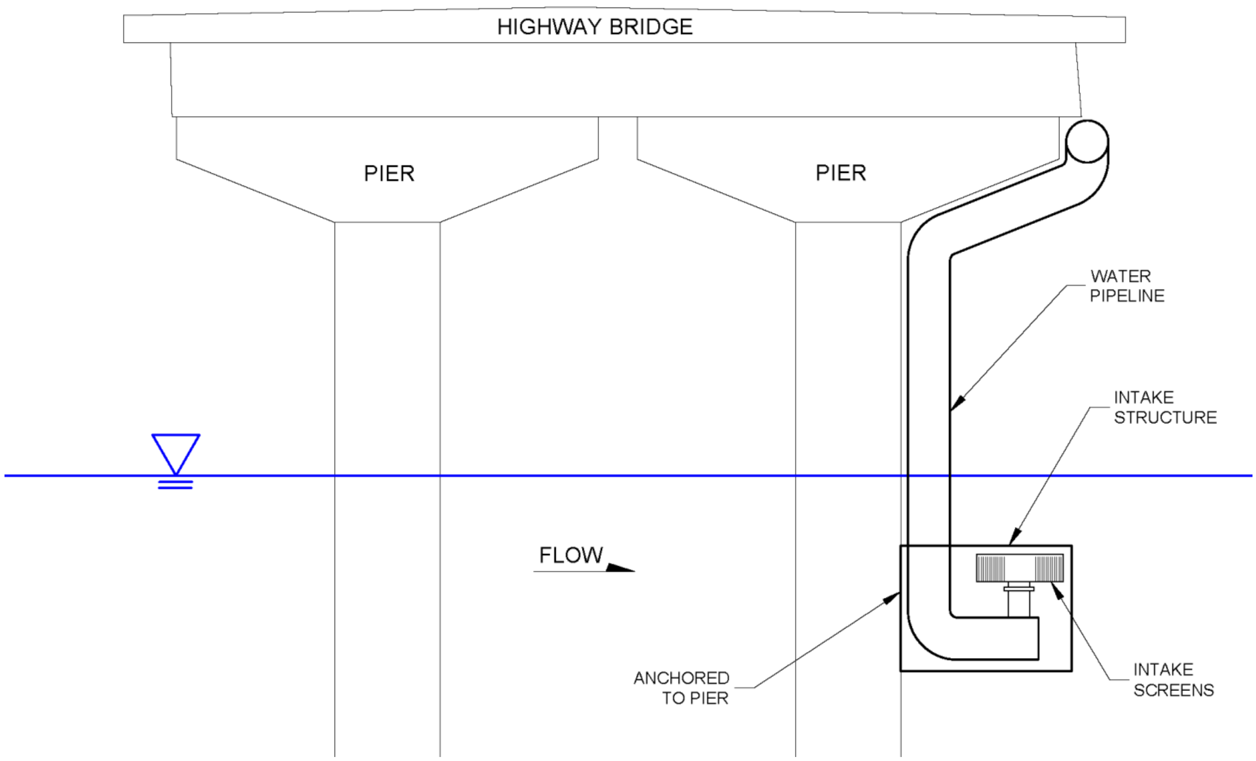


Figure 36: Intake anchored to pier

Preliminary calculations indicate a concrete intake structure would have a dead load of approximately 130 kips. It should be noted the dead load does not account for additional ice loading or the weight of the water lines. This relatively large dead load, driven by the anticipated ice loading the intake structure must withstand, is greater than the existing HS20 design loading vehicle.

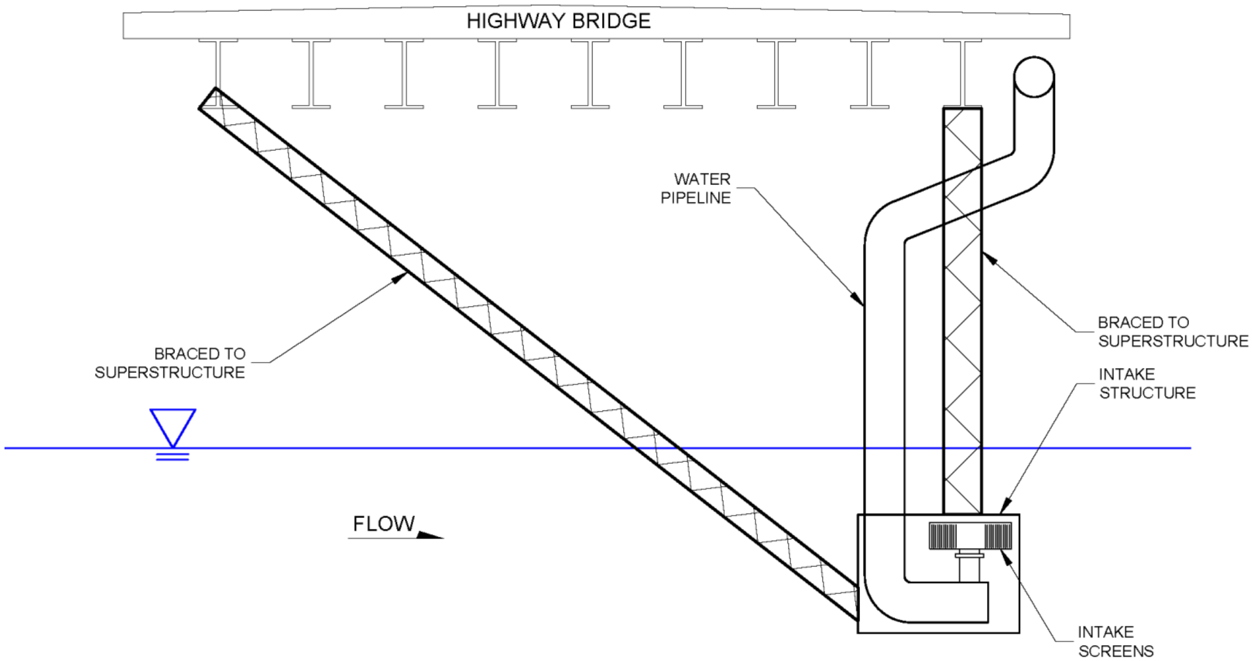


Figure 37: Intake anchored and braced to superstructure

Regardless of whether or not the intake structure is hung from new or existing bridge girders or anchored to a pier, the loads are transmitted to the drilled shaft foundations. The capacity of the existing drilled shafts would be compromised by the load of the proposed intake structure. Thus, an independent foundation support anchored to the channel bottom/bedrock, such as a drilled shaft or driven steel piles would be required to support an intake structure. The requirement of an independent foundation system for the intake eliminates the mobility advantage of this alternative, leading to an impracticable solution. This alternative will not be considered further.

Alternative 17: Build new bridge to suspend intake and water line

This option would be similar to Alternative 16 except that a separate bridge, immediately downstream of the highway bridge, would be constructed to suspend the water line and intake. The bridge would likely have piers, which would be aligned with the current highway bridge and railroad bridge piers. The superstructure itself would not be excessively costly due to the relatively small dead load of the waterline (36" diameter pipe would hold 441 lb/ft of water). To withstand ice loading and hydraulic forces, the bridge foundation system would need to be anchored to the channel bottom bedrock with steel piles or drilled concrete shafts.

Preliminary estimates indicate a new bridge would cost approximately $2.1 million at this location. This cost does not include the intake structure and any associated piping.

The highway bridge could possibly be used as a work bridge, alleviating the need for a separate work bridge. The new bridge would be within MDT's right-of-way and would require an agreement with the State of Montana. Similar to Alternative 16, the downpipe and screens could be moved horizontally and vertically should the alignment/depth of the river change.

Similar to Alternative 16, the intake structure weight would need to be substantial in order to counteract ice forces. Simply stubbing the water intake piping or hanging an intake structure from a new bridge into the river is not feasible due to the anticipated intake structure weight. To counteract the lateral ice forces the intake structure would need to be anchored to a deep foundation system which again eliminates the mobility advantage of this alternative. This alternative will not be considered further.

Alternative 18: Construct diversion to holding pond; abandon existing intake

The City of Billings no longer uses their intake as the primary source of water for the City. They directly divert off of the river to a holding pond and then to the WTP. The reason for this is apparently because they were also having problems drawing water from their intake. This alternative is attractive because the headworks would be situated along the river bank, making it more easily accessible for O&M than the existing intake. In addition, the holding pond would give frazil ice an opportunity to settle out, thereby reducing problems with clogging of screens.

The system would generally consist of the following components. Water would be diverted off of the river by means of a screened headgate. The water would then flow from the headgate to the holding pond. The holding pond would have to be lined to prevent potential contamination from surrounding soils and may also have to be elevated depending on the floodplain. The purpose of the pond would not be for storage because storing water in this manner for long periods of time can lead to the growth of algae and other bacteria and can reduce water quality. Rather, the purpose of the pond would primarily be to have a reservoir to pump from and to give frazil ice an opportunity to settle out of suspension. The water would then be pumped from the holding pond to the WTP and then treated.

Upon further investigation of this alternative, several difficulties have been identified, including: land acquisition, water rights, bedrock limitations for excavation, elevation differential for gravity flow, and inherent channel instability. Each of these limitations is discussed in more detail in the following paragraphs.

- **Land acquisition**

  Several different locations were considered for the siting of the holding pond and are shown below in Figure 38. The land at each proposed site is owned by CHS. Therefore, it would have to be purchased or some sort of easement agreement would have to be formed. Considering that CHS also draws water from the current intake, they would have an interest in coming to an agreement regarding the land purchase.

- **Water rights**

  It appears, based on a cursory review of Montana water rights law and conversations with the DNRC that the City could <u>move</u> the point of diversion and change the <u>means</u> of diversion by completing a of Notice of Replacement Point of Diversion without going through the Change of Appropriation Water Right process. The following are the criteria listed in the 2012 *Water Rights in Montana* handbook that must be met for a Replacement Point of Diversion:

  - The existing point of diversion is inoperable due to natural causes or deteriorated infrastructure;
  - There are no other changes to the water right;
  - The capacity of the diversion is not increased;
  - There are no points of diversion or intervening water rights between the existing point of diversion and the replacement point of diversion or the appropriator obtains written waivers from all intervening water rights holders;
  - The replacement point of diversion is on the same surface water source and is located as close as reasonably practicable to the existing point of diversion;

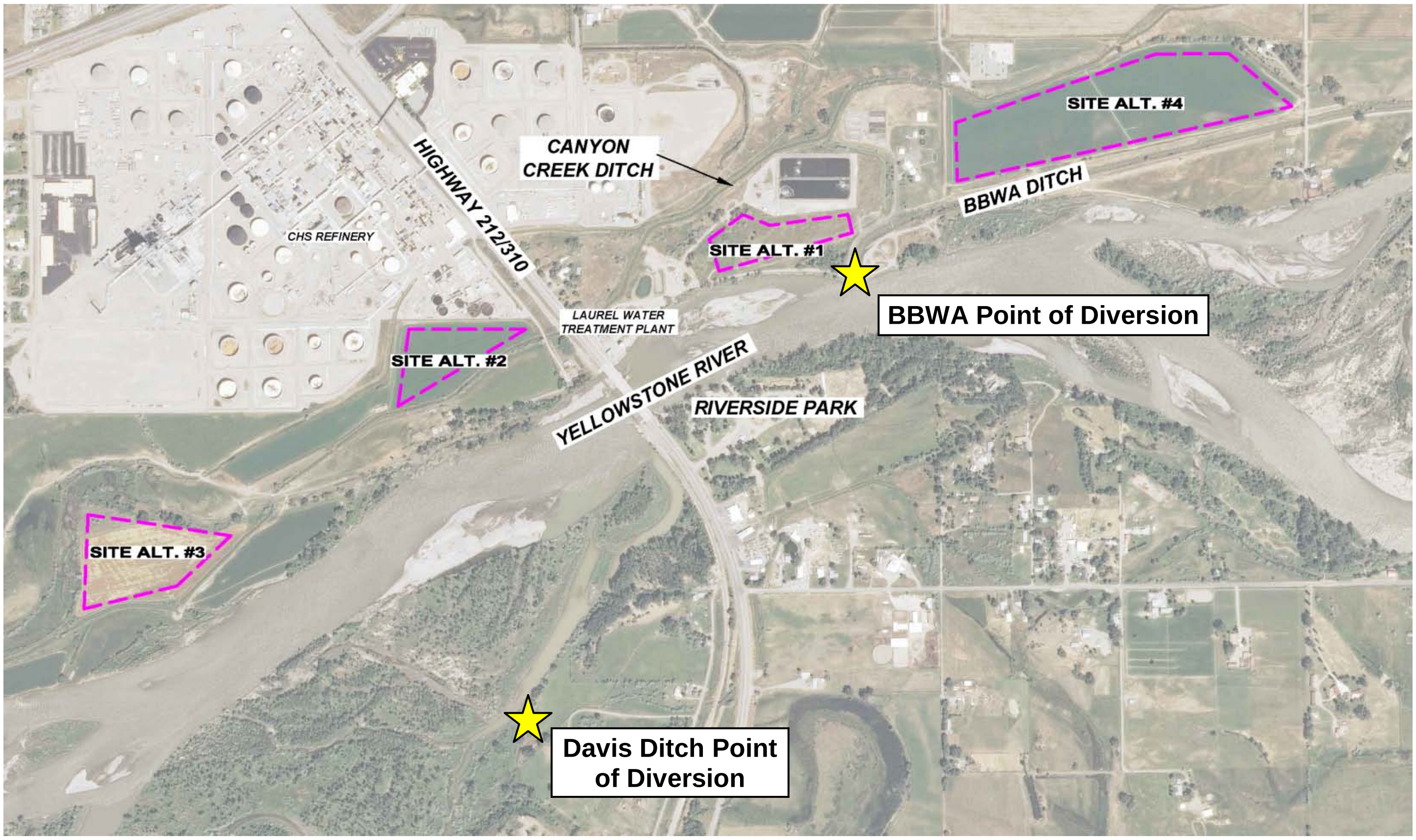


Figure 38: Possible holding pond locations

- The replacement point of diversion replaces an existing point of diversion and the existing point of diversion will no longer be used;
- The appropriator can show that the existing point of diversion has been used in the 10 years prior to the notice for change of appropriation right for a replacement point of diversion; and
- The appropriator can show the change will not increase access to available water, change the method of irrigation, if applicable, or increase the amount of water diverted, used, or consumed.

Two of these criteria should be pointed out. The first is that there cannot be intervening points of diversion between the existing point of the diversion and the replacement point of diversion. If there are intervening points of diversion then a waiver must be obtained from these other water rights holders. Two nearby points of diversion are shown on Figure 38 above, namely the BBWA point of diversion and the Davis Ditch point of diversion. Therefore, sites 3 and 4 would need to obtain waivers from the respective intervening water rights holders. Given the controversial nature of water rights, it is likely that there may be some amount of difficulty in obtaining waivers from these holders.

A Change of Appropriation Water Right process is rigorous and lengthy and should be avoided unless absolutely necessary. One part of the process includes examining the actual historical usage of the water right holder. Part of the process is that "objectors" are allowed protest the change. Given that water is a highly contested resource, opening this door to objections could be problematic.

This water rights discussion will be concluded by stating that <u>before any alternative is considered further which either changes the point or means of diversion, the professional opinion of a water rights attorney would need to be obtained.</u>

There are still issues to be resolved with respect to the water rights implications of this alternative. However, Majel Russell with the Elk River Law Office in Billings, who is acting as the Attorney for the City of Laurel and is also a water rights attorney, has stated that moving the point of diversion would not impact the amount of water that the City is entitled to under its water right and reservation. Further coordination with a water rights attorney and the DNRC will be necessary if this alternative moves forward.

- **Construction limitations: bedrock and elevation differential**

  The bedrock beneath the bank on the north side of the channel is assumed to be approximately 15 feet below the ground surface. This assumption is based on several geological studies by the USGS and the Montana Bureau of Mines and Geology, as well as site specific boring information. The bedrock elevation is, therefore, at or only a few feet below the low water stage. In order to provide gravity flow to a holding pond, a substantial amount of excavation would be required in the bedrock (approximately 15 feet). Based on boring information, the bedrock is classified as soft to moderately hard shale. Excavation would need to take place with the aid of blasting.

- **River channel instability**

  It is recognized that the channel in the vicinity of the BBWA diversion has remained relatively stable for the last 60 years. However, the figure below shows that the channel is prone to lateral migration even in this reach.

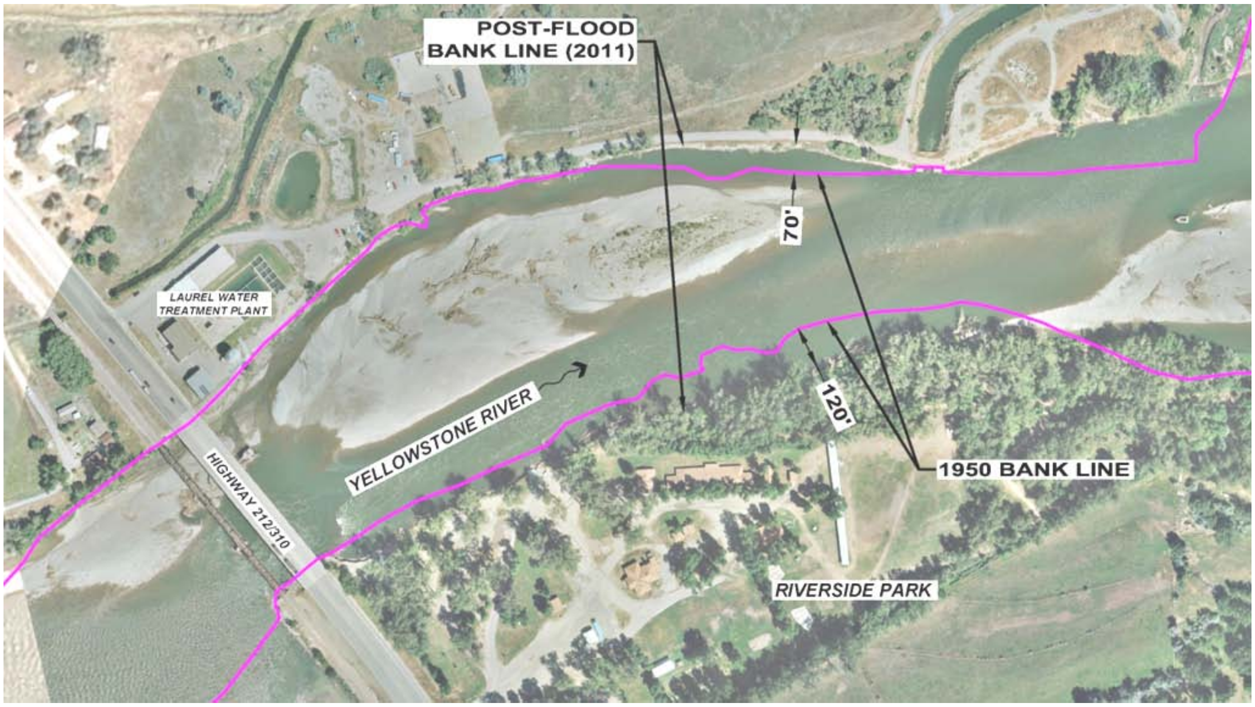


Figure 39: Channel migration in the vicinity of the BBWA diversion

As previously stated with Alternative 14, the Yellowstone River at Laurel is classified as “unconfined anabranching.” Unconfined anabranching is further defined by the following characteristics: low natural confinement, moderate gravel bar frequency, high side channel frequency, and a high relative rate of change.

We feel that it should be safely concluded that the channel near the BBWA diversion, although it appears stable now, will experience unpredictable changes if only given the time. Given the history of migration on the river in this reach, it would be unwise to invest millions of dollars in infrastructure without addressing the inherent instability that exists. Because of the nature of the channel, in order to ensure the longevity of the diversion, measures would need to be implemented which maintain the channel alignment and water surface elevation.

Even if the diversion were sited at one of the stable locations identified in Appendix B, there is no apparent advantage to constructing a diversion to a holding pond as opposed to only a surface water intake. The one slight advantage is the ability to let frazil ice settle out. However, frazil ice can be mitigated in other intake configurations by maintaining adequate submergence of the intake and with the use of hot water.

Site #1 appears to be best site due to its proximity to the WTP and the fact that it lies between the adjacent points of diversion shown above. Because of the shallow bedrock in the area it will also be analyzed whether it would be beneficial to pump water to the holding pond than allow it to flow by gravity. If this is the case, a screened pumping chamber will be necessary at the river. In order to account for river channel instability, a W-weir will be installed downstream of the proposed diversion and the BBWA ditch. This will ensure that an adequate water surface elevation is maintained throughout the year. These features are illustrated in the figure below.

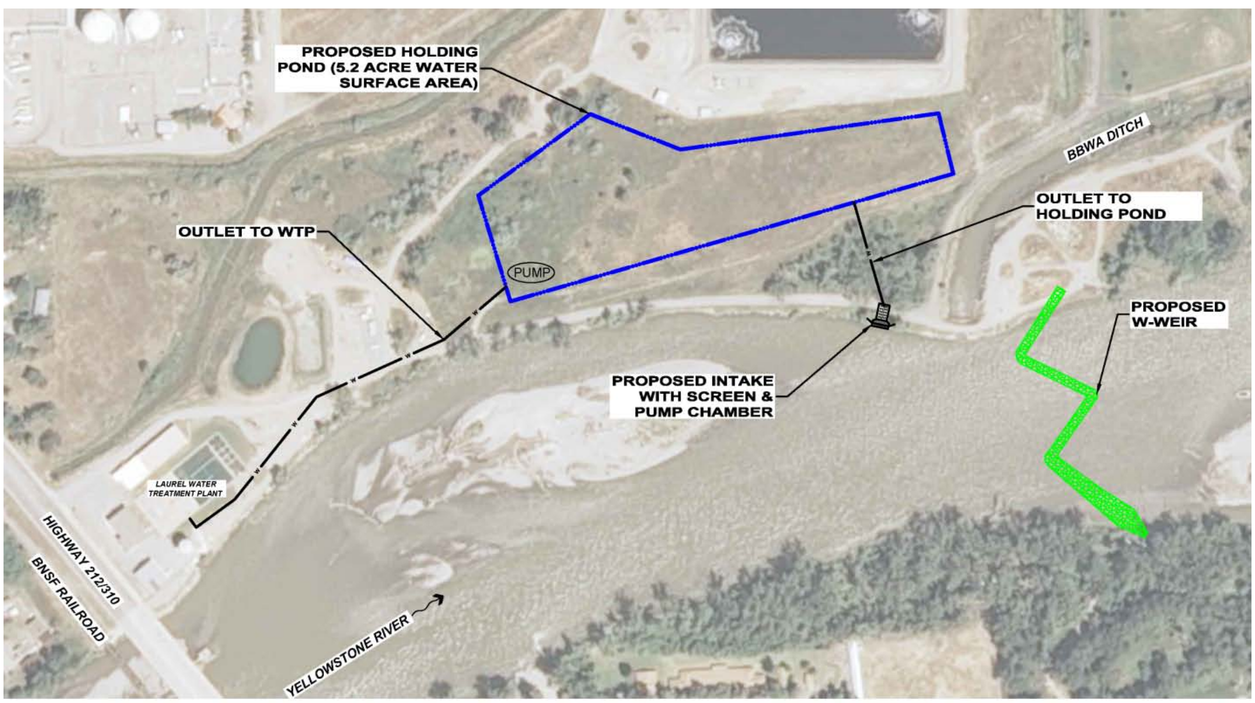


Figure 40: Holding pond alternative layout

In June of 2013, the CHS refinery "belched" diesel, and the sediment basins at the WTP ended up with a sheen of hydrocarbons (see Figure 41 below). The basins were shut down for days while they were drained and cleaned. Any open storage pond in the vicinity of the refinery would face the risk being compromised by future incidents like this.

Figure 41: Diesel in sediment basins at Laurel WTP

In light of all of the aforementioned issues, permitting, land acquisition, water rights, construction limitations, river channel instability, and proximity to the CHS Refinery, this alternative will not be considered further.

Alternative 19: Divert water from the Canyon Creek Ditch Co. ditch

Another option, as opposed to creating a new diversion would be to divert off of the Canyon Creek Ditch (see Figure 38 for the location of the ditch). Canyon Creek Ditch Co., based on preliminary research, has claim to 350 cfs from the diversion on the Yellowstone. 100 cfs has a priority date of 1886 and 250 cfs has a priority date of 1920. Laurel's priority date is 1908. Laurel, at a maximum capacity of 20 MGD equates to 31 cfs. The dimensions of the ditch would need to be verified to ensure that it could convey the additional capacity needed for the City.

There are obvious difficulties with this alternative. Irrigation water is highly valued in Montana, so coming to an agreement with the numerous ditch users may be far-fetched. This option would also face the same water rights issues described in Alternative 18.

The ditch company has been contacted in the past to discuss the possibility of utilizing water from the ditch for emergency situations, such as loss of function of the intake. In these conversations it has been learned that the headgate for the ditch, which is located miles upstream (see Alternative 15), is a severe maintenance problem and requires dredging several times each year. A weir would need to be installed in the channel in order to maintain the water surface at all times throughout the year. Additionally, having water flowing in the ditch throughout the winter would be problematic for the existing irrigation infrastructure on the ditch.

These issues including: coordinating with ditch owners, land acquisition, water rights, winter operations, and the unreliability and maintenance issues of the ditch, render this alternative infeasible; it will be excluded from further consideration.

Alternative 20: Divert Water from the Billings Bench Water Assn. ditch

This alternative is similar to #19, except that water would be diverted from the Billings Bench Water Assn. ditch. It is unclear exactly what their total water right is, but it appears to be at least 600 cfs. Again, Laurel would require 31 cfs at peak future demand (20 MGD). The dimensions of the ditch would need to be verified to ensure that it could convey the additional capacity needed for the City.

This alternative would have similar problems in coming to an agreement with the numerous ditch users and has water rights issues, as discussed in Alternative 19. However, this diversion appears to be better sited and would provide more consistent flows throughout the winter.

The BBWA canal is only used during irrigation months and does not flow in the winter. If the City were to divert off of the ditch they would require that it be flowing year-round. However, water in the ditch in the winter would likely cause ice damage to irrigation infrastructure along the canal. Therefore, another headgate would have to be installed in the canal to prevent water from going past the City's diversion point. This would be costly and would be unattractive to the ditch owners because it would add another aspect of the ditch requiring maintenance and monitoring. The water would also have to be pumped from the holding pond, which would also add significant costs.

As stated in Alternative 14, the river in this reach is characterized by a high rate of change. A W-weir or other channel training would need to be installed to prevent lateral channel migration and degradation and to maintain the required water surface elevation at all times throughout the year.

These issues including coordinating with ditch owners, land acquisition, water rights, and the unreliability and maintenance issues of the ditch, pose serious questions as to the viability of this alternative; it will be excluded from further consideration.

Alternative 21: Divert water from both ditches

This alternative would entail diverting water from both of the aforementioned ditches. Coordination with the ditch users would be twice as difficult, and water rights is still an issue. However, having two diversions would provide some measure of redundancy in the event that one of them became inoperable.

The issues mentioned in Alternatives 18, 19, and 20 would still apply to this alternative and perhaps would be amplified; it will be excluded from further consideration.

Alternative 22: Groundwater Alternatives – hydraulic connectivity to the Yellowstone River, infiltration galleries and radial collector wells

This alternative includes the analysis of infiltration galleries constructed either through open trench method or horizontal directional drilling (HDD), radial collector (Ranney®) wells, and vertical wells. This section will serve to summarize the findings of the full report entitled, *Groundwater Alternatives Analysis* completed by Western Groundwater Services, LLC which is included in Appendix F for reference.

An infiltration gallery was proposed in the 2002 HKM, Inc. study but was ruled out in pre-screening. The study listed several difficulties and unknowns associated with an infiltration gallery. These included: excavation in bedrock, potential of plugging of the screened pipe, backwashing and turbidity concerns, and the size of gallery required to meet the City's demand. However, despite the concerns listed in the HKM study, it was determined that the use of an infiltration gallery or other groundwater collection system presents sufficient benefits compared to other alternatives that it warranted further exploration.

To complete further analysis Western Groundwater Services, LLC (WGS) was contracted to evaluate alternatives for development of a water source outside of the river channel. As the title of the WGS report implies, the alternatives analyzed are considered to be groundwater which is adjacent to and in hydraulic connection with the Yellowstone River. Because of the hydraulic connectivity of the water to a surface water source, the required treatment for the water would be very similar to requirements for surface water pulled directly from the Yellowstone River.

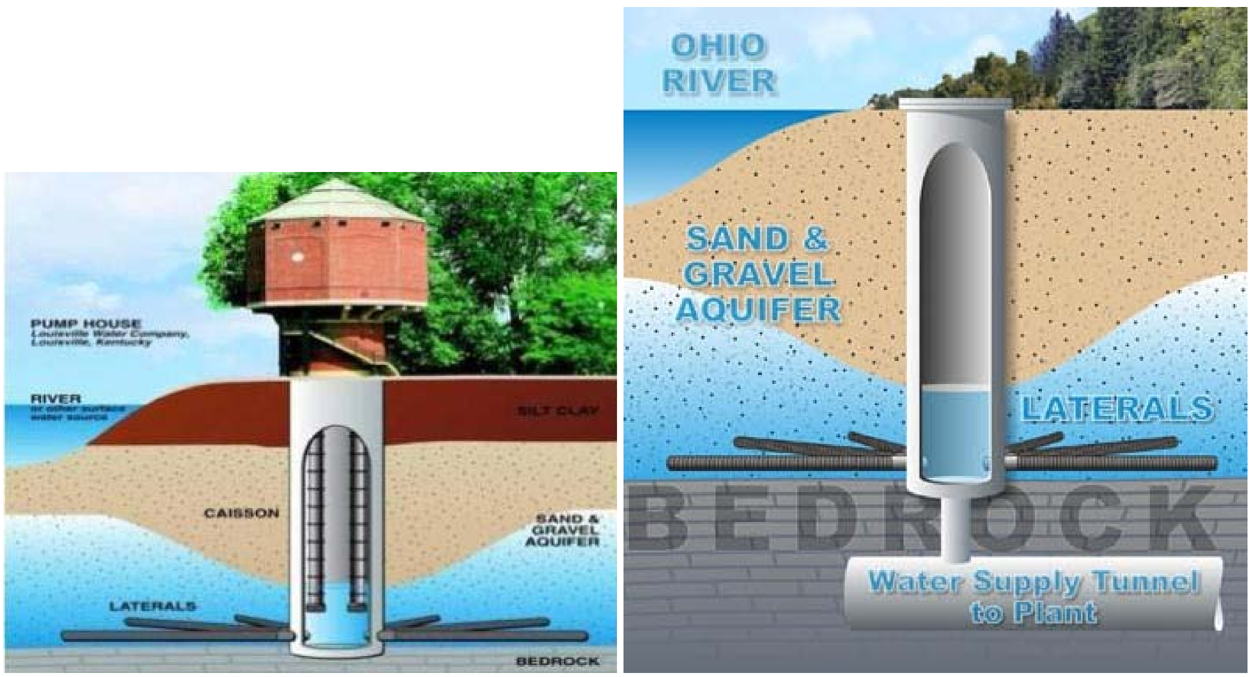


Figure 42: Horizontal collector well

The three alternatives considered include: an infiltration gallery constructed by setting drain pipe in an open trench, an infiltration gallery constructed by horizontal directional drilling, and radial collector wells. Based on the analysis of the geology, well logs, and historical aerial photo analysis of the Yellowstone River, six potential sites were identified as potential sites for groundwater sources. Figure 43 and Figure 44 indicate the locations of each of the sites and how they relate to the current and historical river channel. Only site 1 is located on public land.

According to the WGS report, a new groundwater source is not immune to channel migration impacts, as channel offset is a critical factor in source capacity. At greater offset distances from the channel, groundwater sources produce at lower capacity. If for example a new groundwater source was located on the channel margin, a substantial decline in capacity would be realized if the channel migrated away to create a greater offset. The same situation can arise if a channel bar were to accrete onto the bank at the site of a groundwater source. Given the potential for these conditions, the capacity of a groundwater source cannot be guaranteed into the future to any degree greater than a direct surface water intake.

Modeling of the three alternatives previously mentioned (infiltration gallery – open trench or HDD, and radial collector wells) was completed by WGS. The critical parameters of the model included offset distance (distance of the infiltration gallery or collector well from the river) and drain conductance. According to WGS, the value of the conductance parameter is subjective and is reasoned based on the source construction. For example the use of engineered fill, which would be used for open trench construction, can be specified to achieve a higher conductance through material gradation requirements. On the other hand, if using HDD the material surrounding the collectors is native and the conductance cannot be changed and is much lower than an engineered fill material. Additionally, pipe sizes varied because of construction limitations with HDD. While a 36-inch diameter screen can be used for the trench installation method of an infiltration gallery, only a 20-inch screen can be used for the HDD method of an infiltration gallery and a 12-inch screen for radial collectors. A complete description of the model setup can be reviewed in Section 4 of the report included in Appendix F.

The results of the model are shown in Table 4 through Table 6 below. As can be seen in the tables, various offset distances were modeled; however it should be noted that an offset distance of at least 50 feet is necessary for constructability. As stated in the WGS report, only the infiltration gallery constructed by the trench method was modeled to achieve a capacity close to 20 MGD, and only at Site #1, requiring a 5,000 ft length for the drain pipe parallel to the channel.

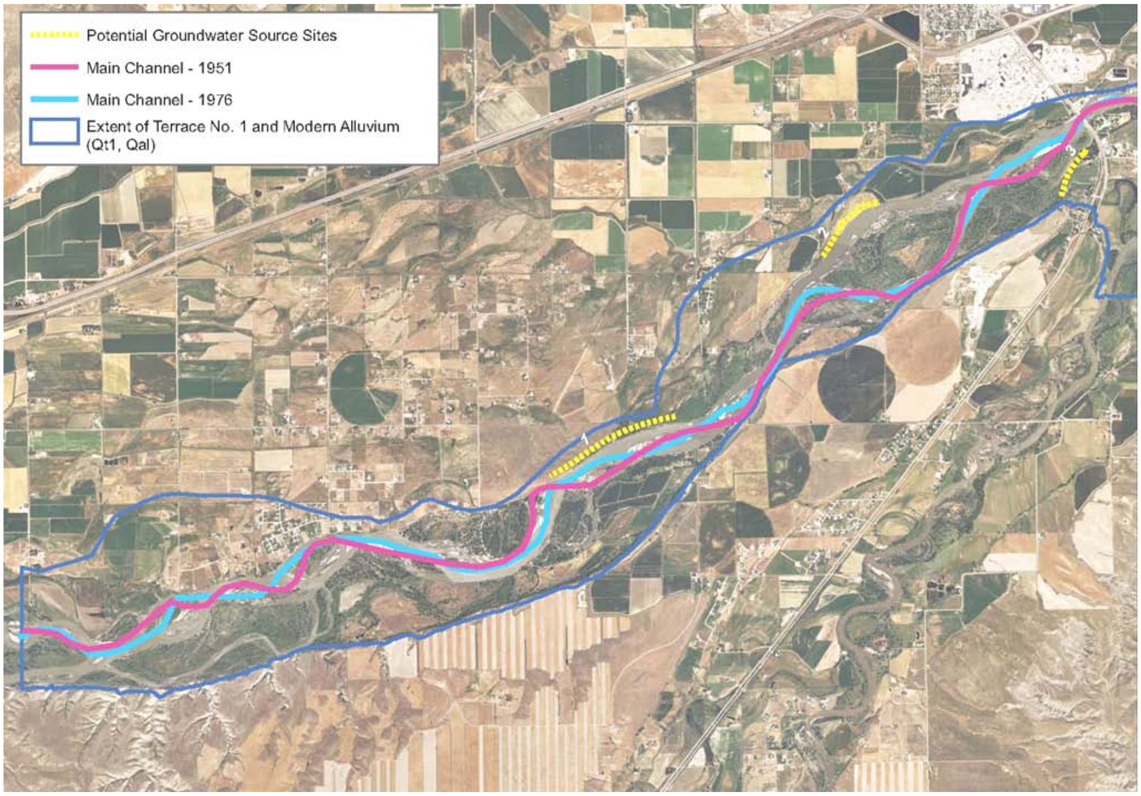


Figure 43: Potential Groundwater Source Sites 1-3 (Figure 3-1A from WGS Report, 2014)

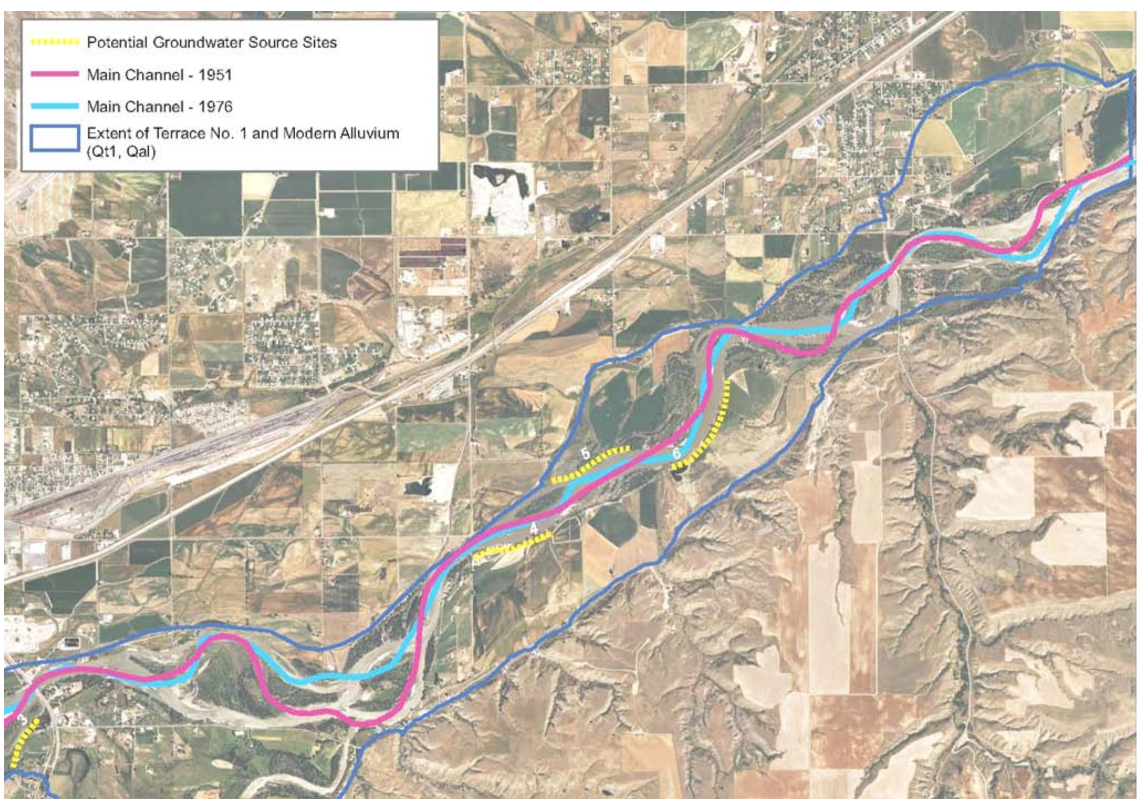


Figure 44: Potential Groundwater Source Sites 4-6 (Figure 3-1B from WGS Report, 2014)

Radial collector well spacing, as determined from modeling, was 750 feet. A total of five wells can possibly be accommodated at Site #1, with fewer well sites available at the other locations. Figure 45 compares the source intake capacity normalized to length of screen. The primary factor differentiating the curves from one another is the drain conductance value (see above). Note that for the 50 ft offset distance, the infiltration gallery is modeled to produce at 3 gpm/ft of screen, whereas the other two source types produce at just under 2 gpm/ft of screen.

Table 4: Infiltration Gallery (Trench Method) Estimated Capacity

Site No.	Length	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5000	45.5	31.8	**19.5**	12.6	7.6
2	2800	25.5	17.8	**10.9**	7.0	4.3
3	1950	17.7	12.4	**7.6**	4.9	3.0
4	2870	26.1	18.2	**11.2**	7.2	4.4
5	3070	27.9	19.5	**12.0**	7.7	4.7
6	3950	35.9	25.1	**15.4**	9.9	6.0

Table 5: Infiltration Gallery (Horizontal Drilling) Estimated Capacity

Site No.	Length	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5000	17.1	14.7	**11.4**	8.6	5.9
2	2800	9.6	8.2	**6.4**	4.8	3.3
3	1950	6.7	5.7	**4.4**	3.4	2.3
4	2870	9.8	8.5	**6.5**	4.9	3.4
5	3070	10.5	9.0	**7.0**	5.3	3.6
6	3950	13.5	11.6	**9.0**	6.8	4.7

Table 6: Radial Collector Wells Estimated Capacity

Site No.	No. Wells	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5	15.8	14.6	**12.4**	9.6	5.6
2	3	9.5	8.8	**7.4**	5.7	3.4
3	2	6.3	5.8	**5.0**	3.8	2.2
4	3	9.5	8.8	**7.4**	5.7	3.4
5	3	9.5	8.8	**7.4**	5.7	3.4
6	4	12.6	11.7	**9.9**	7.7	4.5

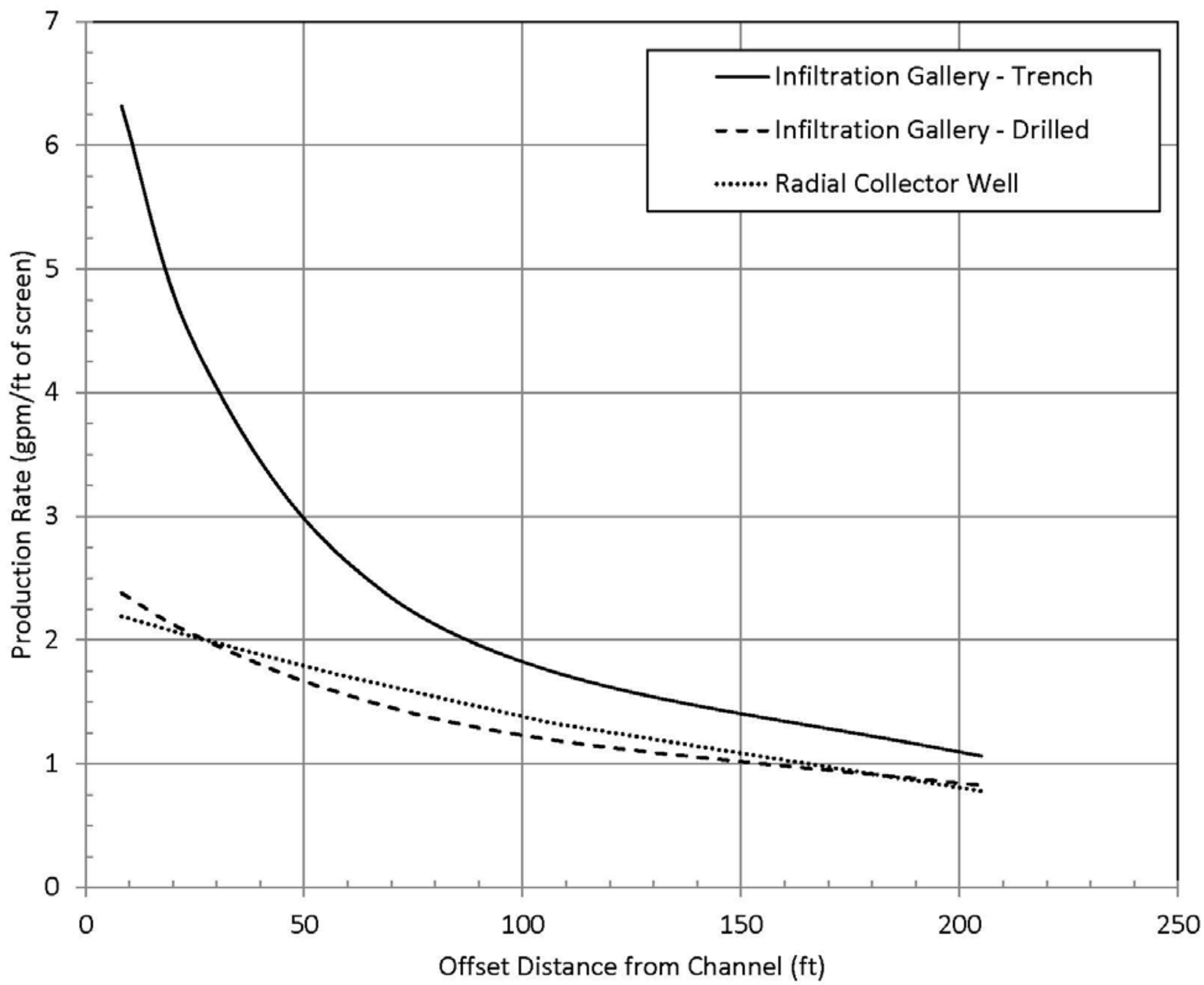


Figure 45: Modeled Normalized Source Capacity (Figure 4-3 from WGS Report, 2014)

Based on the results of the modeling completed by WGS it can be seen that the use of an infiltration gallery installed utilizing the trench method at site #1 does nearly meet the design criteria of 20 MGD. The size of the infiltration gallery is very large, or rather very long, nearly a full mile of 36-inch diameter drain pipe would be necessary. This alternative does not present any more certainty of supply than a screened intake placed in the river channel as it is dependent on offset distance from the river, and the river channel is subject to changes. Other concerns related to the use of an infiltration gallery include:

- Sedimentation buildup within the drain pipe,
- Potential plugging due to algae, and
- Cost of installation in addition to a transmission line to connect to the City

The use of an infiltration gallery will continue to be considered as it appears to present the same amount of reliability as a new intake placed in the river channel, and also adds the benefit of providing a certain amount of filtration which will likely reduce the turbidity of the water as well as eliminate turbidity spikes which would be expected to lower chemical use at the treatment plant for turbidity removal. Only Site 1 with the trenched infiltration gallery will be considered further, as it is the only groundwater alternative that meets the design demand of 20 MGD.

Alternative 23: Vertical groundwater wells

The use of vertical wells was evaluated in the WGS report and was eliminated from further analysis due to the fact that wells installed in the aquifer under consideration would produce a maximum of 300 gpm. To meet the design capacity of 20 MGD, a minimum of 47 vertical wells would be required over a 4.4 mile stretch, if spacing of 500 feet between wells is assumed.

Additionally, numerous studies have been completed by the United States Geology Survey (USGS) and the Montana Bureau of Mines and Geology (MBMG) looking into the hydrogeology of the Yellowstone River valley. The studies that were used are listed below:

Gosling, Arthur W., and Jr., Emil F. Pashley. Water Resources of the Yellowstone River Valley, Billings to Park City, Montana. Hydrologic Investigations Atlas HA-454, U.S. Geological Survey, 1973.

Hall, George M., and C. S. Howard. *Ground Water in Yellowstone and Treasure Counties Montana.* Water-Supply Paper 599, U.S. Geological Survey, 1929.

Hutchinson, R. D. *Yellowstone River Valley, South-Central Montana: Changes in the shallow ground-water resources near Billings, August 1968-1978.* Hydrogeologic Map 6, Montana Bureau of Mines and Geology, 1983.

Olson, John L., and Jon C. Reiten. *Hydrogeology of the West Billings Area: Impacts of Land-Use Changes on Water Resources.* Montana Bureau of Mines and Geology, 2002.

One study concludes that the "ground-water resources of the study area are adequate for domestic and stock supplies; however, in many areas the quality of ground water is marginal for these uses" (Gosling and Pashley 1973).

Another states that the "approximately 2000-foot-thick shale sequence is typically a poor source of ground water, with low yields and poor water quality" (Olson and Reiten 2002).

The 1929 USGS study concludes, "In general public water works dependent on wells will find difficulty in obtaining sufficient supplies" (Hall and Howard 1929).

These and many other geological investigations speak to the poor quality and quantity of water that can be found in the shale deposits underlying the Yellowstone River valley. This alternative will be excluded from further consideration.

4.3 CONCLUSION OF PRELIMINARY SCREENING

The 24 previously identified alternatives were analyzed on a preliminary level in the above discussions. This was done to reduce the number of possible alternatives so that the best, most feasible alternatives may be more thoroughly evaluated.

The prescreening analysis was successful in eliminating several alternatives. In addition, it was identified that the alternatives should be further categorized into primary and secondary alternatives. Primary alternatives are those that when implemented would solve the majority of the loss of function problems associated with the intake. Secondary alternatives should be used in conjunction with primary alternatives in order to provide the most complete solution for restoring function to the intake. The following schematic illustrates this.

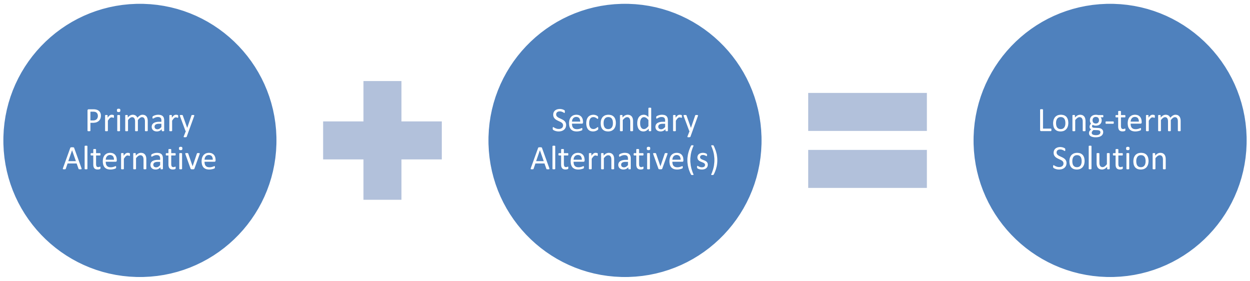


Table 7 below summarizes the results of the prescreening analysis.

Table 7: Summary of Preliminary Screening

Category	Alt. #	Alternative Description	Disposition
Channel training/ alteration	1	Construct bendway weirs/rock vane	Eliminate – does not satisfy project purpose and need
	2	Construct W-weir	Eliminate – environmental impacts
	3	Construct straight weir	Eliminate – environmental impacts
	4	Removal the sediment beneath north side of bridges	Secondary alternative
	5	Raise the channel grade	Eliminate – does not satisfy project purpose and need
Modify intake	6	Lower the existing intake screens	Eliminate – not the preferred method to lower screens
	7	Lower the existing intake screens with concrete modification	Eliminate – not the preferred method to lower screens
	8	Replace existing screens with half-round screens	Secondary alternative
	9	‘V’ deflector installed downstream of intake	Eliminate – does not satisfy project purpose and need
	10	Install hot water heater and appurtenances to utilize hot water flush lines	Secondary alternative
	11A	Install inline booster pumps in WTP	Eliminate – not the preferred method to utilize booster pumps
	11B	Install booster pumps in a new wet well	Eliminate – not the preferred method to utilize booster pumps
	12	Remove existing pumps, replace with dry pit submersible pumps	Primary alternative

New intake	13	Construct a new intake adjacent to the existing intake	Secondary Alternative
	14	Relocate intake 1600 feet downstream	Eliminate – poor location
	15	Relocate new intake three miles upstream, adjacent to Canyon Creek Ditch	Primary alternative
	16	Suspend pipe and intake from highway bridge	Eliminate – infeasible
	17	Build new bridge to suspend intake and water line	Eliminate – infeasible
Alternate source	18	Construct diversion to holding pond	Eliminate – infeasible
	19	Divert water from the Canyon Creek Ditch Co. ditch	Eliminate – infeasible
	20	Divert water from the Billings Bench Water Assn. ditch	Eliminate – infeasible
	21	Divert water from both ditches	Eliminate – infeasible
	22	Groundwater Alternatives – hydraulic connectivity to the Yellowstone River: infiltration galleries, radial collector wells	Primary alternative, Site 1, infiltration gallery, trench method
	23	Vertical groundwater wells	Eliminate – infeasible

4.4 ALTERNATIVES ANALYSIS

The prescreening analysis served to identify alternatives that were clearly not practicable or were not stand-alone and needed to be combined with other alternatives in order to be effective. Resulting from this analysis, the alternatives were reorganized and secondary alternatives were combined with primary alternatives as appropriate. The updated list of alternatives is shown in Table 8 below. An alternate scheme for designating alternatives (letters instead of numerals) has been utilized for clarity to keep them separate from the Prescreening Alternatives.

Table 8: Updated List of Alternatives

(Prescreening Alternative number is shown in parentheses)	
Alt.	**Alternative Description**
A	Remove existing pumps, replace with dry pit submersible pumps (12), remove sediment (4), replace existing screens with half-round screens (8), install hot water heater flush system (10), construct a new intake adjacent to the existing intake (13)
B	Construct new intake three miles upstream, adjacent to Canyon Creek Ditch (15), replace existing screens with half-round screens (8), install hot water heater flush system (10)
C	Construct infiltration gallery using the trench method at Site 1 (22), replace existing screens with half-round screens (8), install hot water heater flush system(10)

The three remaining alternatives are analyzed further below and detailed cost estimates have been prepared.

Alternative A: Remove existing pumps, replace with dry pit submersible pumps; remove sediment; replace existing screens with half-round screens, install hot; water heater; construct new intake adjacent to existing intake

In order to utilize the intake in its current location, several improvements and modifications must be made. Generally speaking, the issues with the current intake are:

- Channel migration caused by 2011 flooding and continued lateral instability of the channel
- Channel scour caused by the 2011 flooding resulted in:
  - Inability to maintain adequate head at the existing pumps, which relates directly to the water surface in the river
  - Lower water surface at the intake and screens, caused by the channel scour, leading to frazil ice buildup due to inadequate cover over screens

The combination of primary and secondary alternatives, which comprise Alternative A, seek to mitigate these issues. The figures below show the various aspects of this alternative.

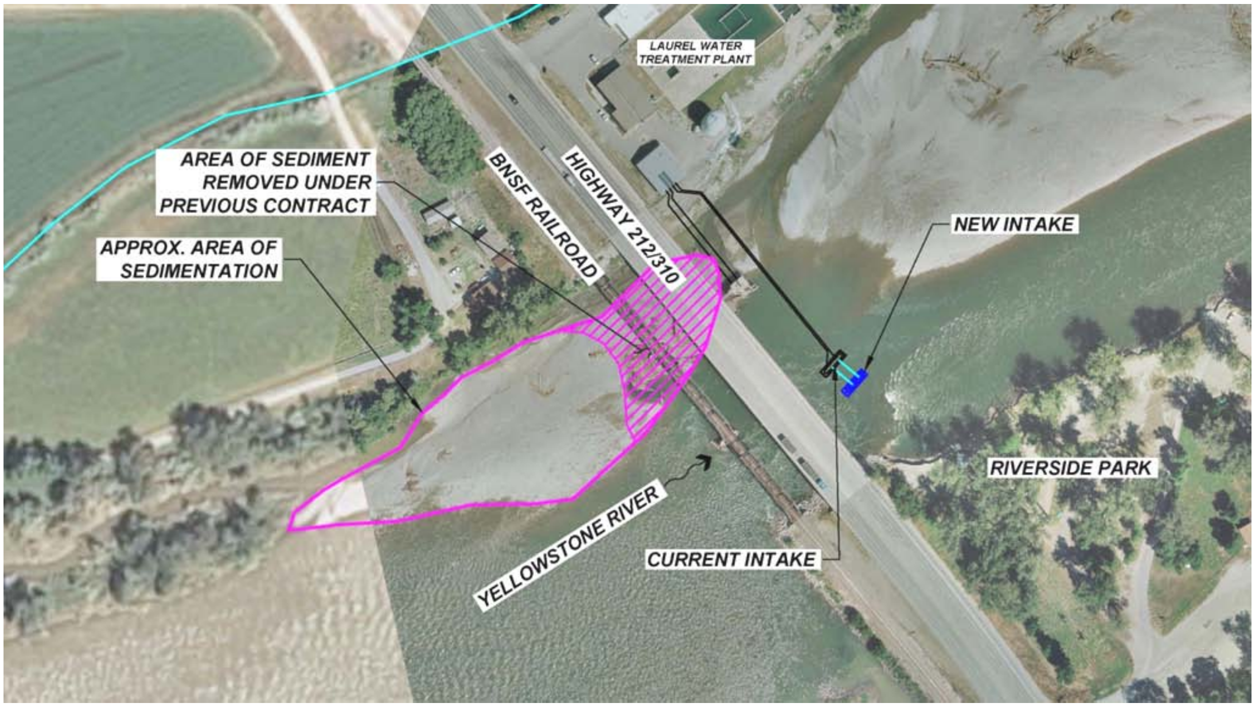


Figure 46: Site Plan of Alternative A

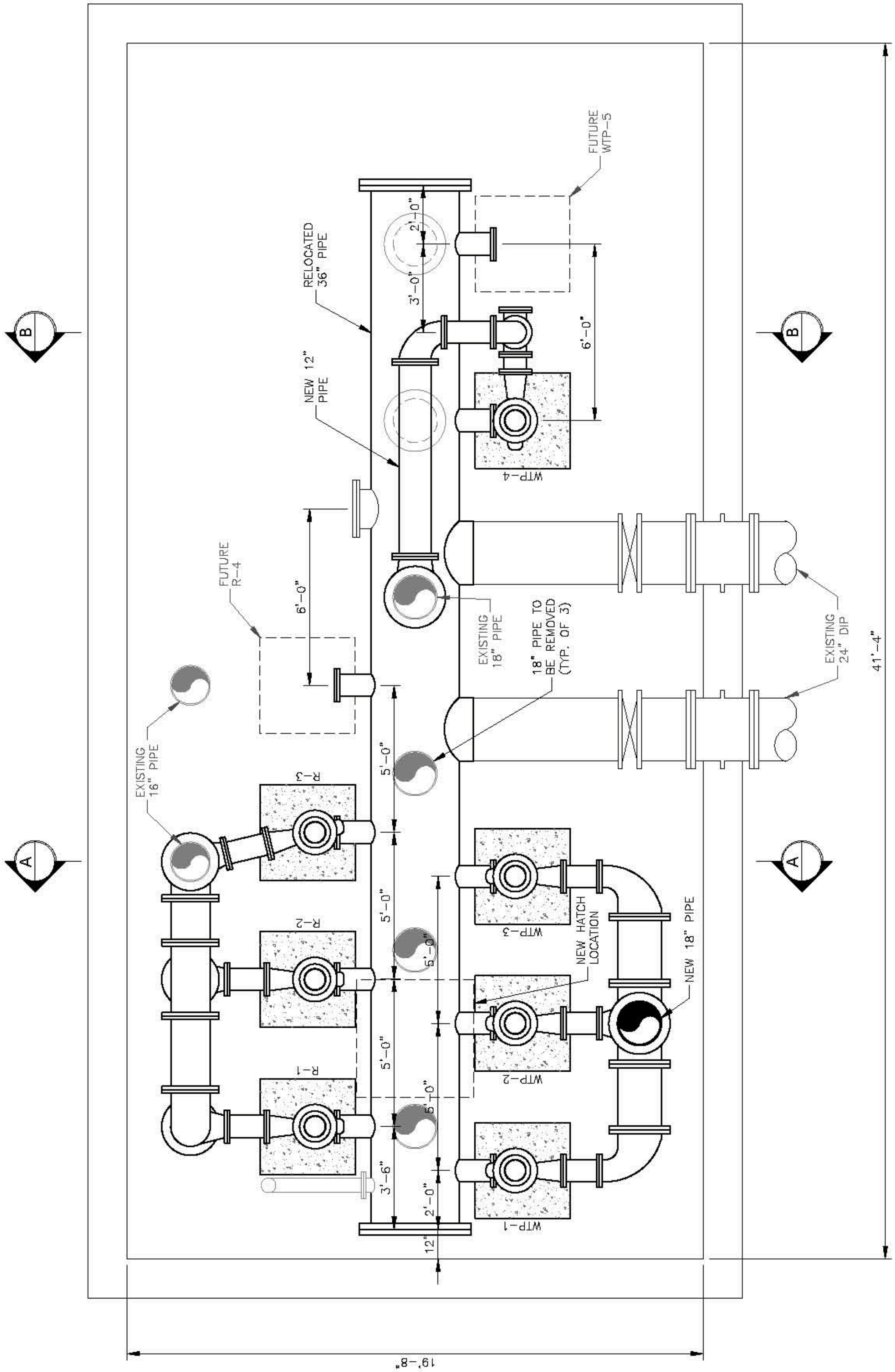


Figure 47: Dry pit submersibles installation, plan view of lower level of pump building

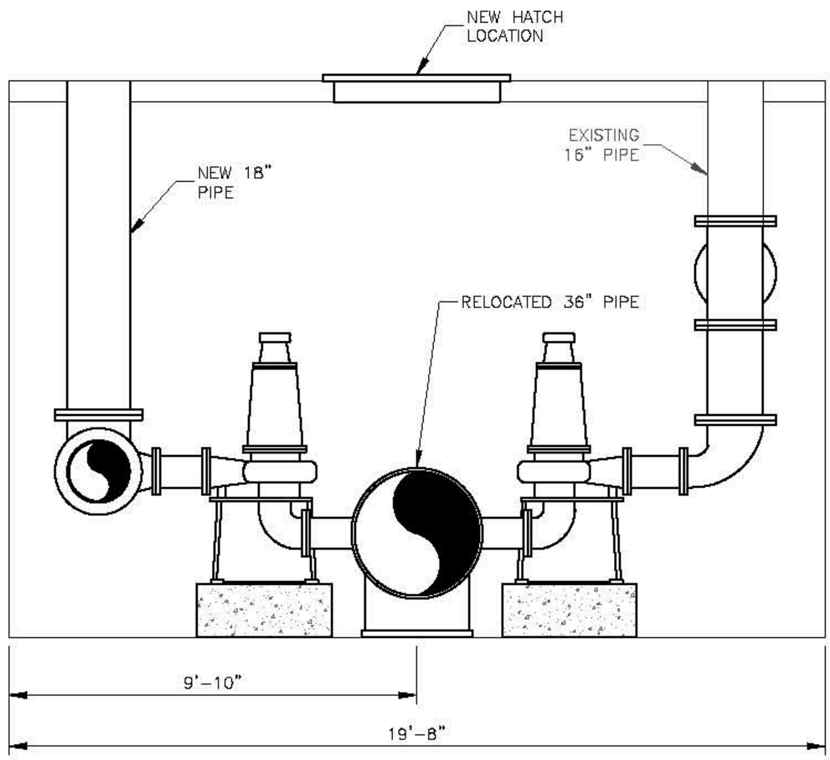


Figure 48: Section A-A, dry pit submersibles installation

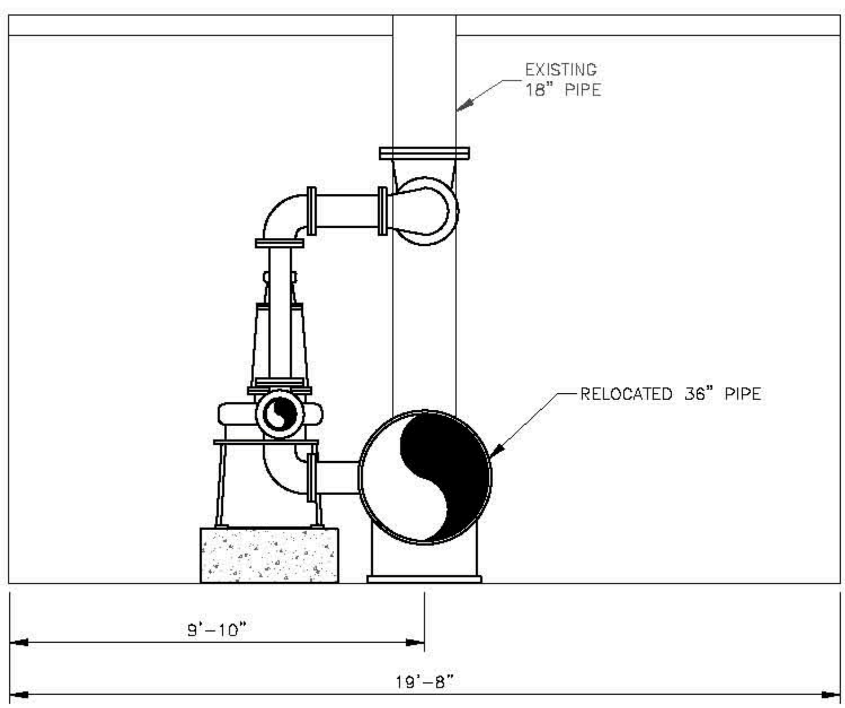


Figure 49: Section B-B, dry pit submersibles installation

Figure 50: Johnson Screens®: Half Intake Screen System

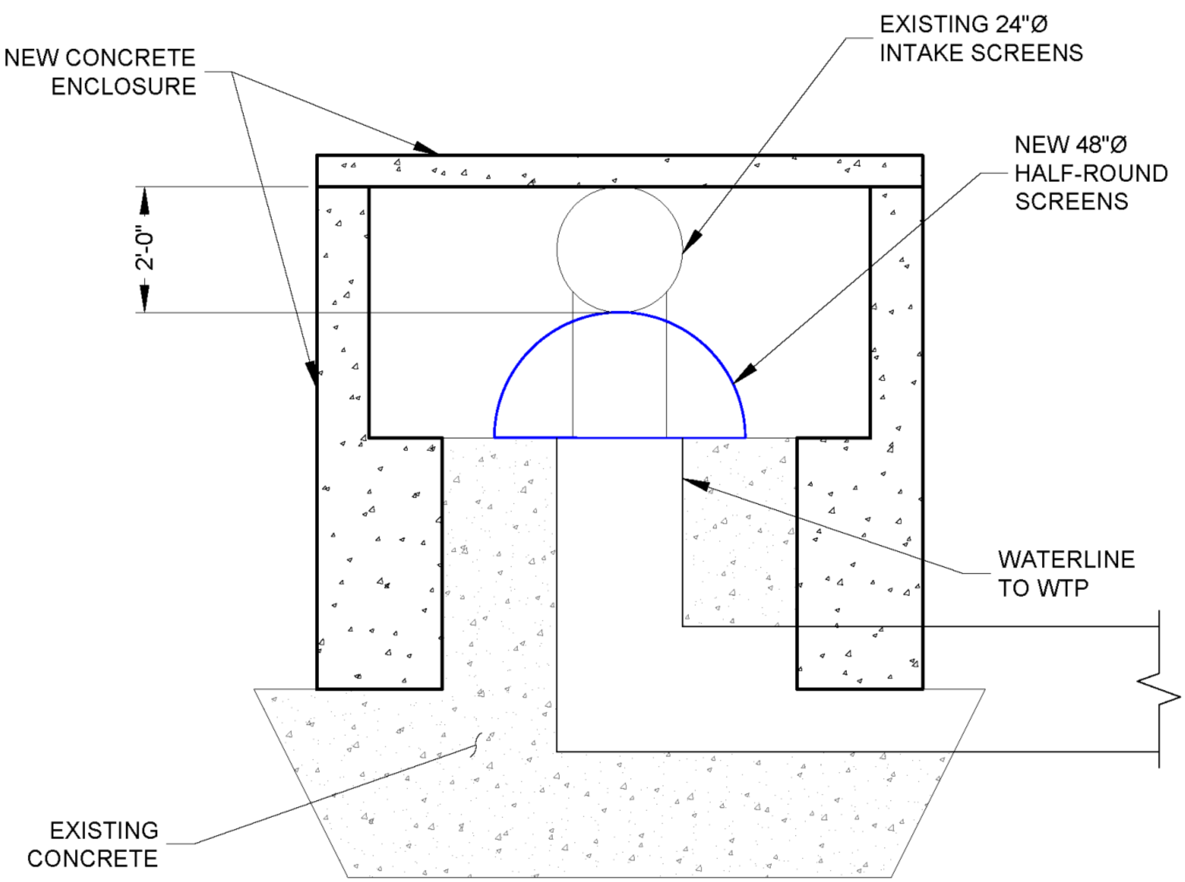


Figure 51: Install half screens in intake

Advantages of this alternative include:

- Lower cost
- Utilize existing infrastructure
- No land acquisition/easements
- Minimal water rights issues
- Minimal wetland impacts
- Minimal cultural resources impacts

Although Alternative A appears advantageous from numerous perspectives, there are also significant drawbacks. This alternative does not allow for any redundancy in the City's ability to draw raw water. The historic intake was once thought to provide redundancy to the system, and piping to the historic intake maintained with the construction of the current intake. However, the historic intake has proved to be very unreliable.

In March of 2013, the City, in an effort to prepare for low flows through the winter, constructed a temporary diversion ditch to the historic intake. The problems with this intake, which led in part to the construction of the new intake, were reconfirmed. The necessary maintenance schedule to keep the old intake operating in both summer and winter are not possible to keep up on a regular basis. Through inspection related to the ongoing construction of the temporary diversion ditch, the City found that there are fine screens in the historic intake structure that are intended to screen fish and aquatic plant material. Based on the historic use of the structure, the screens require manual cleaning every four to six hours. This requires that personnel enter the structure to raise the screens and manually clean them off. During the winter, the old intake requires constant maintenance to prevent slush ice from building up and entering the pumping facility. There are numerous historic instances of the interior chambers of the old intake freezing solid, and that was when the main river channel surrounded the structure. This winter (2013-2014) proved to be no exception, and the interior chamber of the intake froze solid, yet again. Finally, the intake is over 60 years old and is beyond its useful life.

The City is unable to meet the required maintenance schedules on a regular or permanent basis, and the tasks introduce personnel to unacceptable safety risks too frequently. The following is a quote from Kurt Markegard, City of Laurel Public Works Director, "In the 1960's an employee broke a leg cleaning the old intake. Also, every winter the city hired divers to install a perforated pipe into the river connected to the old intake. This was then removed every spring. This pipe was also easily damaged if hit be ice. It also required head pressure in order for this winter line to work. This head pressure was tied directly to water surface elevation which we no longer have after the 2011 flood and scour."

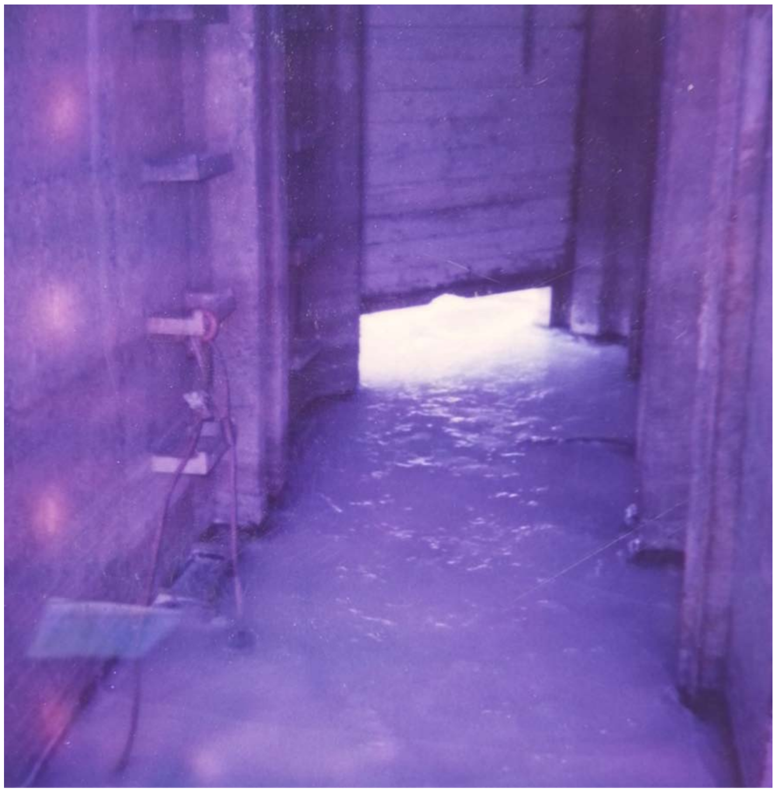


Figure 52: Inside chamber of historic intake, frozen solid, 12/21/1998

Mr. Markegard has documented City Council minutes dating back to 1916 that chronicle the nearly 100 years of problems that the City has had trying to draw water from the Yellowstone at this location. This documentation is included in Appendix N. History points to the fact that the historic intake cannot be relied upon to provide a consistent, year-round measure of redundancy to the system.

In order to add some measure of redundancy to this alternative, a portable diesel bypass pump was added to the cost estimate. It was determined that a portable pump should be provided in the event that the permanent intakes fail. Currently the City rents portable pumps throughout the winter months, but this is very costly. In the event of an emergency, a sump would be dug in the channel near the north bank of the river. The pumps would draw from this sump and pump raw water back to the WTP, connecting to a bypass flange, which then leads into the treatment plant.

Hydraulic calculations were performed (see Appendix M) in order to evaluate the water surface at the existing intake. The hydraulic model assumes that the emergency rock weir has been removed and that the bank stabilization on the south bank has been completed. This analysis was done in order to compare the computed water surface elevation to the elevations of the top of concrete and top of screens, assuming that they are lowered by installing half-round screens, as proposed in this alternative.

Table 9: Comparison of elevations assuming half-round screens are installed

Description	**Elevation above MSL (NAVD88)**
Top of proposed concrete	3260.00
Top of proposed half-round screens	3257.50
Water surface at 50-year low flow of 450 cfs	3258.70
Water surface at base flow of 1900 cfs	3260.79

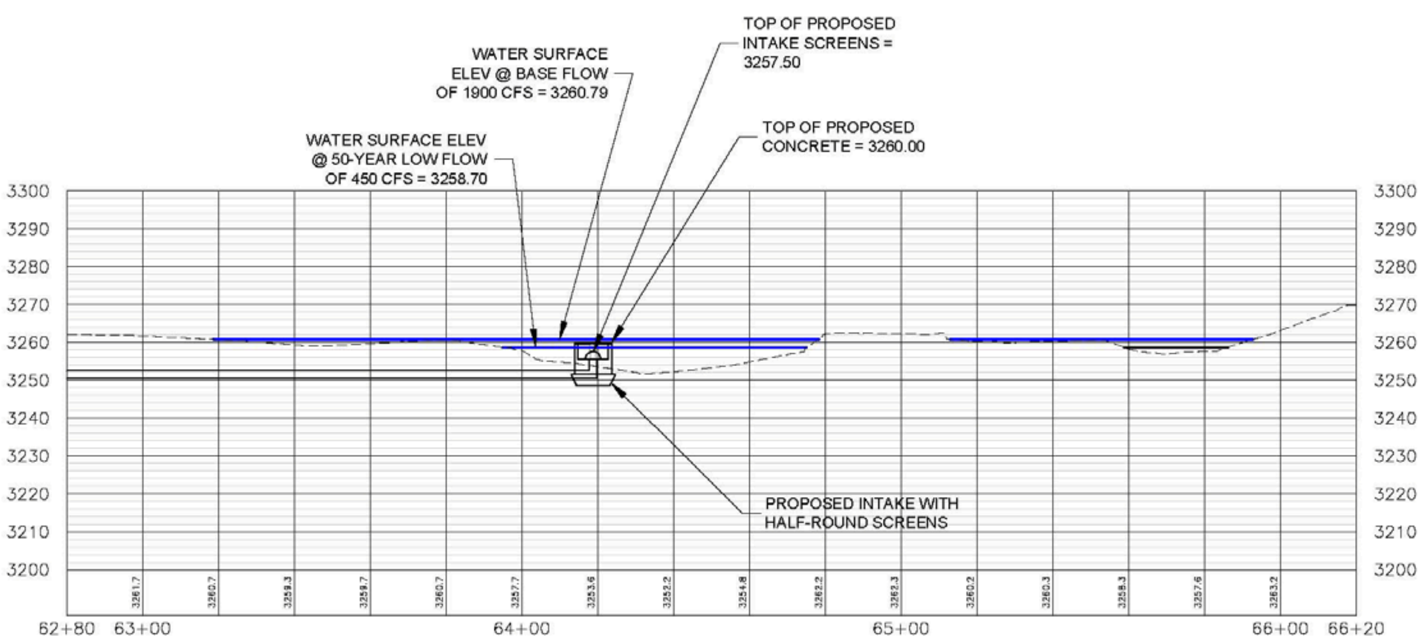


Figure 53: Cross section at current intake, showing water surface elevations

What this analysis shows is that at the design low flow, the top of the concrete structure will protrude over 15 inches above the water surface, and the top of the screens will be submerged by only 14 inches. Certainly, the only reason the intake has remained submerged as of late is because of the presence of the temporary rock weir, installed downstream of the intake.

Having the concrete structure of the intake exposed during the winter months will encourage ice buildup inside of the concrete enclosure, likely in excess of what can be handled by hot water lines. This poses an unacceptable risk to the screens and the ability to continue to draw water. Having the concrete exposed during the summer and fall creates a substantial hazard to recreational traffic on the river. Figure 53 shows a cross section of the proposed intake with half-round screens and the water surface elevation at flows of 450 cfs and 1900 cfs.

The lateral instability of the river in this reach could be argued to be the principal problem posing a risk to the continued function of the intake in its current location. Constructing a new intake to the south adjacent to the existing intake adds some measure of flexibility to the system, by seeking to follow the main channel in its current trend. However, even this is a gamble. In December of 2013, at least 50% of the main flow of the channel shifted to the north bank as a result of an ice jam. The bottom line is that the river is unpredictable and cannot be relied upon to remain in its current location beneath the bridges.

Removal of the sediment upstream of the bridges will allow flood flows to spread out, dissipate energy, and be less prone to erode and scour the channel near the intake. However, even with these measures in place, if history repeats itself and the river migrates, the intake will likely lose function.

Other disadvantages associated with this alternative include:

- Increased O&M costs
- CLOMR/LOMR required with construction in the Floodway

This alternative is the least costly of the three, as shown in Table 10 below. However, unless a weir is installed (prescreening alternative #2 and #3), which will control the river vertically and laterally, the location of the current intake is suspect at best. 100 years of problems with drawing water at this location is evidence enough. The river will migrate again; the only question is when. Investing millions of dollars in new infrastructure, on top of the millions of dollars that already have been invested here, is a poor use of taxpayer dollars. Proceeding forward with this alternative is not recommended unless the stated risks have been acknowledged and deemed acceptable.

Alternative B: Construct new intake three miles upstream, adjacent to Canyon Creek Ditch; replace existing screens with half-round screens; install hot water heater at existing intake

Given the extreme lateral migration of the river channel at the location of the current intake and the resulting problems, the geographic scope for siting an intake was broadened. As previously described, the river has remained stable at a point 3 miles upstream, adjacent to the Canyon Creek Ditch diversion. Two other stable points were identified, but this site was most suitable for an intake. Refer to the Geomorphological Analysis included in Appendix B for further information. The proposed location is shown again in Figure 54 below.

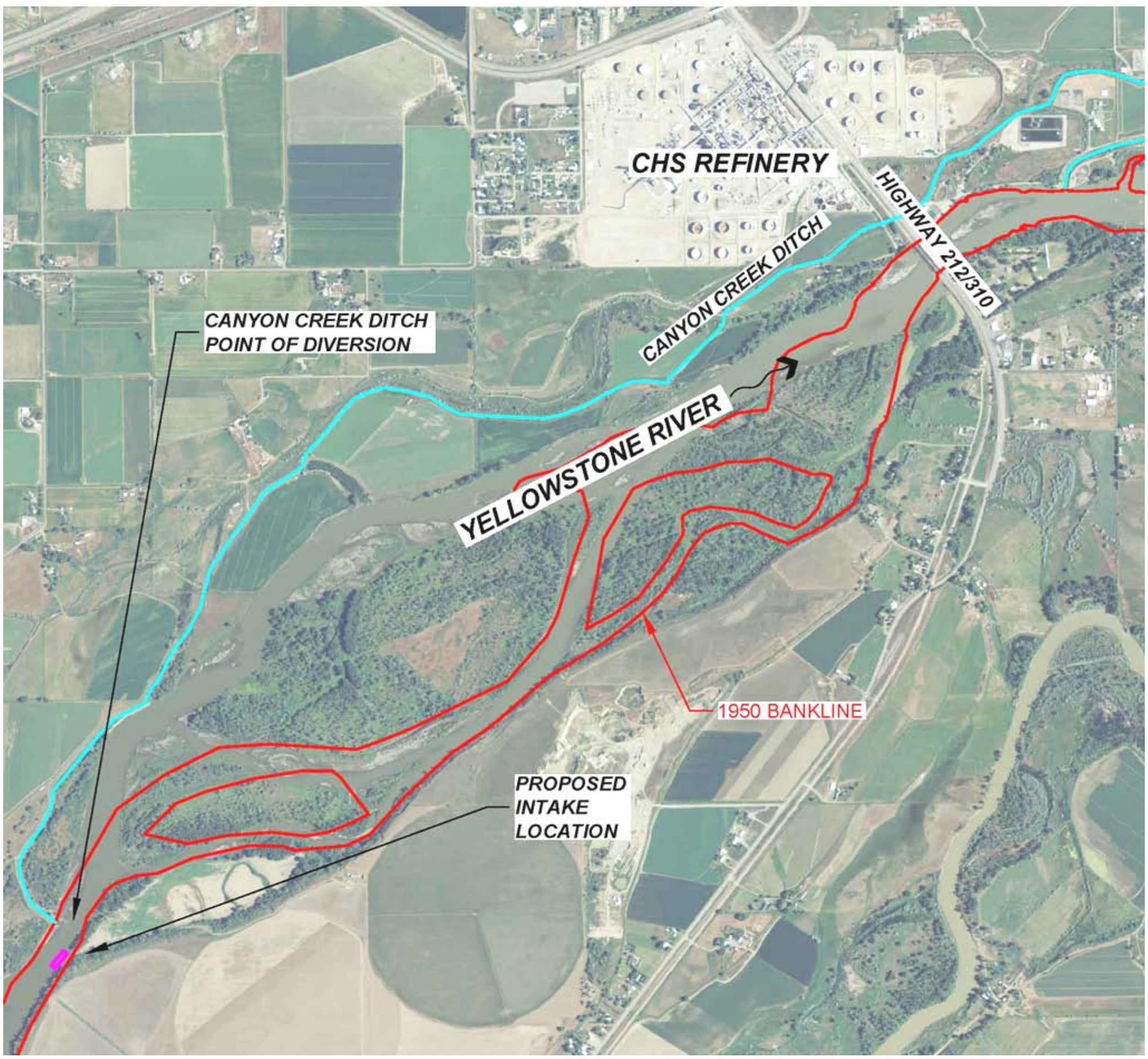


Figure 54: Alternative B, location of proposed intake, adjacent to the Canyon Creek Ditch

Advantages of this alternative include:

- River is confined by a high bank comprised of Belle Fourche shale (see Figure A-19 in Appendix A) and has been stable for over 60 years
- Water surface in river is not as critical since the site is located up-gradient
- The intake will be configured so as to not be exposed during low flows
- Provides an opportunity for inline sediment settling basin
- Provides greater redundancy, having two intakes in completely separate locations

It is proposed, as part of this alternative, that the current intake be left in service. Having two points from which the City can draw water is an immense advantage. If maintenance on one of the intakes is required, it can be taken offline, and the City will still have a means to draw raw water. If one intake is compromised due to icing or channel migration, the other intake may be used.

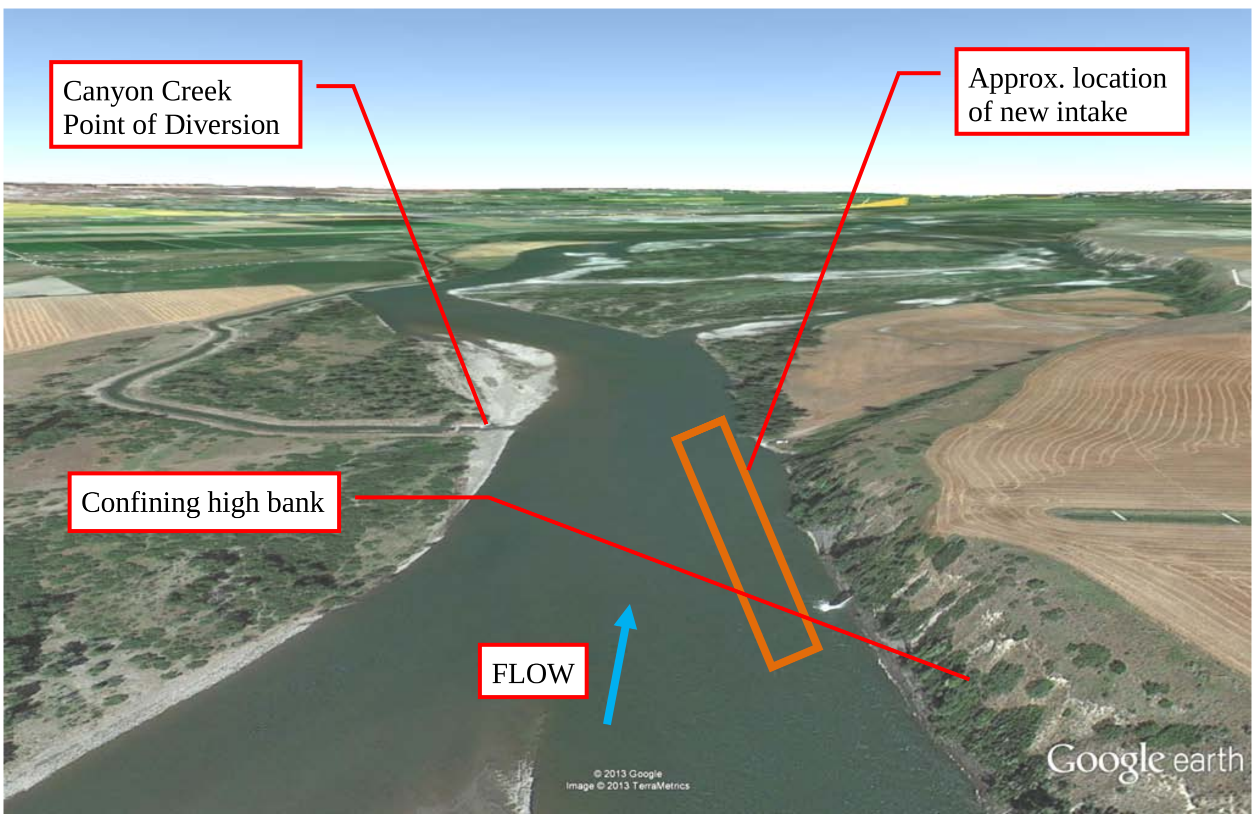


Figure 55: Perspective view of new intake location

In order to leave the existing intake in service, the concrete structure and screens must be lowered, for reasons previously described. When the temporary rock weir is removed, the hydraulic analysis shows that the lowering of the water surface will severely compromise the function of the existing intake if the screens and concrete are not lowered. There will also be risk posed to recreational traffic by a concrete monolith projecting from the river during most of the summer and fall when river recreation is at its peak. This will be a great liability and risk for the City. The hot water heater is also essential to aid the function of the existing intake during the winter months. These work items have been included as part of Alternative B and are reflected in the cost estimate.

Disadvantages of this alternative include:

- More costly than Alternative A
- Water rights concerns
- Required easement/land acquisition
- CLOMR/LOMR required with construction in the Floodway
- Cultural resources inventory required, mitigation possible
- Potential wetland impacts

A detailed cost estimate for this alternative is shown below in Table 11.

Alternative C: Construct infiltration gallery using the trench method at Site 1; replace existing screens with half-round screens; install hot water heater at existing intake

Infiltration was considered in 2002 by HKM, Inc. and was evaluated further as part of this analysis. The perceived benefit to groundwater sources is that they would be more immune to lateral and vertical changes in the river than a surface water intake. WGS was contracted by Great West to perform an in-depth analysis of groundwater alternatives.

According to the WGS report, a new groundwater source is not immune to channel migration impacts, as channel offset is a critical factor in source capacity. At greater offset distances from the channel, groundwater sources produce at lower capacity. If for example a new groundwater source was located on the channel margin, a substantial decline in capacity would be realized if the channel migrated away to create a greater offset. The same situation can arise if a channel bar were to accrete onto the bank at the site of a groundwater source. Given the potential for these conditions, the capacity of a groundwater source cannot be guaranteed into the future to any degree greater than a direct surface water intake.

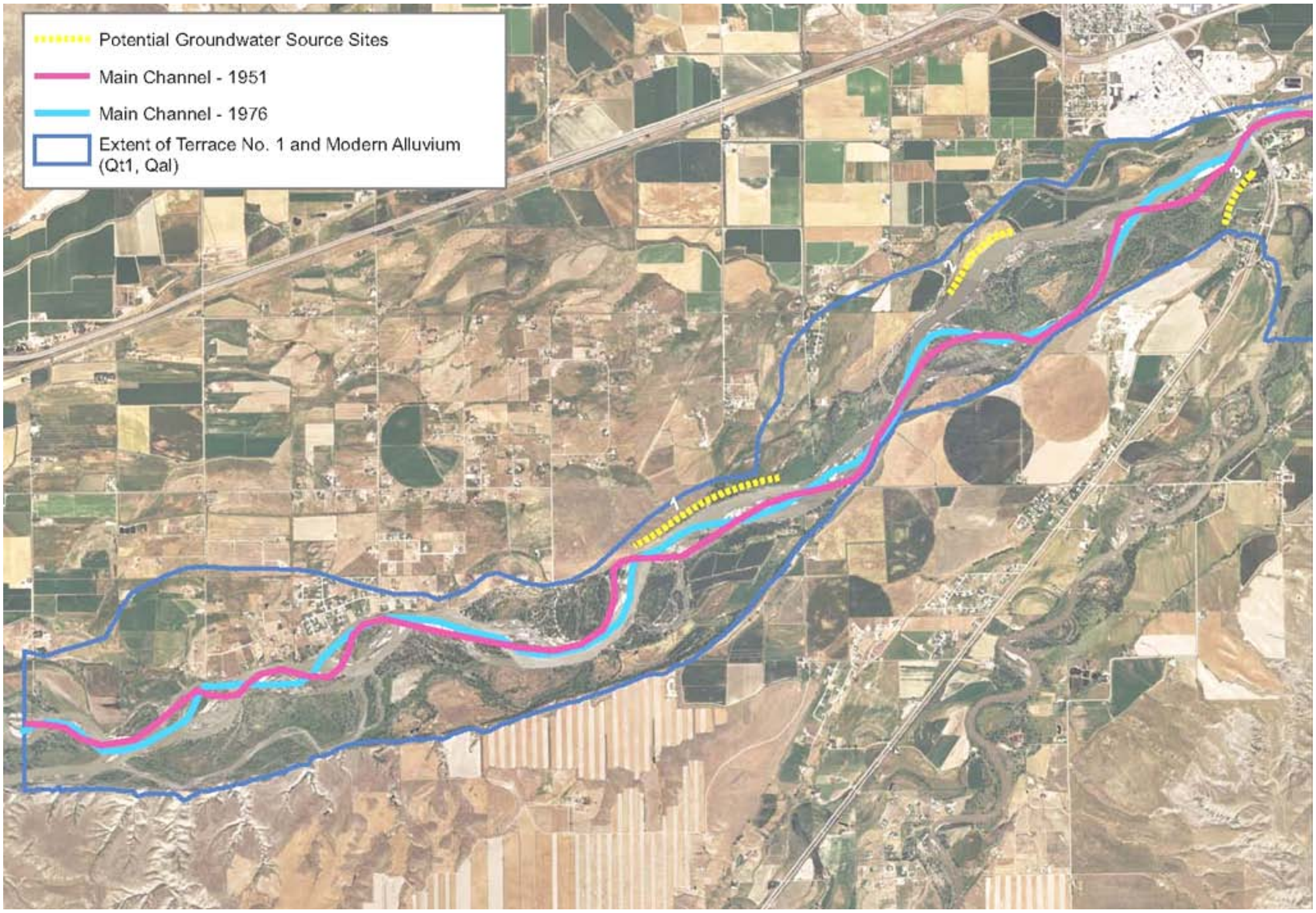


Figure 56: Potential Groundwater Source Sites 1-3 (Figure 3-1A from WGS Report, 2014)

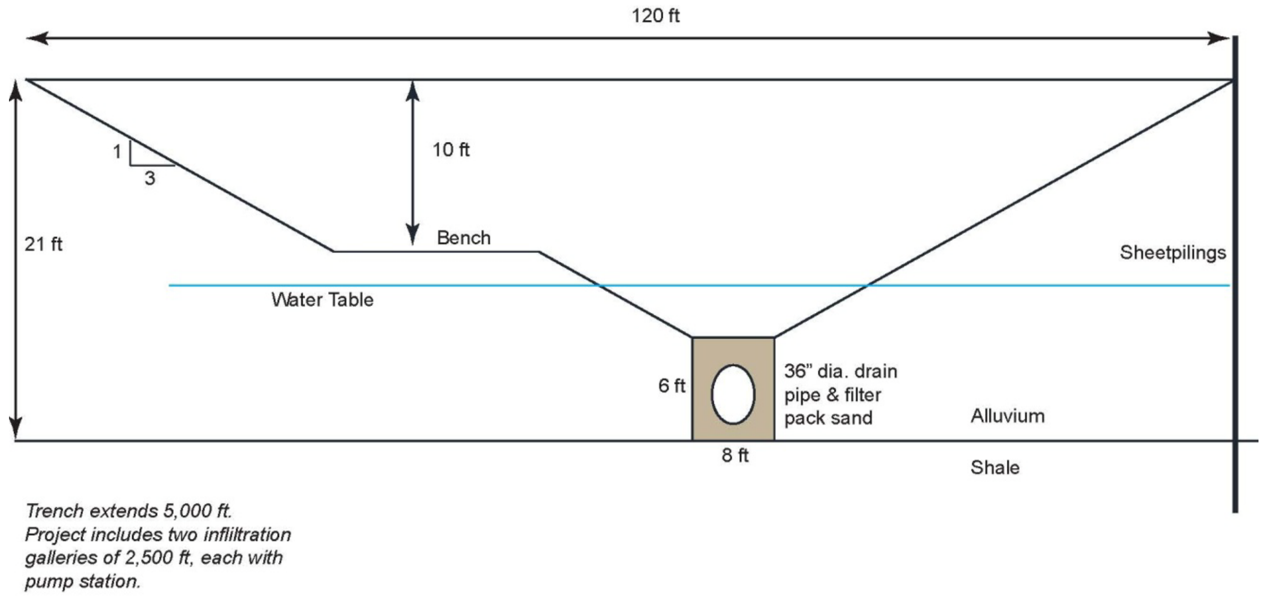


Figure 57: Cross section of construction of infiltration trench (Figure 5-1 from WGS Report, 2014)

Of the alternatives considered in the report, only one was found to meet the stated purpose and need of the project by providing the design demand. This was the infiltration gallery, constructed by the trench method, located at Site 1 (see Figure 56).

It is proposed, as part of this alternative, that the current intake be left in service. Having two points from which the City can draw water is an immense advantage. If maintenance on one of the sources is required, it can be taken offline, and the City will still have a means to draw raw water. If one intake is compromised due to icing or channel migration, the other may be used.

In order to leave the existing intake in service, the concrete structure and screens must be lowered, for reasons previously described. When the temporary rock weir is removed, the hydraulic analysis shows that the lowering of the water surface will severely compromise the function of the existing intake if the screens and concrete are not lowered. There will also be risk posed to recreational traffic by a concrete monolith projecting from the river during most of the summer and fall when river recreation is at its peak. This will be a great liability and risk for the City. The hot water heater is also essential to aid the function of the existing intake during the winter months. These work items have been included as part of Alternative C and are reflected in the cost estimate.

Advantages of this alternative include:

- No structure located in the river channel
- Less long-term environmental impact
- No CLOMR/LOMR required
- Provides an opportunity for inline sediment settling basin
- Provides greater redundancy, having two intakes in completely separate locations

Disadvantages of this alternative include:

- Cost
- Increased timeline due to additional analysis needed
- Required easement/land acquisition
- Cultural resources inventory required, mitigation possible
- Potential wetland impacts
- Sedimentation buildup within the drain pipe,
- Potential plugging due to algae

A detailed cost estimate for this alternative is shown below in Table 12.

Table 10: Alternative A, Cost Estimate

OPINION OF PROBABLE COST

ALTERNATIVE A

Remove existing pumps, replace with dry pit submersible pumps; remove sediment; replace existing screens with half-round screens; install hot water heater; construct new intake adjacent to existing intake

Item No.	Description	Qty	Units	Unit Price	Total
Replace existing vertical turbine pumps with dry pit submersible pumps					
1	Relocate Manifold	1	LS	$25,000	$25,000
2	Discharge Piping	1	LS	$20,000	$20,000
3	Remove Existing Turbines	1	LS	$15,000	$15,000
4	Portable Crane	2	EA	$5,000	$10,000
5	Check Valves	7	EA	$2,500	$17,500
6	Pumps WTP 1 & 2	2	EA	$20,000	$40,000
7	Pumps WTP 3 & 4	2	EA	$25,000	$50,000
8	Pumps Refinery 1, 2 & 3	3	EA	$32,000	$96,000
9	Pump Installation	1	LS	$25,000	$25,000
10	VFDs 1 & 2	2	EA	$10,000	$20,000
11	VFDs 3 & 4	2	EA	$15,000	$30,000
12	VFDs Refinery	3	EA	$22,000	$66,000
13	Controls	1	LS	$25,000	$25,000
14	Building Modifications	1	LS	$45,000	$45,000
				Subtotal	$484,500
Remove sediment					
1	River Sediment & Debris Excavation and Offsite Disposal	10000	CY	$15	$150,000
2	Constructing & Reclaiming Construction Access to the River	200	CY	$20	$4,000
3	Steel Plates to Span Existing Pipeline for Construction Access on Sewer Plant Road	1	EA	$2,000	$2,000
4	Exploratory Excavation	4	HR	$150	$600
5	Protect Existing Water Mains in Place within	4	EA	$2,000	$8,000
6	Place Salvaged Riprap on Riverbank	80	SY	$60	$4,800
				Subtotal	$169,400
Replace existing screens with half-round screens					
1	Cofferdam	70	LF	$1,000	$70,000
2	Work Bridge	1	LS	$150,000	$150,000
3	Pumps for Dewatering	30	DAYS	$1,100	$33,000
4	Concrete Demolition	1	LS	$6,000	$6,000
5	Cast-in-Place Concrete	40	CY	$1,200	$48,000
6	Half-Round Screens	4	EA	$18,000	$72,000
7	Reconnect plumbing	1	LS	$5,000	$5,000
				Subtotal	$384,000

	Install hot water heater				
1	Commercial Hot Water Heater - 1000 gallon	1	LS	$125,000	$125,000
2	Pump (150 GPM)	1	LS	$5,000	$5,000
3	Piping	1	LS	$3,000	$3,000
4	Outbuilding	1	LS	$50,000	$50,000
5	Electronic Controls	1	LS	$5,000	$5,000
				Subtotal	$188,000
	Construct new intake adjacent to existing intake				
1	Earthwork	1	LS	$40,000	$40,000
2	Piping 24-inch DI	80	LF	$175	$14,000
3	Pipe Lean Concrete Encasement	70	CY	$250	$17,500
4	Half-Round Screens	4	EA	$18,000	$72,000
5	Cofferdam	300	LF	$1,000	$300,000
6	Dewatering Pumps	45	DAYS	$1,100	$49,500
7	Concrete	105	CY	$1,200	$126,000
8	Piling	1	LS	$10,000	$10,000
9	Upgrade Air Backwash System	1	LS	$54,000	$54,000
				Subtotal	$683,000
	Remove Emergency Rock Weir				
1	Hydraulic Excavator	40	HR	$240	$9,600
2	Dump Truck	80	HR	$60	$4,800
				Subtotal	$14,400
	Portable Bypass Pumps				
1	Portable Diesel Pump	1	EA	$70,000	$70,000
2	Flexible Piping	400	LF	$10	$4,000
				Subtotal	$74,000
	Direct Construction Subtotal				**$1,997,300**
	Mobilization	10.0%			$199,730
	Contingency	15.0%			$299,595
	Construction Subtotal				**$2,496,625**
	2015 Construction Cost	3.0% [2]			$2,571,524
	Alternatives Analysis & EA				$130,000
	Groundwater Alternatives Analysis				$33,110
	Engineering Design	13.8%			$344,534
	Resident Project Representative				$80,000
	Project Management	1.0%			$24,966
	Geotechnical Investigation				$20,000
	MPDES Permit, Dewatering				$900
	DEQ 410 Certification Fee (1% of related construction)				$12,364
	DEQ 318 Authorization Fee				$250
	CLOMR Application				$20,000
	LOMR Application				$20,000
TOTAL					**$3,257,648**

[1] Estimated unit costs are based upon estimates from suppliers and bid tabs for similar projects throughout Montana.

[2] The ENR 20 year average Construction Cost Index is +2.88% (1994-2013), so capital costs are projected to an anticipated construction date in 2015 using a 3.0% inflation rate.

Table 11: Alternative B, Cost Estimate

OPINION OF PROBABLE COST

ALTERNATIVE B - PREFERRED ALTERNATIVE

Construct new intake 3 miles upstream, adjacent to Canyon Creek Ditch; replace existing screens with half-round screens; install hot water heater at existing intake; remove sediment

Item No.	Description	Qty	Units	Unit Price	Total
1	Earthwork for intake	1	LS	$40,000	$40,000
2	Piping 24-inch DI (parallel pipes in river)	900	LF	$175	$157,500
3	Pipe Lean Concrete Encasement	1255	CY	$250	$313,750
4	Intake Screens	4	EA	$15,000	$60,000
5	Cofferdam	650	LF	$1,000	$650,000
6	Dewatering Pumps	45	DAYS	$1,100	$49,500
7	Work Bridge	1	LS	$175,000	$175,000
8	Cast-in-Place Concrete	105	CY	$1,200	$126,000
9	Piling	1	LS	$10,000	$10,000
10	Air Backwash System	1	LS	$54,000	$54,000
11	Commercial Hot Water Heater - 1000 gallon	1	LS	$125,000	$125,000
12	Pump (150 GPM)	1	LS	$5,000	$5,000
13	Piping for Hot Water	1	LS	$3,000	$3,000
14	3-Phase Power	1	LS	$50,000	$50,000
15	Outbuilding	1	LS	$135,000	$135,000
16	Electronic Controls for Hot Water Heater	1	LS	$5,000	$5,000
17	Electronic Controls from WTP to New Intake Site and Integrate Into SCADA System	1	LS	$90,000	$90,000
18	30" PVC Transmission Main (2 parallel lines)	32000	LF	$100	$3,200,000
19	Jack and Bore Beneath Highway	200	LF	$600	$120,000
				Subtotal	$5,368,750
	Replace existing screens with half-round screens at existing intake				
1	Cofferdam	70	LF	$1,000	$70,000
2	Work Bridge	1	LS	$150,000	$150,000
3	Pumps for Dewatering	30	DAYS	$1,100	$33,000
4	Concrete Demolition	1	LS	$6,000	$6,000
5	Cast-in-Place Concrete	40	CY	$1,200	$48,000
6	Half-Round Screens	4	EA	$18,000	$72,000
7	Reconnect plumbing	1	LS	$5,000	$5,000
				Subtotal	$384,000

	Install hot water heater at existing intake				
1	Commercial Hot Water Heater - 1000 gallon	1	LS	$125,000	$125,000
2	Pump (150 GPM)	1	LS	$5,000	$5,000
3	Piping	1	LS	$3,000	$3,000
4	Outbuilding	1	LS	$50,000	$50,000
5	Electronic Controls	1	LS	$5,000	$5,000
				Subtotal	$188,000
	Remove Emergency Rock Weir				
1	Hydraulic Excavator	40	HR	$240	$9,600
2	Dump Truck	80	HR	$60	$4,800
				Subtotal	$14,400
	Remove sediment				
1	River Sediment & Debris Excavation and Offsite Disposal	10000	CY	$15	$150,000
2	Constructing & Reclaiming Construction Access to the River	200	CY	$20	$4,000
3	Steel Plates to Span Existing Pipeline for Construction Access on Sewer Plant Road	1	EA	$2,000	$2,000
4	Exploratory Excavation	4	HR	$150	$600
5	Protect Existing Water Mains in Place within	4	EA	$2,000	$8,000
6	Place Salvaged Riprap on Riverbank	80	SY	$60	$4,800
				Subtotal	$169,400
	Direct Construction Subtotal				**$6,124,550**
	Mobilization	10.0%			$612,455
	Contingency	15.0%			$918,683
	Construction Subtotal				**$7,655,688**
	2015 Construction Cost	3.0% [2]			$7,885,358
	Alternatives Analysis & EA				$160,000
	Groundwater Alternatives Analysis				$33,110
	Engineering Design	9.0%			$689,012
	Resident Project Representative				$105,000
	Project Management	1.0%			$76,557
	Geotechnical Investigation				$25,000
	Environmental/Archeological				$15,000
	Easement/Right-of-Way Acquisition				$50,000
	MPDES Permit, Dewatering				$900
	DEQ 410 Certification Fee (1% of related construction)				$16,358
	DEQ 318 Authorization Fee				$250
	CLOMR Application				$20,000
	LOMR Application				$20,000
TOTAL					**$9,096,544**

[1] Estimated unit costs are based upon estimates from suppliers and bid tabs for similar projects throughout Montana.

[2] The ENR 20 year average Construction Cost Index is +2.88% (1994-2013), so capital costs are projected to an anticipated construction date in 2015 using a 3.0% inflation rate.

Table 12: Alternative C, Cost Estimate

OPINION OF PROBABLE COST ALTERNATIVE C Construct infiltration gallery using the trench method at Site 1; replace existing screens with half-round screens; install hot water heater at existing intake					
Item No.	**Description**	**Qty**	**Units**	**Unit Price**	**Total**
1	Cost from Table A-3 of WGS Report (minus Mobilization)	1	LS	$8,663,841	$8,663,841
2	30" PVC Transmission Main (2 parallel lines)	32000	LF	$100	$3,200,000
3	Jack and Bore Beneath Highway	200	LF	$600	$120,000
				Subtotal	$11,983,841
	Replace existing screens with half-round screens at existing intake				
1	Cofferdam	70	LF	$1,000	$70,000
2	Work Bridge	1	LS	$150,000	$150,000
3	Pumps for Dewatering	30	DAYS	$1,100	$33,000
4	Concrete Demolition	1	LS	$6,000	$6,000
5	Cast-in-Place Concrete	40	CY	$1,200	$48,000
6	Half-Round Screens	4	EA	$18,000	$72,000
7	Reconnect plumbing	1	LS	$5,000	$5,000
				Subtotal	$384,000
	Install hot water heater at existing intake				
1	Commercial Hot Water Heater - 1000 gallon	1	LS	$125,000	$125,000
2	Pump (150 GPM)	1	LS	$5,000	$5,000
3	Piping	1	LS	$3,000	$3,000
4	Outbuilding	1	LS	$50,000	$50,000
5	Electronic Controls	1	LS	$5,000	$5,000
				Subtotal	$188,000

Remove Emergency Rock Weir					
1	Hydraulic Excavator	40	HR	$240	$9,600
2	Dump Truck	80	HR	$60	$4,800
				Subtotal	$14,400
	Direct Construction Subtotal				**$12,570,241**
	Mobilization	10.0%			$1,257,024
	Contingency	15.0%			$1,885,536
	Construction Subtotal				**$15,712,801**
	2016 Construction Cost	3.0% [2]			$16,669,711
	Alternatives Analysis & EA				$130,000
	Groundwater Alternatives Analysis				$33,110
	Engineering Design	7.9%			$1,246,025
	Resident Project Representative				$140,000
	Project Management	1.0%			$157,128
	Easement/Right-of-Way Acquisition				$50,000
	Environmental/Archeological				$15,000
	Monitoring Wells and Geophysical Survey				$104,140
	Production Test Wells				$355,878
TOTAL					**$18,900,992**

[1] Estimated unit costs are based upon estimates from suppliers and bid tabs for similar projects throughout Montana.

[2] The ENR 20 year average Construction Cost Index is +2.88% (1994-2013), so capital costs are projected to an anticipated construction date in 2016 using a 3.0% inflation rate.

A Summary of the total project cost for each alternative is shown in Table 13.

Table 13: Summary of Costs

Alt.	Description	Total Project Cost
A	Remove existing pumps, replace with dry pit submersible pumps; remove sediment; replace existing screens with half-round screens; install hot water heater; construct new intake adjacent to existing intake	$3,260,000
B	Construct new intake 3 miles upstream, adjacent to Canyon Creek Ditch; replace existing screens with half-round screens; install hot water heater at existing intake; remove sediment	$9,100,000
C	Construct infiltration gallery using the trench method at Site 1; replace existing screens with half-round screens; install hot water heater at existing intake	$18,910,000

Environmental Evaluation

The alternatives were then compared using an objective scoring matrix to assess the environmental impacts of each alternative. The effect of each alternative was analyzed for numerous different environments. The alternatives were given a comparative score, which is explained below:

- Beneficial effect = +1
- Adverse effect = -1
- No effect = 0
- Minimal effect = 0
- Temporary effect = 0

The scores were totaled, and the alternatives were ranked. The results of this analysis are shown in Table 14 below.

Table 14: Evaluation of Environmental Impacts of Alternatives

	Alternative A	Alternative B	Alternative C
Geology and Soils	0	0	-1
Land Use and Planning			
Zoning	0	0	0
Prime Farm Land	0	-1	-1
Floodplain	-1	-1	0
Traffic Circulation	0	0	0
Public Health and Safety	1	1	1
Recreation	0	-1	0
Socioeconomic Issues	0	0	0
Environmental Justice	0	0	0
Air Quality and Climate	0	0	0
Noise	0	0	0
Public Services and Utilities	-1	1	1
Water Quality - Water Resources	0	0	0
Biological Resources			
Wetlands	0	0	0
Threatened or Endangered Species	0	0	0
Vegetation	0	0	-1
Wildlife	0	0	0
Aquatic Resources	0	0	0
Cultural Resources*	0	-1	-1
Hazardous Materials and Wastes	0	0	0
TOTALS	**-1**	**-2**	**-2**
RANK	**1**	**2**	**2**

*It is not definitively known at this time if there will be long-term Cultural Resources impacts associated with Alternatives B & C. A Cultural Resources Inventory will be conducted as part of the Environmental Assessment (EA).

The analysis shows that Alternative A has the least environmental impact; Alternatives B and C have similar environmental impacts but are both more adverse compared to Alternative A.

Practicability Evaluation

The practicability of each alternative must also be analyzed. Considerations for practicability were chosen based upon the stated purpose and need of the project. These included:

- Whether the alternative mitigates for lateral instability of the river
- Whether the alternative mitigates for degradation of the river
- Resistance to frazil ice
- Constructability
- Cost

Alternative A: While this alternative mitigates for degradation of the river by building a new intake, provides measures to handle frazil ice, is constructible, and is the lowest cost, it does not sufficiently address the lateral instability of the river and cannot provide a long-term reliable source of raw water for the City.

Alternative B: This alternative satisfies all practicability considerations, although it does represent a high cost than Alternative A.

Alternative C: This alternative, although it is somewhat resistant to lateral change in the river, does not sufficiently address this criterion. Alternative C is resistant to frazil ice and is constructible, but comes at a much higher monetary cost compared to the other two alternatives.

4.5 SUMMARY AND RECOMMENDATIONS

The prescreening analysis began with 24 alternatives, which were analyzed to determine their feasibility and whether or not they met the stated purpose and need. The prescreening analysis resulted in several alternatives being eliminated from further consideration and others being recognized as secondary alternatives and combined with other primary alternatives. The result was three alternatives, which were then evaluated against environmental criteria and practicability criteria, including cost.

It is the recommendation of Great West that the City of Laurel pursue Alternative B, which would construct a new surface water intake three miles upstream, adjacent to the Canyon Creek Ditch diversion, and make modifications to the existing intake. This alternative provides the greatest redundancy in order to provide a sustainable and consistent water supply to the residents and businesses of the City and to ensure that the raw water intake capacity of 20 MGD is maintained.

It is recognized that this recommendation will need to be validated by an Environmental Assessment (EA) in order to ensure that the Least Environmentally Damaging Practicable Alternative (LEDPA) is selected. Alternatives B and C will be evaluated in the EA along with a No Action alternative. Alternative A does not meet the stated Purpose and Need and will not be evaluated further.

APPENDIX D – AGENCY CORRESPONDENCE

MEETING MINUTES

Date: April 30, 2013

To: Meeting Attendees (see attached)

From: Great West Engineering

Subject: City of Laurel, Water Treatment Plant Feasibility Study: Alternatives Prescreening Analysis - Onsite Meeting

---

A meeting was held on April 30th, 2013 at the Riverside Park in Laurel to discuss the Water Treatment Plant Intake Feasibility Study. A record of the meeting follows.

Time	Notes
11:00 a.m. – 12:30 p.m.	• Introduction of all parties. • Brief history of project and problem. • Jeremiah Theys, Project Manager with Great West Engineering gave a general overview of all the alternatives that were considered in the Alternatives Prescreening Analysis. • Handouts were distributed showing schematics of the proposed W-weir alternative. PDF's of the handouts are attached to these minutes. • The group split up and some walked over to the river bank to see how the W-weir would be laid out. • Mike Ruggles with Montana FWP; o Expressed concerns about boat and fish passage with the W-weir. o Prefers the holding pond alternative with a headgate structure located near the Billings Bench Water Association (BBWA) diversion without a river-spanning structure. • David Leitheiser with MDT; o Expressed concerns about how the W-weir would tie into the riprap at the bridge abutments.

- Kasie Holle with BNSF Railway;
  - Expressed concerns about how the W-weir would affect the hydraulics through the railroad bridge. One of the piers on the bridge is especially susceptible to scour.
  - Brought up the possibility of adding a booster pump(s) in order to increase the head at the existing WTP pumps instead of installing the W-weir.
  - Asked to be given a copy of our hydraulic model for verification purposes.

12:30 p.m. – 1:30 p.m.	• Several from the group continued the meeting informally over lunch.

Mr. Jeff Ryan with the Montana DEQ was not able to attend the meeting in person, but he submitted questions via email prior to the meeting. His questions and our responses are listed below:

1. What previous experience does Great West Engineering have at recommending, designing and construction oversight of large w-weirs and other large cross channel structures on major Montana rivers? As noted in my previous comments, the structures are very complicated to design and build and their use is questionable in systems that move a lot of bedload, woody debris and ice. At this site, what is the expected operations and maintenance schedule for the structures?

   Great West Engineering has a staff of seasoned engineers and scientists that have been involved with a multitude of stream restoration/rehabilitation projects involving the use of w-weirs. Specifically he have a senior Geomorphologist that's has over 30-years experience working with in-stream structures in all types of river systems across the northwest. Great West wants to ensure a successful project is completed and addresses issues that have been presented. Should the need arise; Great West will hire specialized experts to assist in final design.

2. What are the limitations on the HECRAS modeling that was done at this site – can it accommodate the unknown variables involving bedload, woody debris and ice?

   The Bureau of Reclamation, in conjunction with Colorado State University, has been conducting much needed research on the hydraulics of river-spanning rock structures (including W-weirs). We utilized the following reports in the development of our hydraulic model:

   - **Holmquist-Johnson, Christopher Lee. *Numerical Analysis of River Spanning Rock U-Weirs: Evaluating Effects of Structure Geometry on Local Hydraulics*. Fort Collins: Colorado State University, 2011.**
   - **Meneghetti, Anthony M. *Stage-Discharge Relationships for U-, W-, and A-Weirs in Unsubmerged Conditions*. Fort Collins: Colorado State University, 2009.**
   - **Scurlock, S. Michael. *Equilibrium Scour Downstream of Three-Dimensional Grade-Control Structures*. Fort Collins: Colorado State University, 2009.**

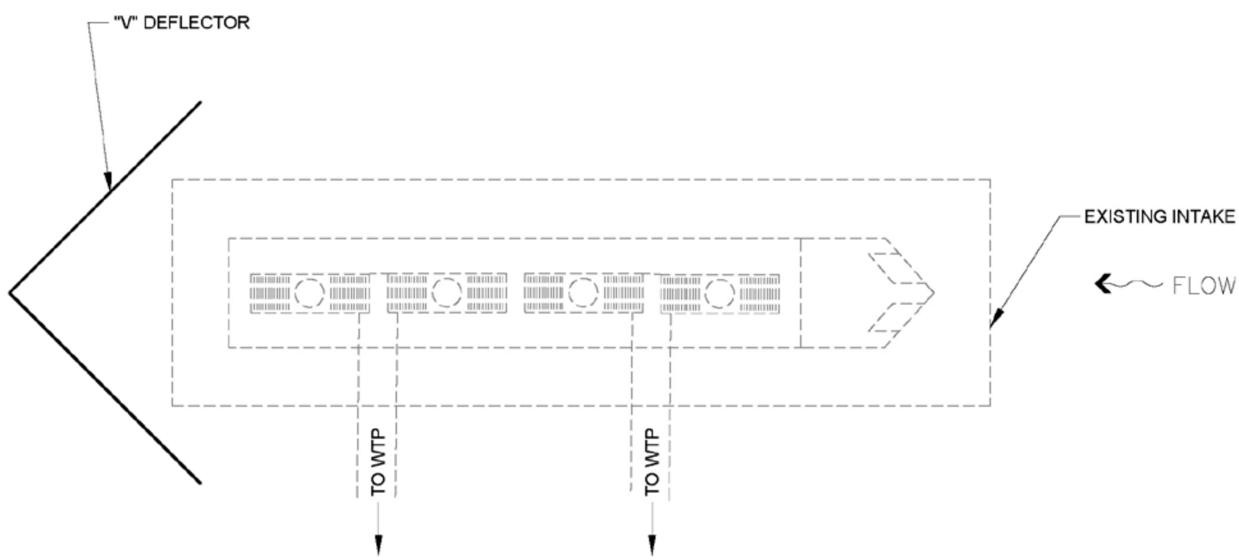
   Their research does state that 3-D numerical modeling techniques do most accurately predict and describe the hydraulics of these structures. However, the reports give stage-discharge relationships, which we used to calibrate our 1-D HEC RAS model.

   We also referenced a report developed by the Cold Regions Research and Engineering Laboratory of the U.S. Army Corps of Engineers titled Physical Model Study of Cross Vanes and Ice, May 2009 (ERDC/CRREL TR-09-7). One conclusion from the report is given in the following quote:

"A possible reason for non-occurrence of jams with the structures in place is the increased water velocity through the gap, which maintained the ice conveyance capacity even though the effective flow area was reduced…Though the flume experiments did not demonstrate with certainty that cross-vane structures increase the potential for ice jamming, this should not be taken as a sign that the structures necessarily improve ice conveyance through a reach of river."

3. Will the potential alternative we recently discussed on the phone come under more evaluation? That alternative suggested some experimentation with a "v" shaped metal deflector attached to the mid-river intake. The v-deflector wings would point upstream and hopefully funnel/pile up water in front and over the intake structure as the wings converged together. The deflectors would need to stick above the lowest water elevation and would propose some hazard to floaters, but the existing intake structure may be even more hazardous, because it appears to be just below the water and not readily visible from the river. The v-deflector should be a small fraction of the cost of any of the other alternatives analyzed.

   First of all, thank you for being willing to offer other suggestions and thinking outside the box. The following schematic is our interpretation of what you are proposing:

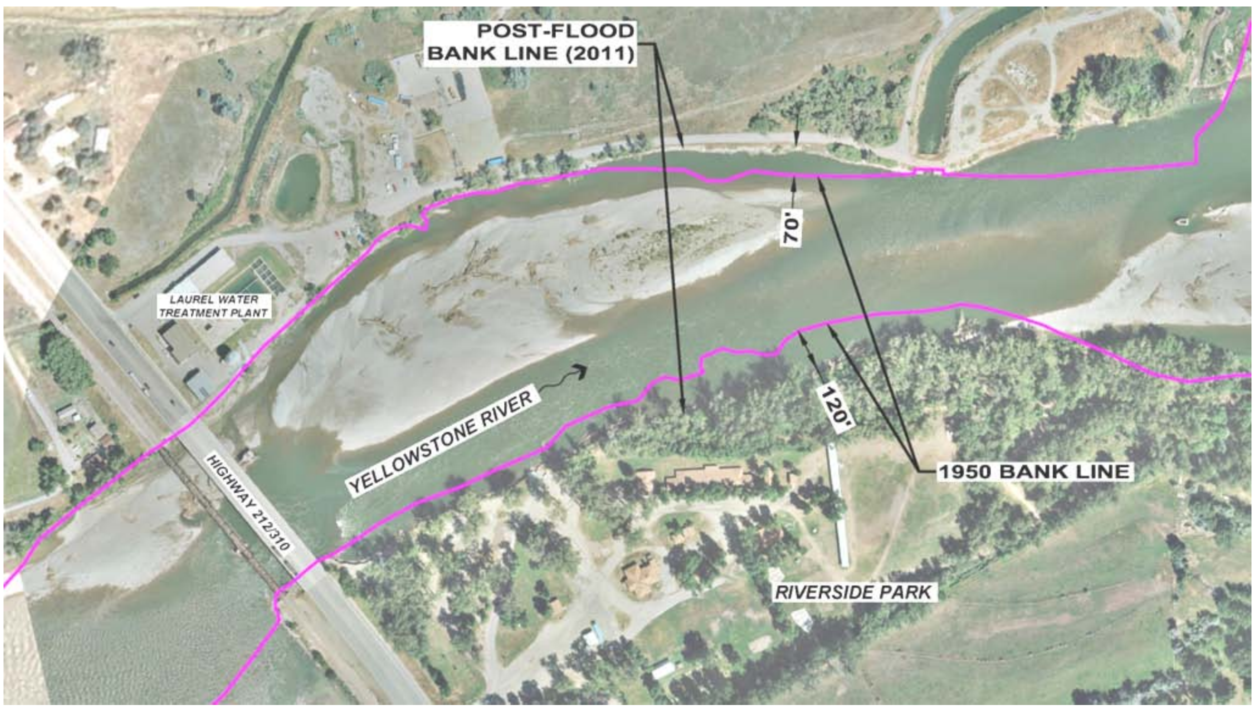


   Our initial thoughts are that this alternative may help to increase the water surface elevation, but it would likely not function properly at very low flows. As stated in the response Memo, dated 4/26/13, our hydraulic models show that at a flow of 700 cfs, the water surface elevation would be 1.5 feet below the design low water stage. A localized deflector like this would not achieve a 1.5-foot rise in the water

surface elevation over the entire length of the structure (43 feet). The shape would also be very prone to collect debris and ice.

4. Will further analysis be done for alternative #14 (holding pond). A more in depth analysis might support providing a screened intake on the river bank just upstream of the BBWA water intake without the need for a complicated expensive w-weir. The historical aerial photos that were provided with the alternatives report appear to show good river access to that location and perhaps more important, the BBWA inlet immediately down river from the proposed water intake has apparently been provided water for decades.

   You are correct that the channel, in the vicinity of the BBWA diversion has remained relatively stable for the last 60 years. However, the image below shows that the channel is prone to lateral migration and erosion even in this reach.



   In the Alternatives Prescreening Analysis we reference the Geomorphic Reconnaissance and GIS Development, Yellowstone River, Montana report which classifies the reach through Laurel as "unconfined anabranching". This is further defined by the following characteristics: low natural confinement, moderate gravel bar frequency, high side channel frequency, and a high relative rate of change.

   We feel that it should be safely concluded that the channel near the BBWA diversion, although it appears stable now, will experience unpredictable changes if only given the time. Given the history of migration on the river in this reach, it would be unwise to invest millions of dollars in infrastructure without addressing the inherent instability that exists.

Great West engineering

CITY OF LAUREL

Water Treatment Plant Intake Feasibility Study

On-site Meeting

April 30, 2013

Sign-In Sheet

Name	Company	email	Telephone
JONATHAN WEAVER	GREAT WEST ENG.	JWEAVER @ GREATWESTENG.COM	(406) 437-2137
Heidi Jensen	City of Laurel	hjensen@laurel.mt.gov	406-628-4796
CHAD HANSON	GREAT WEST	chanson@greatwesteng.com	652-5000
Tim Reiter	City of Laurel	TReiter@Laurel.mt.gov	860 9209
Tim Thennis	MT DES	tthennis@mt.gov	324-4783
Jennifer Ros	Laurel Outlook	news@laureloutlook.com	628-4412
Mayor Ken Olson	City of Laurel	citymayor@laurel.mt.gov	628-8456
Rachel Court	Senator Jon Tester	Rachel_Court@tester.senate.gov	252.0550
BRETT BAILEY	STRUCTURES SUP BNSF	BRETT.BAILEY@BNSF.COM	206)491-4693
ERICH SCHMITZ	TSC	EGSCHMITZ@TRANSYSTEMS.COM	816-329-8650

Great West engineering

CITY OF LAUREL

Water Treatment Plant Intake Feasibility Study

On-site Meeting

April 30, 2013

Sign-In Sheet

Name	Company	email	Telephone
Liz Ching	Sen Max Baucus	elizabeth_ching@baucus.senate.gov	406-657-6795
Kasie Holle	BNSF Railway	kasie.holle@bnsf.com	913-551-4060
Mike Ruggles for Ken Frazer	MTFWP	mikeruggles@mt.gov Kfrazer@mt.gov	247-2863 Mike 247-2961 Ken
Cathy Juhas	USACE	catherine.d.juhas@usace.army.mil	406-657-5910
Tom Bernard	FEMA	thomas.bernard@fema.dhs.gov	303-202-8909
Jeff Bollman	DNRC Southern Land Office	jbollman@mt.gov	247-4404
Tim Miller	Yellowstone Co. Floodplain	tmiller@co.yellowstone.mt.gov	256-2735
Sam Johnson	MT DNRC	sam.johnson@mt.gov	247-4423
Dave Leitheiser	MDT-Hydr	dleitheiser@mt.gov	4064447225
Jeremiah Theys	Great West Engineering	jtheys@greatwesteng.com	406-431-6650

PLAN VIEW EXHIBIT
W-WEIR WITH CURRENT WTP INTAKE

NEW WATER TREATMENT PLANT INTAKE
LAUREL, MONTANA

GreatWest engineering®

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GreatWest engineering®

PERSPECTIVE EXHIBIT
W-WEIR WITH CURRENT WTP INTAKE

NEW WATER TREATMENT PLANT INTAKE
LAUREL, MONTANA

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MEMORANDUM

Date: April 26, 2013

To: Distribution (via email)

From: Jeremiah Theys, PE
Project Manager

Subject: City of Laurel Water Treatment Plant Intake Feasibility Study
Alternatives Preliminary Screening Analysis

Thank you to all of those who provided comments and questions in response to the Alternatives Preliminary Screening Analysis for the City of Laurel Water Treatment Plant Intake, dated February 25, 2013.

We received responses from the following entities:

- Darin Swenson, Yellowstone County Public Works Department, Floodplain
- Jeff Ryan , MT Department of Environmental Quality
- Tom Barnard, DHS/FEMA
- David Leitheiser, Montana Department of Transportation
- Ken Frazer, Montana Fish, Wildlife, and Parks
- Ron Berry, BNSF Railway
- Jeff Bollman, Montana Department of Natural Resources and Conservation
- Jim Boyd, U.S. Fish and Wildlife Service
- Todd Tillinger and Shannon Johnson, U.S. Army Corps of Engineers
- Kathryn Ore and Damon Murdo, Montana State Historic Preservation Office
- Martin P. Miller, Montana Natural Heritage Program
- Jim Berkley, U.S. Environmental Protection Agency

The responses, in their entirety, are enclosed with this Memo for your review. Selected comments and/or questions were chosen from the responses and are addressed in this Memo. Our responses to the comments are in bold, italicized font.

Darin Swenson, Yellowstone County, Floodplain

- "Whichever proposal is selected, Great West Engineering will be able to state that in their professional opinion the selected proposal will not raise the Base Flood Elevation (BFE)."

  We recognize the benefit, from a permitting perspective, of selecting an alternative that does not raise the BFE. However, should the selected alternative raise the BFE, we will be prepared to go through the CLOMR/LOMR process.

Jeff Ryan, Montana Department of Environmental Quality

- Mr. Ryan identifies sedimentation, ice jamming, and long-term maintenance as major risks associated with a W-weir. Boater and fish passage are also major difficulties.

  These risks and difficulties have been noted and recognized. Should an alternative be selected which incorporates a W-weir, every effort will be made to mitigate these risks to the maximum extent possible. It should also be noted that any alternative which does not address the lateral migration and degradation of the channel poses a serious risk to the residents and businesses of the City of Laurel and the CHS refinery.

- Mr. Ryan suggests an alternative that would utilize a holding pond as a buffer for peak demand periods.

  Preliminary calculations indicate that Site Alt. #1, with a surface area of 5.2 acres and a depth of 8 feet, would provide 0.7 days of storage at the design flow. Also, as pointed out in the alternatives analysis, storing water in this manner for long periods of time can lead to the growth of algae and other bacteria and can reduce water quality. Alterations to the treatment plant may be necessary to treat for this.

- Mr. Ryan suggests using the historic intake as a backup if the new intake becomes inoperable.

  In March 2013, the City constructed a diversion channel to the old intake, which allowed water to be drawn from it to the treatment plant. While the old intake did function, it was found to be problematic and maintenance intensive in order to keep the screens free of ice and algae. See the response below to the COE for more information on the historic intake.

Tom Barnard, FEMA/DHS

- "…the hot water system identified in #10, is very likely not eligible for FEMA funding because it is not needed as a result of the disaster and was not a part of the pre-disaster design, function, or capacity…"

  The City understands that the hot water flush system is likely not eligible for FEMA funding and that if it is chosen as part of the long-term solution, the costs associated with it would be the responsibility of the City.

<u>David Leitheiser, Montana Department of Transportation</u>

- "Please provide information on how any construction would involve the bridge abutment riprap; ongoing design coordination is requested."

  The risk of flanking of the weir is recognized and additional armoring along the bank and tying into the bridge abutments will be necessary. These details will be developed further as the Environmental Analysis is completed. We will coordinate with MDT to ensure the layout is acceptable.

- "We would like to see the modeling that evaluates the impacts to the bridge (WSE, water velocities, etc.) to compare the original bridge design parameters."

  The following table is taken from a HEC RAS model, which compares proposed conditions with the permanent bank stabilization against proposed conditions with the permanent bank stabilization and the W-weir.

  The table shows a negligible increase in water surface elevation and a reduction in velocity at the 100-year flood event as a result of constructing the W-weir.

			Proposed Conditions with Permanent Bank Stabilization		***Proposed Conditions with Permanent Bank Stabilization and <u>W-Weir</u>***	
River Station (2007 Flood Study)	***Flow (cfs)***	***Return Interval***	***W.S. Elev. (ft)***	***Velocity (ft/s)***	***W.S. Elev. (ft)***	***Velocity (ft/s)***
141204.9	56,700	Q100	3274.55	6.72	3274.55	6.72
141096.0	56,700	Q100	3273.78	8.25	3273.78	8.24
Bridge U/S	56,700	Q100	3273.34	9.35	3273.35	9.34
Bridge D/S	56,700	Q100	3273.33	8.07	3273.34	8.07
141034.4	56,700	Q100	3272.58	10.02	3272.59	10.01
141020.2	56,700	Q100	3272.09	10.86	3272.10	10.85

Note: All elevations are given in NAVD88 datum.

<u>Ken Frazer, MT Fish, Wildlife, & Parks</u>

- "From a fish and wildlife standpoint alternative 14 would be the most acceptable of the selected alternatives. Even though it still includes a w-weir I think the location of this weir would have less impact than a structure right below the bridges as proposed in alternatives 2 and 3."

  It is agreed that locating the W-weir just downstream of the BBWA ditch would pose less of a risk to infrastructure and buildings near the current intake, including the railroad and highway bridges, Riverside Park, and the water treatment plant. However, siting the W-weir in this location would require the

construction of a holding pond or other means of diversion, which increases the cost substantially in relation to other alternatives.

Ron Berry, BNSF Railway

- "In Alternative 2, is the intent of the construction to promote two low flow channels through the existing highway and railroad structures?"

  The elevation of the north apex of the W-weir will be set slightly higher than the south apex. It is our intention to largely keep the thalweg of the channel on the south half of the river, where the intake is located. However, we did not want to completely block off the north low-flow channel due to fear that the BBWA ditch would become inoperable. Additionally, it is generally accepted that W-weirs be installed instead of U-weirs in rivers with bankfull widths greater than 100 feet.

- "According to the APA (page 14), grouted rock riprap is the preferred option and, in order for successful installation, some level of dewatering will need to occur. Dewatering discussed on page 15, is anticipated to involve the construction of temporary cofferdams directly upstream of the weir or upstream of the BNSF bridge. As the south BNSF pier has historically experienced settlement issues and continues to be monitored regularly for settlement, installation of cofferdams near our foundations pose concern."

  Dewatering will be necessary in order to properly construct the grouted rock weir, and it will undoubtedly be difficult. The dewatering plan will be fully developed during final design, depending on which alternative is selected. We will work closely with BNSF to ensure that the proposed location and methods of dewatering do not pose a risk to the piers on the railroad bridge.

- "Has a detailed hydraulic study been performed to determine the backwater effects, if any, associated with the construction of the alternatives other than alternative 5? If so, what are those impacts?"

  We have developed a model of the W-weir using HEC RAS. Comparing water surface elevations and velocities with the W-weir installed against the proposed conditions with the permanent bank stabilization installed, shows a negligible increase in backwater and little change in velocity. See the table above.

- "We understand from page 14 that loose rock is not preferred due to potential damage caused by ice. Has the likelihood of damage to a grouted rock alternative been evaluated? Specifically, could damage resulting from ice impact cause flow to be detrimental to stream bank stability?"

  We feel that damage from ice jamming would be less likely to occur with a grouted rock alternative than with a "loose rock" alternative. The banks in the vicinity of the intake are or will be heavily armored. This will mitigate against damage from ice impact.

- Have the ultimate limits of sediment excavation underneath the BNSF bridge and Highway 212 bridge been defined? If so, what are the limits and what time frame has been set for this removal?

A portion of this sediment was removed in March 2013 (approximately 6,000 CY). The extent of removal, if this is selected as part of the long-term solution, will depend on the water level at the time of construction.

Todd Tillinger and Shannon Johnson, U.S. Army Corps of Engineers

- 1) "Our understanding of the problem currently at Laurel is that the existing intake during low flows does not have the designed water surface elevation 0.3 feet of "cover" over it. It is our understanding based on information from the City that the lack of cover during low flows is an issue to the intake although the extent, severity, and probability of the issues are not identified in the report."

  The current problem with the intake at Laurel is more clearly explained in the paragraphs below. On page 2 of the report it states, "A water surface elevation of 3260.7 (NAVD88), which is 0.3' below the top of the intake structure, must be maintained in order for the intake to function as designed." The top of the concrete lid on the intake is set at approximately elevation 3261. Therefore, the design low water stage of the river (3260.7) is 0.3' below this elevation. Refer to Appendix H of the report for an excerpt from the design plans for the intake, which give the design criteria and other pertinent data.

  The intake is passive and does not "suck" water from the river. Water flows by gravity from the intake screens, through two 24" diameter pipes, and then enters a manifold in the pump building where it is then pumped by a series of vertical turbine pumps to the water treatment plant and the CHS refinery. In order for the pumps to operate and avoid cavitation, a certain Net Positive Suction Head (NPSH) must be maintained and is directly related to the water surface elevation at the pumps. Cavitation results in reduced operational capacity and even damage to the pumps.

  The pumps were designed so that when the water surface elevation in the river is 3260.7 or greater, there is sufficient NPSH for the pumps to operate. Hydraulic modeling of existing conditions with the permanent bank stabilization installed for a flow of 700 cfs (which was recommended as the design low flow in Appendix A of the 2000 COE report) shows the water surface elevation at the intake would be 3259.25 (NAVD88); that is nearly 1.5 feet below the design low water stage.

- "Based on the report, alternatives 6, 7, and 8, address the alternative 4b above which would of lower the intake to regain the 0.3 feet of cover under the existing scour conditions. However, we don't believe they were evaluated independently to solve the problem. It appears that they were automatically placed as potential secondary alternatives to the solutions in 4a and only in combination with alternatives 2 and 3. We believe that these alternatives were not sufficiently evaluated independently."

  Alternatives 6, 7, and 8 would not solve the identified problem independently, and therefore, were evaluated as secondary alternatives. The following is a quote from the Alternatives Prescreening Analysis, page 22:

"The establishment of the design low water surface elevation is a function of the depth of water required over the screens, but more importantly, it is a function of the hydrostatic head required at the pumps in the WTP in order for them to maintain suction without cavitating. This is pointed out to show that lowering the screens does not, in and of itself, restore complete function to the intake because it does nothing to raise the water surface relative to the pumps. Therefore, lowering the screens should be combined with other alternatives which act to maintain the required water surface elevation at the intake."

- Clearly alternatives, 9, 12, 13, 18, and 19 could be incorporated into any combination of alternatives considered under 4b above. It is also apparent that utilizing the original intake has not been included in this report.

  It would not be an effective solution to use alternatives 8, 12, 13, 18, and 19 in combination with alternatives considered under 4b (Alternatives 6, 7, and 8). We hope that the response above helps to clarify this point by more clearly describing the problem.

  Alternatives 6, 7, and 8 all result in the lowering of the intake screens. However, since the intake is passive, lowering the screens would do nothing to raise the water surface and increase the NPSH at the pumps. The primary benefits of lowering the screens would be to make them less susceptible to clogging by frazil (slush) ice and to provide a sufficient depth over the structure for the safe passage of recreational traffic.

  In March of this year, the City, in an effort to prepare for low flows through the winter, constructed a temporary diversion ditch to the old intake. The problems with the original intake, which led in part to the construction of the new intake were reconfirmed. The necessary maintenance schedule to keep the old intake operating in both summer and winter would not be possible to keep up on a regular basis. Through inspection related to the ongoing construction of the temporary diversion ditch, the City has found that there are fine screens in the old intake structure that are intended to screen fish and aquatic plant material. Based on the historic use of the structure, the screens require manual cleaning every four to six hours. This requires that personnel enter the structure to raise the screens and manually clean them off. During the winter, the old intake requires constant maintenance to prevent slush ice from building up and entering the pumping facility. There are even historic instances of the interior chambers of the old intake freezing solid, and that was when the main river channel surrounded the structure. Now that the old intake is "high and dry" (with the exception of the temporary diversion ditch), it is even more likely that it could freeze solid during the winter. The City is unable to meet the required maintenance schedules on a regular or permanent basis, and the tasks introduce personnel to unacceptable safety risks too frequently.

  The following is a quote from Kurt Markegard, City of Laurel Public Works Director,

> ***"In the 1960's an employee broke a leg cleaning the old intake. Also, every winter the city hired divers to install a perforated pipe into the river connected to the old intake. This was then removed every spring. This pipe was also easily damaged if hit be ice. It also required head pressure in order for this winter line to work. This head pressure was tied directly to water surface elevation which we no longer have after the 2011 flood and scour."***

Again, we appreciate your input as this process moves forward. We will continue to strive to develop and alternative or a combination of alternatives that balances risk and environmental impact, while still ensuring a reliable supply of water for the residents and businesses of the City of Laurel, as well as the CHS refinery.

The on-site meeting is scheduled for Tuesday, April 30, from 11:00 a.m. to 1:00 p.m. We hope that you are able to attend. In the meantime, please don't hesitate to contact me with any questions or concerns.

Distribution:

Tom Barnard, DHS/FEMA
Steve Hardegen, Regional Environmental Officer, DHS/FEMA
Darin Swenson, Yellowstone County Floodplain Administrator
Todd Tillinger, State Program Manager, U.S. Army Corps of Engineers
Shannon Johnson, U.S. Army Corps of Engineers
Jeff Ryan, Environmental Science Specialist, Montana Department of Environmental Quality
David Leitheiser, Billings District Hydraulic Engineer, Montana Department of Transportation
Stefan Streeter, Billings District Administrator, Montana Department of Transportation
Randy Roth, Montana Department of Transportation
Ken Frazer, Fisheries Manager, Montana Fish, Wildlife, & Parks
Jim Berkley, Water Resources Engineer, U.S. Environmental Protection Agency
Jim Boyd, U.S. Fish & Wildlife Service
Damon Murdo, Cultural Records Manager, State Historic Preservation Office
Ronald G. Berry, Director of Bridge Engineering, BNSF Railway
Kasie Holle, Mgr. Structures Design, BNSF Railway
Erich Schmitz, TranSystems
Tim Thennis, MT DES
Jeff Bollman, Planner, Montana Department of Natural Resources & Conservation
Martin P. Miller, Montana Natural Heritage Program
Sam Johnson, Regional Engineering Specialist, Montana Department of Natural Resources & Conservation
Elizabeth Ching, Economic Development Director, Sen. Baucus
Rachel Court, Regional Director, Sen. Tester

cc:

City of Laurel
Chad Hanson, Great West Engineering
Jeremiah Theys, Great West Engineering
Jonathan Weaver, Great West Engineering
Project File

AGENCY RESPONSES

February 27, 2013

Jeremiah Theys, PE
Great West Engineering
P.O. Box 4817
Helena, MT 59604

Dear Mr. Theys:

I have reviewed the City of Laurel Water Treatment Plant Intake Feasibility Study, Alternatives Preliminary Screening Analysis for Yellowstone County Floodplain (YCF) and the following are the comments that YCF has:

It appears that the analysis done on each of the proposals was very thorough.

From a floodplain standpoint, YCF does not endorse one proposal over another. The only things that YCF would require are:

1. Whichever proposal is selected, Great West Engineering will be able to state that in their professional opinion the selected proposal will not raise the Base Flood Elevation (BFE).

2. All required permits are obtained prior to starting any work in the floodplain.

3. Great West Engineering will be able to state that in their professional opinion that there will be no adverse impacts either upstream, downstream, or across from the project area.

If you have any questions, please feel free to contact YCF either via phone (406) 256-2735 or email pubworks@co.yellowstone.mt.gov.

Sincerely yours,

Darin Swenson EI, CFM
Yellowstone County Public Works Department

March 5, 2013 Jeff Ryan, DEQ

Comments:

Subject: “City of Laurel Water Treatment Plant Intake Feasibility Study – Alternatives Preliminary Screening Analysis” Great West Engineering - February 25, 2013 Analysis

I would like to commend Great West Engineering for their comprehensive analysis of the issues surrounding the City’s water intake and the analysis of the potential alternatives to consider for a long-term solution at the site. The problems at the site are certainly not new. Attached is a 2002 violation letter from DEQ that in part led to the construction of the new intake in 2003, that is now not functioning properly. The point being - there may not be a solution at this site that is truly “long-term”.

The river at this site is unstable due primarily to the highway and railroad bridge constrictions in the floodplain. The constrictions cause a backwater effect upstream of the bridges and that in turn causes the river to deposit large woody debris and bedload, which contributes to excessive lateral migration of the river. Without a substantial increase in bridge lengths (unlikely to occur due to surrounding infrastructure) this situation will continue.

19 alternatives were examined in the subject document and most were deemed infeasible, except for alternatives 2, 3 and 14 which all involve a “weir” like large rock feature in the river. Unfortunately, in my opinion, the use of weirs in large unstable river channels that carry substantial large woody debris and bedload with additional “ice jam” issues, provide too much uncertainty and risk to be considered. The initial construction costs and long-term main costs are also a major issue to consider with these structures.

The subject document does note that in 2002 comments from USFWS, there was a recommendation to consider a “W-weir” at the site and quotes Dave Rosgen on design specifics. At the time, Rosgen was providing extensive training sessions in Montana and they all suggested the utility of rock weirs for river training purposes. Although, at the time, few if any, had been installed in the state. Since then, several weir like structures have been installed on Montana rivers with mixed results.

Probably the most notable is the “Tucker Split” a large weir structure on the Bitterroot River just south of Tucker crossing. The intent was to split east and west flow channels of the river to provide a measured flow to an irrigation ditch. Almost immediately the structure caused an accumulation (thousands of cubic yards) of bedload material, completely burying the structure and resulted in unacceptable river migration away from the irrigation ditch. Further down river on the east split channel of the Bitterroot, a weir was installed by Rosgen for an irrigation diversion. That weir did function properly, but was installed in a stable segment of river with little bedload movement. Just north of Hamilton on the Bitterroot River at Blodgett Park a couple weirs were installed – they too were immediately buried by bedload, but may have contributed to some stability of the river.

A newer weir on the Boulder River near Big Timber is functioning okay to divert water to an irrigation canal. However, that segment of river is stable and pretty efficient at transporting bedload.

Recently, a weir like structure was constructed on a stable segment of the Big Hole River to provide a diversion for one of Butte's major drinking water supplies. The structure is functioning okay relative to transporting bedload down river and supplying water to the pumping facility, but at certain water flows is a hazard for recreation boater use.

Maintenance is a major issue with weir structures. In Missoula, the "Brenan's Wave" weir structure is currently considering major expensive re-grouting of large rock that was installed several years ago in that irrigation diversion. The "Intake" straight weir, near Glendive, noted in the subject document, actually has a tram system to continually supply more large rock to the weir that dislodges annually. Fish and boater passage is also a major problem at this site.

The bottom line is - these type of structures are very risky. In unstable systems that carry excessive bedload and large woody debris, coupled with the potential for ice jams, present considerable uncertainty and risk. Also, in consideration of long-term maintenance issues (grouted or un-grouted rock) and possible fish and boater passage problems, the use of weirs, or any in-stream river training structure, should probably not be considered.

Of all the longer-term alternatives presented, alternative # 14 (holding pond) may warrant further consideration - without the proposed W-weir. As previously noted, the weir structure is very risky, but perhaps analyzing some alternative water delivery systems to the pond at (site alt. #1) is appropriate. A structure or series of structures similar to the "Ranney well" (or a type of infiltration gallery) positioned on the river's edge along the river side of the pond's perimeter might work. Or perhaps a portable pump system, similar to that which some major irrigators now use to "chase" water in unstable river segments might be worthy of consideration. The pond could be sized to provide a buffer for peak water use and during low use time periods, the pond could be refilled from a delivery system that doesn't have to match the peak water use limits.

One last consideration for perhaps the short-term, before trying any long-term approaches, would be a series of things. First, would be to see if the existing historic water intake could be re-activated at minimal expense. When the new intake was constructed in 2003 I thought the plan was to keep the old intake functional as a back-up or if the river channel moved back in its direction. Currently, that intake is in a major bedload deposition area, but if at least some of that material was removed, that intake could help contribute to water supply.

The removal of some of the bedload deposition under the bridge on the north side of the river should be considered, at least incrementally, to monitor how the river might react to that change. Ordinarily, that approach is not considered feasible, because of the river's ability to redeposit extraordinary amounts of bedload in short periods of time is a concern. However, the 2011 event was a major uncommon event and to a degree the river will need time to process the bedload associated with that event. Calculated manipulation of the north side bedload, in conjunction with the proposed bank work at Riverside Park will somewhat mimic the situation that allowed the newer intake to function from 2003 to 2011. Again, monitoring that response should be considered before contemplating further expensive risky options.

Thank you for the opportunity to respond. I wish there were more perspectives to offer on a long-term solution at this site, but it is undoubtedly a very difficult site. It has been suggested that a multi-interest/agency meeting might be considered to discuss issues – I would endorse that idea and offer to participate in those efforts.

Montana Department of
ENVIRONMENTAL QUALITY

Judy Martz, Governor

P.O. Box 200901 • Helena, MT 59620-0901 • (406) 444-2544 • www.deq.state.mt.us

November 19, 2002

John E. Johnson Jr.
Mayor, Laurel
P.O. Box 10
Laurel, Mt. 59044

Subject: Montana Water Quality Act Violation Yellowstone River CVID# 2982

Dear Mr. Johnson:

On Monday, November 18, 2002, I and several other regulatory agency personnel met with Mr. Larry McCann and Mr. Gay Easton in Helena to discuss the circumstances relating to the recent unauthorized river activity by the City of Laurel. At this meeting I indicated I would request, based on the on-going history of Montana Water Quality Act violations by the city at the site, more formal enforcement by the Montana Department of Environmental Quality's (DEQ) Enforcement Division.

My request would involve having the Enforcement Division send what we refer to as a "611" letter to the City of Laurel. The letter identifies a specific penalty and a deadline for compliance with the violation that if not met, would result in levying the noted fine against the city. My recommendation to the Enforcement Division would be to calculate a penalty based on days of violation starting November 4, 2002 (when the river work commenced) through February 28, 2003 when reclamation of the river impacts is anticipated to be completed. This would involve over one hundred days of violation/penalty calculation. The daily penalty amount is calculated by a formula the Enforcement Division applies on a case-by-case basis, but can involve several thousands of dollars per day in penalty. If however, the deadline to reclaim the river damage is met, no penalty is levied. Some flexibility on extending the compliance deadline may be considered, based on unanticipated weather conditions at the site

Do not hesitate to contact me if you have any questions 444-4626 or jeryan@stae.mt.us.

Sincerely,

Jeff Ryan
Water Quality/Wetland Specialist

cc: Allan Steinle, COE Kris Knutson, EPA Glenn Phillips, FWP
Ed Thamke/Bonnie Lovelace, DEQ

Jonathan Weaver

From: Jeremiah Theys
Sent: Wednesday, March 06, 2013 2:11 PM
To: Jonathan Weaver; Ryan Holm
Cc: Heidi Jensen; Kurt Markegard
Subject: Fwd: Laurel Preliminary Screening Analysis

FYI

Sent from my iPhone

Begin forwarded message:

From: "Barnard, Thomas" <Thomas.Barnard@fema.dhs.gov>
Date: March 6, 2013, 2:03:09 PM MST
To: Jeremiah Theys <jtheys@greatwesteng.com>
Cc: "Lucas, David" <David.Lucas4@fema.dhs.gov>, "Hardegen, Steven" <Steven.Hardegen@fema.dhs.gov>
Subject: RE: Laurel Preliminary Screening Analysis

I spent the morning reviewing your preliminary screening analysis. It is well done and I am not aware of any other potential alternatives.
It will be interesting to see the responses from the various Regulatory Agencies. Their responses may identify other possible alternatives but may also eliminate some of those you have identified for further evaluation.
As the process continues we must always keep in mind that the selected alterative must be of reasonable cost, must be cost effective, and that potential FEMA funding is limited to only those costs that are necessary to restore the function of the intake to pre-disaster design, function, and capacity. I think you are aware of this but thought it best to bring it up again. I mention this because the City needs to be aware that one proposed add on to the alternatives, the hot water system identified in #10, is very likely not eligible for FEMA funding because it is not needed as a result of the disaster and was not a part of the pre-disaster design, function, or capacity. That does not mean that it can't be a part of the final selected alternative, only that the associated costs would be the responsibility of the City.

I look forward to bringing this to a final conclusion that is acceptable to FEMA and will resolve this problem once and for all for the City.

At this point in time I don't see the need for a face to face meeting with all involved parties, however, if others feel it is necessary I am sure that FEMA would participate.

From: Jeremiah Theys [mailto:jtheys@greatwesteng.com]
Sent: Monday, March 04, 2013 3:52 PM
To: Lucas, David; Hardegen, Steven; Barnard, Thomas
Cc: Heidi Jensen
Subject: Laurel Preliminary Screening Analysis

Attached please find the Preliminary Screening Analysis for a long-term solution for water at the City of laurel.

Thanks,

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Montana Department of Transportation

2701 Prospect
PO Box 201001
Helena MT 59620-1001

Michael T. Tooley, Director
Steve Bullock, Governor

RECEIVED
MAR 8 2013
Great West

March 6, 2013

Jeremiah Theys, PE
Project Manager
PO Box 4817
Helena MT 59604

Subject: MDT's Response to 'City of Laurel Water Treatment Plant Intake Feasibility Study Alternatives Preliminary Screening Analysis'

Jeremiah,

Thank you for the opportunity to review and comment. Our comments are limited to the three primary and three secondary alternatives identified for further study. The following are MDT's comments on these selected primary and secondary alternatives:

Primary Alternatives # 2 and 3. The construction of a weir across the Yellowstone River at the location shown would likely require additional armoring to prevent flanking of the weir ends. This armoring would likely be into the river banks and/or extend into the upstream structures (MDT's bridge abutment riprap).

Please provide information on how any construction would involve the bridge abutment riprap; ongoing design coordination is requested. We would like to see the modeling that evaluates the impacts to the bridge (WSE, water velocities, etc.) to compare with the original bridge design parameters.

Primary Alternative # 14. No comments.

Secondary Alternative # 4. This comment is to similar to MDT's previous comments about temporary work and construction near the bridge piers, abutments, and riprap. Please coordinate closely with MDT as to construction limits, excavation depths, etc. to prevent any potential damage to this vital infrastructure component.

Secondary Alternatives # 8 and 10. No comments.

General. Please keep MDT informed as to which final Primary and Secondary Alternatives are selected and their construction dates and schedules. Please keep MDT informed of any meetings that may arise. Please notify MDT and allow further comments if any of the other alternatives are selected or new alternatives are advanced.

Thanks again for the opportunity to review and comment.

David A. Leitheiser

David A. Leitheiser, P.E.
MDT-Highways Bureau-Hydraulic Section
Billings District Hydraulic Engineer
(406) 444-7225 | dleitheiser@mt.gov

cc: Stefan Streeter, P.E., Billings District Administrator
Mark Goodman, Hydraulics Engineer
Paul Ferry, P.E., Highways Engineer
Randy Roth, Billings District Maintenance
Gary Neville, District Preconstruction Manager

From: Jeremiah Theys
Sent: Monday, March 11, 2013 3:09 PM
To: Jonathan Weaver
Subject: Fwd: Laurel water intake feasability study

Sent from my iPhone

Begin forwarded message:

> **From:** "Frazer, Ken" <kfrazer@mt.gov>
> **Date:** March 11, 2013, 2:49:56 PM MDT
> **To:** "jtheys@greatweateng.com" <jtheys@greatweateng.com>
> **Cc:** "Shannon Johnson (shannon.l.johnson@usace.army.mil)" <shannon.l.johnson@usace.army.mil>, "Ivie, LaVerne" <livie@mt.gov>
> **Subject: Laurel water intake feasability study**
>
> Jeremiah,
>
> I reviewed your preliminary screening analysis for the Laurel water intake project and think you did a very good job reviewing the different alternatives. I was disappointed that all the alternatives that made the final list include some kind of weir across the entire river. From a fish and wildlife standpoint alternative 14 would be the most acceptable of the selected alternatives. Even though it still includes a w-weir I think the location of this weir would have less impact than a structure right below the bridges as proposed in alternatives 2 and 3. Any structure across the river is going to slow flows and cause deposition upstream of the structure. We are already having serious problems with sediment deposition under the bridges. If a structure causes the river to aggrade in the vicinity of the bridges it will put more pressure on the river to migrate laterally which I would expect to greatly increase pressure against the railroad and roadway on the south side of the river. Another concern with constructing any type of weir in this section of the river would be ice jamming. This section of river is already prone to some serious ice jams. Building any structure across the river here could increase the potential of large ice jams forming which could potentially push the river out of its natural channel, flooding the water treatment plant if not even more of Laurel, and potentially pushing major flows down the Canyon Creek or BBWA ditch during the middle of winter.
>
> From both a permitting and a fisheries and recreational standpoint I do not feel alternative 3 is a feasible alternative. Putting another "dam" across the Yellowstone River is not acceptable. We are already spending a lot of time, money and effort working on fish passage and boat passage issues at most of the existing diversion dams across the Yellowstone further downstream. As part of the permitting process any structure built across the Yellowstone River, whether it is a straight or w-weir, is going to have to be designed to accommodate fish passage and to allow safe up and downstream passage of both jet boats and floaters. Based on work with the diversion structures further downstream in the Yellowstone, once you start designing in fish and boat passage I would expect the cost of this alternative to be much higher than your preliminary estimates.
>
> Alternative 2 with the w-weir combined with replacing the existing screens with half-round screens would be more acceptable than alternative 3 because it may be easier to incorporate fish and boat passage into a w-weir than into a "dam". Again, passage would be a requirement in getting this project permitted and this could increase costs significantly from your initial estimates. I would much rather see

a non-grouted rather than a grouted structure built, but I don't know how easy it would be to keep any structure in place with the scour and icing that occurs in this section of river. As indicated above, any type of weir should be designed to allow as much natural sediment movement as possible past the structure. Removing the sediment from under the north side of the bridges (alternative 4) could provide a short term benefit with limited environmental impacts, but it is likely sediment will redeposit in this same area in the future, especially if a weir is constructed downstream.

Thank you for the opportunity to comment on this initial screening and I will continue to work with you in the future as you refine your alternatives.

Ken Frazer
Regional Fisheries Manager
Montana Fish, Wildlife and Parks
2300 lake Elmo Drive
Billings, MT 59105
(406) 247-2961

Jonathan Weaver

From: Jeremiah Theys
Sent: Tuesday, March 12, 2013 4:27 PM
To: Jonathan Weaver
Subject: FW: Laurel MT WTP Prescreening Analysis - BNSF comments (0005-514.15)

Jeremiah Theys, PE

Great West Engineering, Inc.
Direct: 406-495-6193
Cell: 406-431-6650
jtheys@greatwesteng.com

-----Original Message-----
From: Berry, Ronald G [mailto:Ronald.Berry@BNSF.com]
Sent: Tuesday, March 12, 2013 4:14 PM
To: Jeremiah Theys
Cc: 'egschmitz@transystems.com'; Knutson, Cory C; Holle, Kasie C
Subject: Laurel MT WTP Prescreening Analysis - BNSF comments (0005-514.15)

Mr. Theys,

BNSF Railway Company has performed a preliminary review of the Alternatives Prescreening Analysis (APA) and has some initial questions and concerns in regards to the alternatives presented. These questions and concerns are not intended to be the extent of our comments as we are aware that the plan is currently in the conceptual phase. As the plan continues to be refined, BNSF anticipates additional questions and comments in regards to the long-term stability and safety of our adjacent railway bridge.

The questions and comments we have to date are the following:

In Alternative 2, is the intent of the construction to promote two low flow channels through the existing highway and railroad structures?

According to the APA (page 14), grouted rock riprap is the preferred option and, in order for successful installation, some level of dewatering will need to occur. Dewatering discussed on page 15, is anticipated to involve the construction of temporary cofferdams directly upstream of the weir or upstream of the BNSF bridge. As the south BNSF pier has historically experienced settlement issues and continues to be monitored regularly for settlement, installation of cofferdams near our foundations pose concern.

Has a detailed hydraulic study been performed to determine the backwater effects, if any, associated with the construction of the alternatives other than alternative 5? If so, what are those impacts?

We understand from page 14 that loose rock is not preferred due to potential damage caused by ice. Has the likelihood of damage to a grouted rock alternative been evaluated? Specifically, could damage resulting from ice impact cause flow to be detrimental to stream bank stability?

Have the ultimate limits of sediment excavation underneath the BNSF bridge and Highway 212 bridge been defined? If so, what are the limits and what time frame has been set for this removal?

We think that the proposed face-to-face meeting with the stakeholders and agencies is important, and we plan on attending. We feel it will be an important start in our process to understand and feel comfortable with the potential impacts to our bridge.

I appreciate the opportunity to meet with you face to face and discuss these initial concerns. Please provide details of the meeting arrangements.

Regards

Ron Berry, P.E.
Director Bridge Engineering
BNSF Railway
913-551-4164

Jonathan Weaver

From: Holle, Kasie C [Kasie.Holle@BNSF.com]
Sent: Friday, May 24, 2013 4:49 PM
To: Jonathan Weaver; Jeremiah Theys
Cc: Leitheiser, David; Schmitz, Erich (TranSystems); Holle, Kasie C; Berry, Ronald G
Subject: City of Laurel Alternative Discussion (0005-514.15)

Jeremiah and Jonathan;

We appreciated the opportunity to meet with you and discuss the significant challenges associated with the work in Laurel. We'd also like to thank you for supplying additional information as follow-up.

From the BNSF's perspective, we certainly want to see the city have reliable access to the water they need. In reviewing the alternatives and following the site visit, we prefer alternatives that do not involve river training structures adjacent to the bridges.

As per our conversation on-site, we would request the opportunity to review both the hydraulic model and the recently collected underwater survey data. Assuming the W-Weir is the City's preferred option, BNSF is still concerned with the potential impact this construction could have on our operations. Specifically, our concerns are with the potential increase in ice jamming severity and frequency, potential for additional sediment and debris accumulation within our bridge opening, and potential for unintended post-construction vertical/lateral stream instabilities issues. We understand that the submittal we commented on was generally focused on the evaluation of alternatives and we assume that, as the process progresses, subsequent agency submittals will contain more detailed performance evaluations.

We can appreciate the City's desire to keep the project moving and work their way through the permitting process as quickly as possible. We will respond in a timely manner to any questions, comments, or requests that you have.

Please feel free to give me a call if you have any questions.

Kasie C. Holle | BNSF Railway | Mgr. Structures Design | ✉ kasie.holle@bnsf.com | ☎ (913) 551-4060 | ☎ (806) 543-4328 cell

Jonathan Weaver

From: Jeremiah Theys
Sent: Wednesday, March 20, 2013 11:37 AM
To: Jonathan Weaver
Subject: Fwd: Laurel WTP Intake Feasibility Study Comments

Sent from my iPhone

Begin forwarded message:

> **From:** "Bollman, Jeff" <jbollman@mt.gov>
> **Date:** March 20, 2013, 11:24:06 AM MDT
> **To:** Jeremiah Theys <jtheys@greatwesteng.com>
> **Subject: Laurel WTP Intake Feasibility Study Comments**
>
> Mr. Theys:
>
> Thank you for the opportunity to review the City of Laurel WTP Intake Feasibility study and provide comments.
>
> As you are aware, the State of Montana claims ownership of the riverbed of the Yellowstone River as well as any islands that form out of the Yellowstone. The comments provided are therefore given from that perspective. The preference of the DNRC would be the selection of an alternative that would have a minimal amount of impact to this reach of the Yellowstone that has seen more than its fair share of activity between the low water marks the last few years. This activity has not only related to the city of Laurel's water intake issues, but also the removal of abandoned natural gas and petroleum pipelines that became exposed during the floods of 2011. Based on the alternatives identified for further study, it would seem that Alternative 14 would have the least impact to the state ownership and therefore the preferred alternative.
>
> Alternative #4 will require some additional internal discussions within DNRC regarding its feasibility since it is proposing to entirely remove a forming state-owned island. As you know, the DNRC issued a Land Use License to the City of Laurel in late 2012 to allow some of this sediment to be removed, but it still left the "footprint" of the formation intact. If this secondary alternative is critical to the success of the primary alternatives that it is attached, it may be beneficial for Great West and the DNRC to sit down and discuss this alternative further.
>
> Any alternative that would require a physical occupation of the river between the low water marks, either temporary or permanent, would require obtaining an easement and/or license from the DNRC.
>
> Please feel free to contact me with any questions.
>
> Cordially,
> Jeff
>
> Jeff Bollman, AICP
> Planner
> Southern Land Office

MT Dept of Natural Resources & Conservation
1371 Rimtop Drive
Billings, MT 59105
406.247.4404 (Phone)
406.247.4410 (Fax)

United States Department of the Interior

Fish and Wildlife Service

Ecological Services
Montana Field Office
585 Shepard Way, Suite 1
Helena, Montana 59601-6287
Phone: (406) 449-5225 Fax: (406) 449-5339

File: M29 (I)   March 26, 2013

Jeremiah Theys, P. E.
Project Manager
Great West Engineering, Inc.
2501 Belt View Drive
Helena, MT 59601

Dear Mr. Theys:

This letter is in response to your February 25, 2013 letter requesting U.S. Fish and Wildlife Service (Service) comment on the City of Laurel Water Treatment Plant Intake Feasibility Study. The letter was accompanied by the City of Laurel Alternatives Prescreening Analysis (Analysis). The Analysis includes numerous alternatives, all of which are proposed to restore function to the existing intake or identify other means to ensure the long-term viability of the City of Laurel water supply. Your letter was received at our office on February 27, 2013.

We offer the following comments under the authority of and in accordance with the Migratory Bird Treaty Act (MBTA; 16 U.S.C 703 et seq.), as amended, Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668-668d, 54 Stat. 250), as amended, Executive Order 13186 *Responsibilities of Federal Agencies to Protect Migratory Birds*, Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.) as amended, and the Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq*.).

The Analysis appears to present a reasonable range of alternatives addressing the City of Laurel water intake issues, including a "W" weir as recommended by the Service in 2002. Any alternative chosen (and associated structures) should accommodate fish passage for all Yellowstone River species and all life stages. The chosen alternative should also not entrain fish, by including screened intakes or similar structures. In addition, any new structures should not promote scour in areas traversed by buried pipelines.

Given the proposed project location, scope of work, and alternatives described in your letter and accompanying materials, we do not anticipate adverse effects to threatened, endangered, or candidate species or critical habitat to result from proposed project implementation at the proposed site. Bald and golden eagle nest territories have not been documented within a mile of the proposed project area. If eagle nests are observed in proximity of the project area, we highly recommend that you coordinate with Montana Fish, Wildlife & Parks at 1420 East Sixth Ave., P.O. Box 200701, Helena, MT 59620-0701, 406-444-2535, prior to initiating project construction. Should occupied eagle nests occur within 0.5 mile of the proposed site, we would advise that you comply with the recommended temporary seasonal and distance constructions buffers stipulated in the *2010 Montana Bald Eagle Management Guidelines: An Addendum to*

Montana Bald Eagle Management Plan (1994).
Other recommendations include the following:

- If work is proposed to take place during the breeding season and may result in take of migratory birds, their eggs, or active nests, the Service recommends that the project proponent take all practicable measures to avoid and minimize take, such as maintaining adequate buffers, to protect the birds until the young have fledged. Active nests may not be removed.

- We recommend that any new power lines be buried where possible. To minimize the electrocution and collision hazards to birds, we recommend that any proposed newly constructed overhead power lines be designed and built to the APLIC standards in *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* and *Reducing Away Collisions with Power Lines: The State of the Art in 2012*.

- We recommend coordination with Montana Fish, Wildlife & Parks and the Montana Natural Heritage Program, 1515 East 6th Avenue, Box 201800, Helena, MT 59620-1800, 406-444-5354. Both of these agencies may be able to provide updated, site-specific information regarding eagle and other raptor nests, as well as all other fish, wildlife, and sensitive plant resources occurring in the proposed project areas.

The Service appreciates your efforts to incorporate fish and wildlife resource concerns, including threatened and endangered species, into your project planning. If you have questions or comments related to this issue, please contact Jim Boyd at 406-449-5225, extension 216.

Sincerely,

Brent Esmoil
Acting Field Supervisor

From:	Jeremiah Theys
Sent:	Wednesday, March 13, 2013 1:48 PM
To:	Jonathan Weaver; Ryan Holm
Cc:	Kurt Markegard
Subject:	Fwd: Alternatives - Laurel (UNCLASSIFIED)

Sent from my iPhone

Begin forwarded message:

> **From:** "Tillinger, Todd N NWO" <Todd.N.Tillinger@usace.army.mil>
> **Date:** March 13, 2013, 9:58:43 AM MDT
> **To:** Jeremiah Theys <jtheys@greatwesteng.com>
> **Cc:** "Johnson, Shannon L NWO" <Shannon.L.Johnson@usace.army.mil>, "LaGrone, David L NWO" <David.L.Lagrone@usace.army.mil>, Ryan Holm <RHolm@greatwesteng.com>, Heidi Jensen <hjensen@laurel.mt.gov>, "Barnard, Thomas (Thomas.Barnard@fema.dhs.gov)" <Thomas.Barnard@fema.dhs.gov>, "Ryan, Jeff" <jeryan@mt.gov>, "Darling, Jim" <jdarling@mt.gov>
> **Subject: Alternatives - Laurel (UNCLASSIFIED)**
>
> Classification: UNCLASSIFIED
> Caveats: NONE
>
> Jeremiah,
>
> We received your Alternatives/Feasibility Study for the City of Laurel Water Intake late in February, and noted that you expected comments no later than 12 March 2013. The Corps Regulatory Program is still reviewing the 19 alternatives presented in the document. Because of the number and scope of the range of alternatives, we have been unable to complete our review at this time and are presently unable to provide comments yet as they relate to the Corps Regulatory Program. However, the Corps does have comments regarding alternatives and will provide them when our review is complete.
>
> As you know, in accordance with the 404(b)(1) Guidelines the Corps can only permit the least environmental damaging practicable alternative (LEDPA) on the River. The practicability test considers the cost, logistics, and technology available to the Applicant. Please understand that cross-channel structures on the interstate and navigable Yellowstone River are among the least permittable types of structures, and from a permitting standpoint they should represent the last possible courses of action and not the preferred alternative, especially when there are alternatives that would result in less adverse impact on the Yellowstone River.
>
> We look forward to responding with more focused and specific comments in the coming weeks; until then, thank you for your patience and please let myself or Shannon Johnson know if you have questions.
>
> Todd N. Tillinger, P.E.
> Montana Program Manager

US Army Corps of Engineers
Omaha District - Regulatory
10 West 15th Street, Suite 2200
Helena, Montana 59626

Phone 406-441-1376
Blackberry/Cell 406-422-7527
Fax 406-441-1380

http://www.nwo.usace.army.mil/Missions/RegulatoryProgram/Montana.aspx

Classification: UNCLASSIFIED
Caveats: NONE

Comments on February 26, 2013 letter and report from Great West Engineering concerning the Laurel Water Intake

The report does not follow a typical format for this level of study. A typical study would:

1) identify the issues and problem Identification,
2) specify the goals and objectives,
3) establish criteria for evaluation of alternatives,
4) identify the potential alternatives,
5) evaluate all the alternatives based on the same established criteria
6) select the best alternatives for further study.

However, based on the information in the report and the Corps Regulatory Branches knowledge of the situation at Laurel we can provide the following comments.

1) Our understanding of the problem currently at Laurel is that the existing intake during low flows does not have the designed water surface elevation 0.3 feet of "cover" over it. It is our understanding based on information from the City that the lack of cover during low flows is an issue to the intake although the extent, severity, and probability of the issues are not identified in the report.

2) We assume that the goals and objective of the study is to develop a reliable water source for the "existing" water treatment plant.

3) The criteria for evaluation is to limit the alternatives to the existing water treatment plant, minimize the costs, minimize impacts to the environment, avoid any water rights issues, avoid any water quality issues

4) Alternatives appear to be categorized by:
    a) adjust the river to regain the 0.3 feet of cover lost due to the localized scour from the 2011 flood,
    b) modify the existing intakes to obtain the 0.3 feet of cover at low flows with the existing scour in place,
    c) obtain the water from an alternative source
    d) a combination of any of the above

5) There were 19 alternatives identified in the study however the hot water flushing system (alternative 10) is a separate issue of the existing system and existed prior to the 2011 event. While this appears to need resolution, it should not be included in this evaluation since it is not specific to the problem at hand. We do believe that the hot water flushing should be considered as a secondary item if modification of the existing intake is selected. Likewise, removal of the upstream sediment, unless it is tied to an alternative in 4a, 4b, or 4c should not be in the alternatives since it to would be a secondary item if selection of 4a, or 4b were to occur.

6) Based on the information provided, we assume that the alternatives which were evaluated under 4a above to regain the 0.3 feet of cover through river modification are alternatives, 1, 2, 3, 4, and 5. The report then concludes that only alternatives 2 and 3 would be feasible. We believe that in reality alternatives 2 and 3 are variations of the same alternative which is a low head dam across the Yellowstone River. This category of alternatives will be environmentally problematic but there might be a solution. We don't believe that this alternative has been fully evaluated.

   Based on the report, alternatives 6, 7, and 8, address the alternative 4b above which would of lower the intake to regain the 0.3 feet of cover under the existing scour conditions. However, we don't believe they were evaluated independently to solve the problem. It appears that they were automatically placed as potential secondary alternatives to the solutions in 4a and only in combination with alternatives 2 and 3. We believe that these alternatives were not sufficiently evaluated independently.

   It appears that the remaining alternatives 9- 19 (eliminating alternative 10 as discussed above) all address 4c above and provide alternative sources of water. All but one alternative was eliminated. We are concerned about the evaluation of these alternatives because most of them were developed specifically abandoning the existing intake and without allowing consideration of their use in combination with the alternatives under 4 a or 4b. Clearly alternatives, 9, 12, 13, 18, and 19 could be incorporated into any combination of alternatives considered under 4b above. It is also apparent that utilizing the original intake has not been included in this report.

In conclusion, we make the following suggestions:

1) We believe that the problem should be more clearly specified to explain the issues surrounding the lack of 0.3 feet of cover during low flows. The issues impacts to the intake, the extent, severity, and probability of the issues are not identified.
2) We believe that the sedimentation issues occurring due to the constriction of the bridges, in combination with the movable river bed and recent flood events needs to be expressed for those not necessarily experienced in these disciplines. This explanation should bring to light why the chute effect which occurs during flood events and creates deposits both up and downstream of the bridge is either localized and heals over time between flood events or is symptomatic of a greater instability problem which is occurring on a larger scale. The alternative analysis is going to hinge on this.
3) We don't believe that a complete evaluation has been completed on the alternatives presented, independently or in combination with another and we believe this should be done. We believe lowering the intake to regain the cover should be evaluated in more detail and in combination with an additional intake source. While we are interested in seeing the alternative of a diversion and holding pond evaluated, we are also interested in seeing options under 4b considered along with utilizing the original intake and/or a third intake located further southeast.

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Historic Preservation
Museum
Outreach & Interpretation
Publications
Research Center

February 27, 2013

Jeremiah Theys
Great West Engineering
P.O. Box 4817
Helena, MT 59604

RE: City of Laurel Water Treatment Plant Intake Feasibility Study
Alternatives Preliminary Screening Analysis

Dear Mr. Theys:

Thank you for the opportunity to comment on the City of Laurel Water Treatment Plant Intake Feasibility Study, *Alternatives Preliminary Screening Analysis*. It appears that the several of the proposed alternatives may have the potential to adversely affect unidentified cultural resources. Therefore, we strongly recommend that the project proponent discuss the requirements listed under Section 106 of the National Historic Preservation Act with FEMA early in the project planning process. Additionally, our office would like to receive a copy of the Draft Environmental Assessment and Feasibility Study for review and comment.

If you have any questions or concerns, please do not hesitate to contact me at (406) 444-0388 or kore@mt.gov. Thank you for consulting with us.

Sincerely,

Kathryn Ore
Review and Compliance Officer
Montana State Historic Preservation Office

RECEIVED
MAR 1 2013
Great West

File: FEMA – 2013 – 2013022604

225 North Roberts Street
P. O. Box 201201
Helena, MT 59620-1201
(406) 444-2694
(406) 444-2696 FAX
montanahistoricalsociety.org

Jonathan Weaver

From: Murdo, Damon [dmurdo@mt.gov]
Sent: Wednesday, March 06, 2013 3:00 PM
To: Jonathan Weaver
Subject: RE: SHPO File Search Request
Attachments: 2013030611.xls; CRABS.pdf; CRIS.pdf

Big Sky. Big Land. Big History.
Montana
Historical Society

March 6, 2013

Jonathan Weaver
Great West Engineering
PO Box 4817
Helena MT 59604

RE: CITY OF LAUREL WATER TREATMENT PLANT INTAKE FEASIBILITY STUDY. SHPO Project #:2013030611

Dear Mr. Weaver:

I have conducted a cultural resource file search for the above-cited project located in Sections 15, 16, 21, 22, T2S R24E. According to our records there have been a few previously recorded sites within the designated search locales. In addition to the sites there have been a few previously conducted cultural resource inventories done in the areas. I've attached a list of these sites and reports. If you would like any further information regarding these sites or reports you may contact me at the number listed below.

It is SHPO's position that any structure over fifty years of age is considered historic and is potentially eligible for listing on the National Register of Historic Places. If any structures are to be altered and are over fifty years old we would recommend that they be recorded and a determination of their eligibility be made.

If there is to be new ground disturbing activities required by this undertaking there is the potential that cultural properties may be impacted. Therefore, we would ask that an updated request be sent to our office when more detailed project alternatives have been agreed upon and precise project locations have been determined.

If you have any further questions or comments you may contact me at (406) 444-7767 or by e-mail at dmurdo@mt.gov. I have attached an invoice for the file search. Thank you for consulting with us.

Sincerely,

Damon Murdo
Cultural Records Manager
State Historic Preservation Office

File: DEQ/AIR&WATER WASTE MNG/2013

Township: 2 S Range: 24E Section: 15

LIGHT TIMOTHY

12 /19 /1990 *CULTURAL RESOURCE INVENTORY, LAUREL-BRIDGER 100 KV TRANSMISSION LINE (LBTL), YELLOWSTONE AND CARBON COUNTIES, MONTANA*

CRABS Document Number: YL 6 11928 Agency Document Number:

Township: 2 S Range: 24E Section: 15

FREDLUND LYNN B.

2 /20 /1986 *CULTURAL RESOURCE INVENTORY AND ASSESSMENT: YELLOWSTONE RIVER BRIDGE - LAUREL*

CRABS Document Number: YL 4 10689 Agency Document Number: BRF4-2(6)54

Township: 2 S Range: 24E Section: 15

GRAVES NATALIE

8 /1 /2011 *YELLOWSTONE HDD PROJECT INTENSIVE CULTURAL RESOURCE INVESTIGATION*

CRABS Document Number: YL 6 32982 Agency Document Number:

Township: 2 S Range: 24E Section: 15

MARTINSON RENEA D. ET.AL.

10 /4 /2011 *EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS*

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 24E Section: 16

GCM SERVICES INC. ANONYMOUS

1 /1 /1996 *A CULTURAL RESOURCE SURVEY & EVALUATION OF THREE ALTERNATIVE ROUTES FOR A NEW STORM DRAIN SYSTEM IN THE CITY OF LAUREL, YELLOWSTONE COUNTY, MONTANA*

CRABS Document Number: YL 4 17664 Agency Document Number: STPE 4-2(13)53

Township: 2 S Range: 24E Section: 16

PETERSON LYNELLE A.

7 /15 /1996 *ADDENDUM TO EXPRESS PIPELINE MONTANA SEGMENT*

CRABS Document Number: ZZ 2 17775 Agency Document Number:

Township: 2 S Range: 24E Section: 16

CAYWOOD JANENE M., ET AL.

1 /6 /1984 *CULTURAL RESOURCE INVENTORY BRIDGER TO LAUREL TRANSMISSION LINE PROJECT*

CRABS Document Number: CB 6 1609 Agency Document Number:

Township: 2 S Range: 24E Section: 16

FREDLUND LYNN B.

2 /20 /1986 *CULTURAL RESOURCE INVENTORY AND ASSESSMENT: YELLOWSTONE RIVER BRIDGE - LAUREL*

CRABS Document Number: YL 4 10689 Agency Document Number: BRF4-2(6)54

Township: 2 S Range: 24E Section: 16

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 21

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 21

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 21

WOOD GARVEY C. AND KATHERINE H. POLLOCK

7/15/1996 ***KROFT GRAVEL SOURCE***

CRABS Document Number: YL 4 17715 Agency Document Number:

Township: 2 S Range: 24E Section: 22

GRAVES NATALIE

8/1/2011 ***YELLOWSTONE HDD PROJECT INTENSIVE CULTURAL RESOURCE INVESTIGATION***

CRABS Document Number: YL 6 32982 Agency Document Number:

Township: 2 S Range: 24E Section: 22

VINCENT WILLIAM B., ET AL.

8/12/1978 ***CULTURAL RESOURCE SURVEY OF NE/NW SECTION 22, RANGE 24 EAST, TOWNSHIP 2 SOUTH***

CRABS Document Number: YL 6 10717 Agency Document Number:

Township: 2 S Range: 24E Section: 22

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 22

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 22

WOOD GARVEY C. AND KATHERINE H. POLLOCK

7 /15 /1996 *KROFT GRAVEL SOURCE*

CRABS Document Number: YL 4 17715 Agency Document Number:

Township: 2 S Range: 24E Section: 22

PASSMANN DORI

3 /6 /1995 *ALTMAN IRRIGATION STRUCTURE REPLACEMENT*

CRABS Document Number: YL 6 17029 Agency Document Number:

Township: 2 S Range: 24E Section: 22

LIGHT TIMOTHY

12 /19 /1990 *CULTURAL RESOURCE INVENTORY, LAUREL-BRIDGER 100 KV TRANSMISSION LINE (LBTL), YELLOWSTONE AND CARBON COUNTIES, MONTANA*

CRABS Document Number: YL 6 11928 Agency Document Number:

Township: 2 S Range: 24E Section: 22

FREDLUND LYNN B.

2 /20 /1986 *CULTURAL RESOURCE INVENTORY AND ASSESSMENT: YELLOWSTONE RIVER BRIDGE - LAUREL*

CRABS Document Number: YL 4 10689 Agency Document Number: BRF4-2(6)54

Township: 2 S Range: 24E Section: 22

MARTINSON RENEA D. ET.AL.

10 /4 /2011 *EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS*

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 24E Section: 22

CAYWOOD JANENE M., ET AL.

1 /6 /1984 *CULTURAL RESOURCE INVENTORY BRIDGER TO LAUREL TRANSMISSION LINE PROJECT*

CRABS Document Number: CB 6 1609 Agency Document Number:

Site #	Twp	Rng	Sec	Qs	Site Type1	Site Type 2	Time Period	Owner	NR Status
24YL0171	2 S	24 E	15	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24YL0663	2 S	24 E	15	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	CD
24YL0175	2 S	24 E	15	SW	Historic Vehicular/Foot Bridge	Null	1920-1930	Private	undetermined
24YL0161	2 S	24 E	15	comb	Historic Agriculture	Historic Irrigation System	Historic More Than One Decade	Private	CD
24YL0172	2 S	24 E	15		Historic Agriculture	Historic Irrigation System	1890-1899	No Data	undetermined
24YL0171	2 S	24 E	16	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24YL0663	2 S	24 E	16	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	CD
24YL1533	2 S	24 E	16	Comb	Historic Railroad, Stage Route, Travel	Null	Historic More Than One Decade	Private	CD
24YL0990	2 S	24 E	16	NW	Historic Hotel/Motel	Null	Historic More Than One Decade	Private	undetermined
24YL1799	2 S	24 E	16	NW	Historic Gas Station	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1796	2 S	24 E	16	NW	Historic Residence	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1855	2 S	24 E	16	NW	Historic District	Null	Historic More Than One Decade	Other	NR Listed
24YL1798	2 S	24 E	16	NW	Historic Hotel/Motel	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL0174	2 S	24 E	16	SE	Historic Architecture	Historic Residence	1920-1930	Private	undetermined
24YL0173	2 S	24 E	16	SE	Historic Architecture	Historic Residence	Historic Period	Private	undetermined
24YL0167	2 S	24 E	16	SE	Historic Campsite	Historic Residence	1920-1930	Private	undetermined
24YL0166	2 S	24 E	16	SE	Historic Architecture	Historic Residence	1920-1930	Private	undetermined
24YL0165	2 S	24 E	16	SE	Historic Architecture	Historic Residence	1920-1930	Private	undetermined
24YL0164	2 S	24 E	16	SE	Historic Architecture	Historic Residence	1920-1930	Private	undetermined
24YL1775	2 S	24 E	16	SE	Historic Railroad Building/Structure	Historic Architecture	Historic More Than One Decade	Private	undetermined
24YL0277	2 S	24 E	16	comb	Historic Railroad	Null	Historic More Than One Decade	Private	CD
24YL0171	2 S	24 E	21	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24YL1534	2 S	24 E	21	Comb	Historic Irrigation System	Null	Historic Period	No Data	Unresolved
24YL0170	2 S	24 E	21	Comb	Historic Irrigation System	Null	1880-1889	No Data	Ineligible
24YL1533	2 S	24 E	21	Comb	Historic Railroad, Stage Route, Travel	Null	Historic More Than One Decade	Private	CD
24YL1522	2 S	24 E	21	SE	Historic Railroad Building/Structure	Null	Historic More Than One Decade	Private	undetermined
24YL0172	2 S	24 E	21		Historic Agriculture	Historic Irrigation System	1890-1899	No Data	undetermined
24YL0170	2 S	24 E	22	Comb	Historic Irrigation System	Null	1880-1889	No Data	Ineligible
24YL1533	2 S	24 E	22	Comb	Historic Railroad, Stage Route, Travel	Null	Historic More Than One Decade	Private	CD
24YL0169	2 S	24 E	22	NW	Historic Recreation/Tourism	Other	1930-1939	State Owned	CD
24YL0168	2 S	24 E	22	NW	Historic Architecture	Historic Residence	1910-1919	Private	undetermined

Jonathan Weaver

From: Murdo, Damon [dmurdo@mt.gov]
Sent: Thursday, February 06, 2014 12:09 PM
To: Jonathan Weaver
Subject: RE: SHPO File Search Request
Attachments: CRABS.pdf; CRIS.pdf; 2014020501.pdf

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Montana
Historical Society

February 6, 2014

Jonathan Weaver
Great West Engineering
PO Box 4817
Helena MT 59604

RE: CITY OF LAUREL WATER TREATMENT PLANT INTAKE ALTERNATIVES ANALYSIS.
SHPO Project #:2014020501

Dear Mr. Weaver:

I have conducted a cultural resource file search for the above-cited project. According to our records there have been a few previously recorded sites within the designated search locales. In addition to the sites there have been a few previously conducted cultural resource inventories done in the areas. I've attached a list of these sites and reports. If you would like any further information regarding these sites or reports you may contact me at the number listed below.

It is SHPO's position that any structure over fifty years of age is considered historic and is potentially eligible for listing on the National Register of Historic Places. If any structures are to be altered and are over fifty years old we would recommend that they be recorded and a determination of their eligibility be made.

If there is to be new ground disturbance required by this undertaking we feel that this project has the potential to impact cultural properties. We, therefore, recommend that a cultural resource inventory be conducted in order to determine whether or not sites exist and if they will be impacted prior to any disturbance taking place.

If you have any further questions or comments you may contact me at (406) 444-7767 or by e-mail at dmurdo@mt.gov. I have attached an invoice for the file search. Thank you for consulting with us.

Sincerely,

Damon Murdo
Cultural Records Manager
State Historic Preservation Office

File: DEQ/AIR&WATER WASTE MNG/2014

Site #	Twp	Rng	Sec	Qs	Site Type1	Site Type 2	Time Period	Owner	NR Status
24CB1584	2 S	23E	36	SE	Historic Irrigation System	Null	Historic More Than One Decade	Combination	Unresolved
24YL0663	2 S	24E	9	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	CD
24YL1782	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1781	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1755	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1768	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1767	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1766	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL0985	2 S	24E	9	SE	Historic Recreation/Tourism	Historic Political/Government	Historic More Than One Decade	Other	CD
24YL0985	2 S	24E	9	SE	Other	Null	Historic More Than One Decade	Other	CD
24YL1611	2 S	24E	9	SE	Historic Residence	Null	Historic More Than One Decade	Private	NR Listed
24YL1611	2 S	24E	9	SE	Historic Residence	Null	Historic More Than One Decade	Private	NR Listed
24YL1769	2 S	24E	9	SE	Historic Apartment House	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1770	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1794	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1794	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1771	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1764	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1763	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1762	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL1772	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1761	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL1760	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1773	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1759	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1774	2 S	24E	9	SE	Historic Hotel/Motel	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1758	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1757	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1756	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1776	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1777	2 S	24E	9	SE	Historic Commercial Development	Null	Historic More Than One Decade	Private	Ineligible
24YL1780	2 S	24E	9	SE	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1779	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL1751	2 S	24E	9	SE	Historic Education	Historic Architecture	Historic More Than One Decade	Private	undetermined
24YL1753	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1754	2 S	24E	9	SE	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1778	2 S	24E	9	SE	Historic Commercial Development	Historic Gas Station	Historic More Than One Decade	Private	NR Listed
24YL1786	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL1752	2 S	24E	9	SW	Historic Apartment House	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1784	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1783	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1855	2 S	24E	9	SW	Historic District	Null	Historic More Than One Decade	Other	NR Listed
24YL1785	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1750	2 S	24E	9	SW	Historic Library	Historic Architecture	Historic More Than One Decade	Other	NR Listed
24YL1749	2 S	24E	9	SW	Historic Political/Government	Historic Architecture	Historic More Than One Decade	Other	NR Listed
24YL1748	2 S	24E	9	SW	Historic Religion	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1511	2 S	24E	9	SW	Historic Residence	Null	Historic More Than One Decade	Private	Ineligible
24YL1576	2 S	24E	9	SW	Historic Apartment House	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed

Site #	Twp	Rng	Sec	Qs	Site Type1	Site Type 2	Time Period	Owner	NR Status
24YL1577	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1578	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1579	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1788	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1789	2 S	24E	9	SW	Historic Gas Station	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1790	2 S	24E	9	SW	Historic Agriculture	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1791	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1793	2 S	24E	9	SW	Historic Apartment House	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1792	2 S	24E	9	SW	Historic Grain Elevator	Null	Historic More Than One Decade	Private	Ineligible
24YL1797	2 S	24E	9	SW	Historic Fraternal Lodge	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1740	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1738	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1739	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1737	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1736	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1787	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1795	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL1741	2 S	24E	9	SW	Historic Residence	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1741	2 S	24E	9	SW	Historic Residence	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1743	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1744	2 S	24E	9	SW	Historic Religion	Historic Commercial Development	Historic More Than One Decade	Private	Ineligible
24YL1745	2 S	24E	9	SW	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	NR Listed
24YL1746	2 S	24E	9	SW	Historic Religion	Historic Architecture	Historic More Than One Decade	Private	undetermined
24YL1747	2 S	24E	9	SW	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1734	2 S	24E	9	comb	Historic Architecture	Historic Commercial Development	Historic More Than One Decade	Private	NR Listed
24YL1735	2 S	24E	9	comb	Historic Commercial Development	Historic Architecture	Historic More Than One Decade	Private	Ineligible
24YL0277	2 S	24E	9	comb	Historic Railroad	Null	Historic More Than One Decade	Private	CD
24YL0163	2 S	24E	9	comb	Historic Irrigation System	Null	Historic Period	No Data	Unresolved
24YL1382	2 S	24E	13	SW	Historic Homestead/Farmstead	Historic Log Structure	1920-1930	Private	CD
24YL1021	2 S	24E	13	SW	Historic Trash Dump	Null	1940-1949	Private	undetermined
24YL0161	2 S	24E	13	comb	Historic Irrigation System	Historic Agriculture	Historic More Than One Decade	Private	CD
24YL0171	2 S	24E	14	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24YL0161	2 S	24E	14	comb	Historic Irrigation System	Historic Agriculture	Historic More Than One Decade	Private	CD
24YL0172	2 S	24E	14		Historic Agriculture	Historic Irrigation System	1890-1899	No Data	undetermined
24YL0986	2 S	24E	19	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	CD
24YL0172	2 S	24E	19		Historic Agriculture	Historic Irrigation System	1890-1899	No Data	undetermined
24YL0171	2 S	24E	20	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24YL0986	2 S	24E	20	NE	Historic Irrigation System	Null	Historic More Than One Decade	Private	CD
24YL0172	2 S	24E	20		Historic Agriculture	Historic Irrigation System	1890-1899	No Data	undetermined
24YL1534	2 S	24E	28	Comb	Historic Irrigation System	Null	Historic Period	No Data	Unresolved
24YL1533	2 S	24E	28	Comb	Historic Railroad, Stage Route, Travel	Null	Historic More Than One Decade	Private	CD
24YL1556	2 S	24E	28	SE	Historic Homestead/Farmstead	Null	Historic More Than One Decade	Private	undetermined
24CB1584	2 S	24E	30	SE	Historic Irrigation System	Null	Historic More Than One Decade	Combination	Unresolved
24YL0171	2 S	24E	30	SW	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved
24CB1584	2 S	24E	31	NW	Historic Irrigation System	Null	Historic More Than One Decade	Combination	Unresolved
24YL0277	2 S	25E	5	comb	Historic Railroad	Null	Historic More Than One Decade	Private	CD
24YL0161	2 S	25E	5	comb	Historic Irrigation System	Historic Agriculture	Historic More Than One Decade	Private	CD
24YL0171	2 S	25E	6	Comb	Historic Irrigation System	Null	Historic More Than One Decade	Private	Unresolved

STATE HISTORIC PRESERVATION OFFICE

Cultural Resource Information Systems

CRIS Township, Range, Section Report

Report Date:
02/06/2014

Site #	Twp	Rng	Sec	Qs	Site Type1	Site Type 2	Time Period	Owner	NR Status
24YL0277	2 S	25 E	6	comb	Historic Railroad	Null	Historic More Than One Decade	Private	CD
24YL0161	2 S	25 E	6	comb	Historic Irrigation System	Historic Agriculture	Historic More Than One Decade	Private	CD
24YL0891	2 S	25 E	7	NE	Historic Outbuildings	Null	Historic More Than One Decade	Private	undetermined
24YL1019	2 S	25 E	7	SW	Historic Irrigation System	Null	1930-1939	Private	undetermined
24YL0161	2 S	25 E	7	comb	Historic Irrigation System	Historic Agriculture	Historic More Than One Decade	Private	CD
24YL1019	2 S	25 E	18	comb	Historic Irrigation System	Null	1930-1939	Private	undetermined

Township: 2 S Range: 23E Section: 36

LAHREN LARRY A.

3 / 21 / 1979 *CULTURAL RESOURCE INSPECTIONS OF THE BUFFALO MIRAGE (SPORTSMEN'S PARK) FISHERY ACCESS SITE, LAUREL, MONTANA*

CRABS Document Number: YL 6 10718 Agency Document Number:

Township: 2 S Range: 23E Section: 36

ETHNOSCIENCE ANONYMOUS

2 / 1 / 1995 *ALTAMONT GAS PIPELINE PROJECT - MONTANA SEGMENT; REVISED VERSION (RESTRICTED) **SEE ALSO ZZ-6-16925: NATIVE AMERICAN CONSULTATION FOR THE PROPOSED ALTAMONT GAS PIPELINE PROJECT (ALSO RESTRICTED)*

CRABS Document Number: ZZ 6 16123 Agency Document Number:

Township: 2 S Range: 24E Section: 13

ROBSON LARRY G.

6 / 15 / 1991 *JUNELLE HARTMAN BANK STABILIZATION, RIGHT BANK, YELLOWSTONE RIVER*

CRABS Document Number: YL 6 12532 Agency Document Number:

Township: 2 S Range: 24E Section: 13

VANDER STEEN KENNETH F., ET AL.

2 / / 1993 *PROPOSED CENEX 8 IN GAS LINE CROSSING ON THE YELLOWSTONE RIVER*

CRABS Document Number: YL 6 14587 Agency Document Number:

Township: 2 S Range: 24E Section: 13

MARTINSON RENEA D. ET.AL.

10 / 4 / 2011 *EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS*

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 24E Section: 28

WOOD GARVEY C. AND KATHERINE H. POLLOCK

7 / 15 / 1996 *KROFT GRAVEL SOURCE*

CRABS Document Number: YL 4 17715 Agency Document Number:

Township: 2 S Range: 24E Section: 28

AXLINE JON A.

11 / 21 / 1994 *CLARK'S FORK OF THE YELLOWSTONE RIVER - THREE MILES SOUTH OF LAUREL(ADDENDUM)*

CRABS Document Number: YL 4 16846 Agency Document Number: BR 9056(25)

Township: 2 S Range: 24E Section: 28

CAYWOOD JANENE M., ET AL.

1 / 6 / 1984 *CULTURAL RESOURCE INVENTORY BRIDGER TO LAUREL TRANSMISSION LINE PROJECT*

CRABS Document Number: CB 6 1609 Agency Document Number:

Township: 2 S Range: 24E Section: 28

AXLINE JON A.

5/27/1993 ***CLARK'S FORK OF THE YELLOWSTONE - 3 MILES SOUTH OF LAUREL***

CRABS Document Number: YL 4 15059 Agency Document Number: BR 9056(25)

Township: 2 S Range: 24E Section: 28

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 28

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 28

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 29

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 29

PASSMANN DORI AND GREG EVERTZ

8/20/2001 ***WHITEHORSE CANAL REORGANIZATION IN CARBON COUNTY MONTANA***

CRABS Document Number: CB 6 23879 Agency Document Number:

Township: 2 S Range: 24E Section: 30

PASSMANN DORI

2/13/2002 ***2001 STIPULATION D EXCEPTIONS UNDER THE IRRIGATION PA***

CRABS Document Number: ZZ 6 24469 Agency Document Number:

Township: 2 S Range: 24E Section: 31

STRAIT JAMES, ET AL.

9/30/2001 ***PROPOSED HIGHWAY 310 EXPANSION AND ALTERNATIVE ROUTES BETWEEN LAUREL AND ROCKVALE IN YELLOWSTONE COUNTY MONTANA***

CRABS Document Number: YL 4 24057 Agency Document Number: NH 4-1(21)42

Township: 2 S Range: 24E Section: 31

PASSMANN DORI AND GREG EVERTZ

8 / 20 / 2001 *WHITEHORSE CANAL REORGANIZATION IN CARBON COUNTY MONTANA*

CRABS Document Number: CB 6 23879 Agency Document Number:

Township: 2 S Range: 24E Section: 31

STRAIT JAMES D.

8 / / 2002 *ADDENDUM TO THE CULTURAL RESOURCES INVENTORY OF THE PROPOSED HIGHWAY 212 EXPANSION AND ALTERNATIVE ROUTES, BETWEEN LAUREL AND ROCKVALE, YELLOWSTONE AND CARBON COUNTIES, MONTANA*

CRABS Document Number: ZZ 4 25171 Agency Document Number:

Township: 2 S Range: 24E Section: 31

GCM SERVICES INC. ANONYMOUS

12 / / 1991 *PROPOSED BANK STABILIZATION PROJECT IN YELLOWSTONE COUNTY (JAMES DAVENPORT PERMIT)*

CRABS Document Number: YL 6 13303 Agency Document Number: 199175835

Township: 2 S Range: 25E Section: 5

MARTINSON RENEA D. ET.AL.

10 / 4 / 2011 *EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS*

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 25E Section: 5

STIPE FRANK

3 / / 2012 *A CULTURAL RESOURCE SURVEY OF THE BIL RUDIO CELLULAR TOWER COMPOUND PROJECT, BILLINGS, YELLOWSTONE COUNTY, MONTANA - SECTION 32, T1S, R25E*

CRABS Document Number: YL 6 33493 Agency Document Number:

Township: 2 S Range: 25E Section: 6

STRAIT JAMES D.

11 / / 2002 *A CLASS III CULTURAL RESOURCES INVENTORY OF THE KINDSFATHER PIT WETLANDS PROJECT IN YELLOWSTONE COUNTY MONTANA*

CRABS Document Number: YL 4 25365 Agency Document Number:

Township: 2 S Range: 25E Section: 6

STIPE FRANK

3 / / 2012 *A CULTURAL RESOURCE SURVEY OF THE BIL RUDIO CELLULAR TOWER COMPOUND PROJECT, BILLINGS, YELLOWSTONE COUNTY, MONTANA - SECTION 32, T1S, R25E*

CRABS Document Number: YL 6 33493 Agency Document Number:

Township: 2 S Range: 25E Section: 7

MARTINSON RENEA D. ET.AL.

10 / 4 / 2011 *EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS*

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 25E Section: 8

MARTINSON RENEA D. ET.AL.

10 / 4 / 2011 ***EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS***

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 25E Section: 18

MARTINSON RENEA D. ET.AL.

10 / 4 / 2011 ***EXXON MOBIL SILVERTIP PIPELINE INCIDENT RESPONSE - CULTURAL HERITAGE SEGMENT A FORMS***

CRABS Document Number: YL 6 33230 Agency Document Number:

Township: 2 S Range: 25E Section: 18

KYTE MICHAEL A. AND CRAIG LEE

6 / 2 / 1998 ***ALTMAN LAND EXCHANGE : ALTERNATE PARCELS***

CRABS Document Number: YL 2 20323 Agency Document Number: 96-MT-025-19

MONTANA
Natural Heritage Program

P.O. Box 201800 • 1515 East Sixth Avenue • Helena, MT 59620-1800 • fax 406.444.0266 • tel 406.444.5354 • http://mtnhp.org

February 26, 2013

Jeremiah Theys
Great West Engineering
P.O. Box 4817
Helena, Montana 59604

Dear Jeremiah,

I am writing in response to your recent request regarding Montana Species of Concern in the vicinity of the City of Laurel Water Treatment Plant Intake Feasibility Study project, in Sections 15 and 22, T02S, R24E, in Yellowstone County. I checked our databases for information in this general area and have enclosed 12 species occurrence reports for 9 animal species of concern, a map depicting species of concern locations, and a map depicting wetland locations. Note that the maps are in Adobe GeoPDF format. With the appropriate Adobe Reader, it provides a convenient way to query and understand the information presented on the map.

Please keep in mind the following when using and interpreting the enclosed information and maps:

(1) These materials are the result of a search of our database for species of concern that occur in an area defined by the requested township, range and sections with an additional one-mile buffer surrounding the requested area. This is done to provide a more inclusive set of records and to capture records that may be immediately adjacent to the requested area. Please let us know if a buffer greater than 1 mile would be of use to your efforts. Reports are provided for the species of concern that are located in your requested area with a one-mile buffer. Species of concern outside of this buffered area may be depicted on the map due to the map extent, but are not selected for the SOC report.

(2) On the map, polygons represent one or more source features as well as the locational uncertainty associated with the source features. A source feature is a point, line, or polygon that is the basic mapping unit of a Species Occurrence (SO) representation. The recorded location of the occurrence may vary from its true location due to many factors, including the level of expertise of the data collector, differences in survey techniques and equipment used, and the amount and type of information obtained. Therefore, this inaccuracy is characterized as locational uncertainty, and is now incorporated in the representation of an SO. If you have a question concerning a specific SO, please do not hesitate to contact us.

(3) This report may include sensitive data, and is not intended for general distribution, publication, or for use outside of your organization. In particular, public release of specific location information may jeopardize the welfare of threatened, endangered, or sensitive species or biological communities.

(4) The accompanying map(s) display land management status, which may differ from ownership. Features shown on this map do not imply public access to any lands.

(5) Additional biological data for the search area(s) may be available from other sources. We suggest you contact the U.S. Fish and Wildlife Service for any additional information on threatened and endangered species (406-449-5225). For additional fisheries information in your area of interest, you may wish to contact Montana Fish, Wildlife, and Park's Montana Fisheries Information System (phone: 406-444-3373, or web site: **http://fwp.mt.gov/fishing/mFish/**).

(6) Additional information on species habitat, ecology and management is available on our web site in the Plant, Animal, and ecological Systems Field Guides, which we encourage you to consult for valuable information. You can access these guides at http://mtnhp.org. General information on any species can be found by accessing the link to NatureServe Explorer.

The results of a data search by the Montana Natural Heritage Program reflect the current status of our data collection efforts. These results are not intended as a final statement on sensitive species within a given area, or as a substitute for on-site surveys, which may be required for environmental assessments. The information is intended for project screening only with respect to species of concern, and not as a determination of environmental impacts, which should be gained in consultation with appropriate agencies and authorities.

In order to help us improve our services to you, we invite you to take a simple survey. The survey is intended to gather some basic information on the value and quality of the information and services you recently received from the Montana Natural Heritage Program. The survey is short and should not take more than a few minutes to complete. All information will be kept confidential and will be used internally to improve the delivery of services and to help document the value of our services. Use this link to go to the survey: **http://www.surveymonkey.com/s/RYN8Y8L**.

I hope the enclosed information is helpful to you. Please feel free to contact me at (406) 444-3290 or via my e-mail address, below, should you have any questions or require additional information.

Sincerely,

Martin P. Miller
Montana Natural Heritage Program
martinm@mt.gov

Montana Species of Concern
City of Laurel
Water Treatment Plant Intake
Species of Concern / Sites

SPECIES OF CONCERN: A polygon feature representing only what is known from direct observation with a defined level of certainty regarding the spatial location of the feature.

NonVascular Plants
- NonVascular Plants

Vascular Plants
- Vascular Plants

Invertebrates
- Invertebrates

Amphibians
- Amphibians

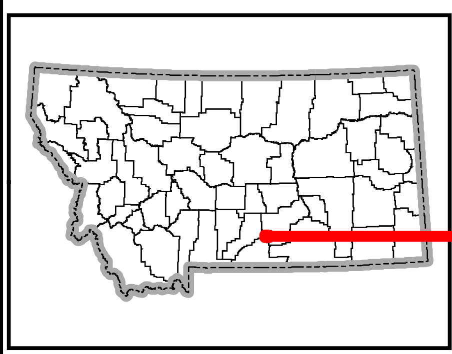
Fish
- Fish

Reptiles
- Reptiles

Birds
- Birds

Mammals
- Mammals

Sites
- Sites

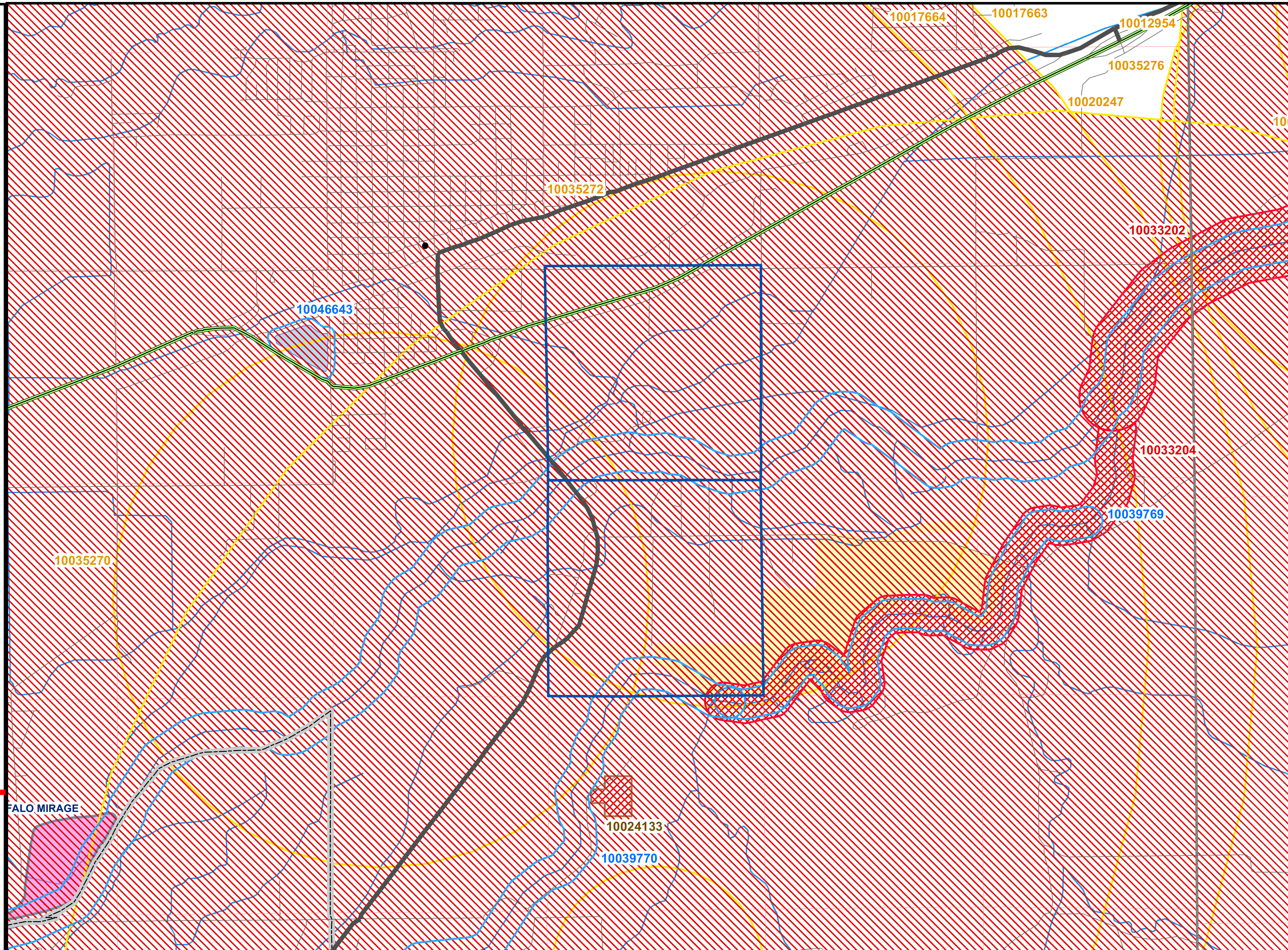


Not all legend items may occur on the map.

Features shown on this map do not imply public access to any lands.

This map displays management status, which may vary from ownership.

Montana Natural Heritage Program



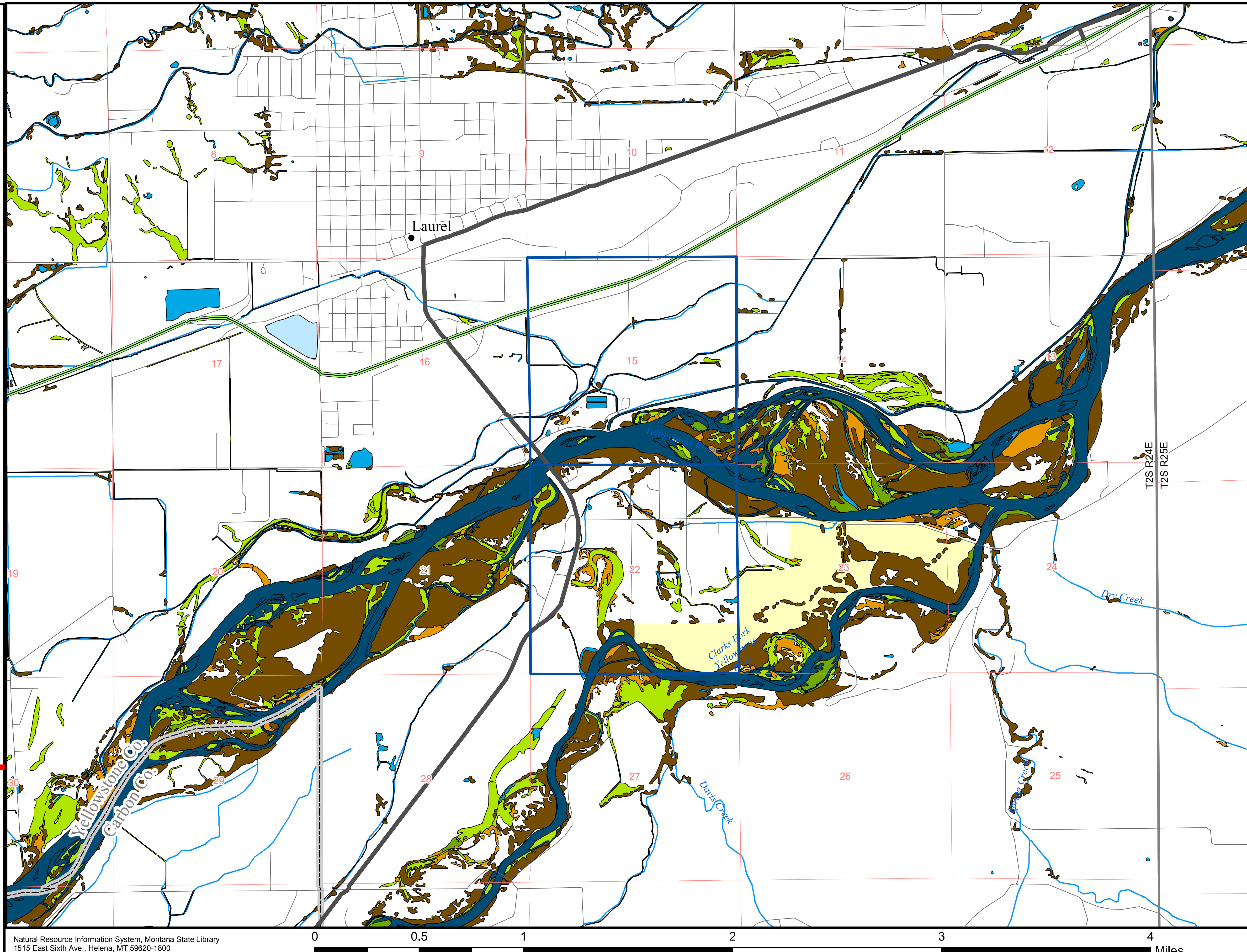
0 0.5 1 2 3 4 Miles

Natural Resource Information System, Montana State Library
1515 East Sixth Ave., Helena, MT 59620-1800

406 444-5354 http://mtnhp.org mtnhp@mt.gov

Map Document: K:\REQUESTS\Requests\13\PRVT\13prvt0148\13prvt0148.mxd (2/26/2013)

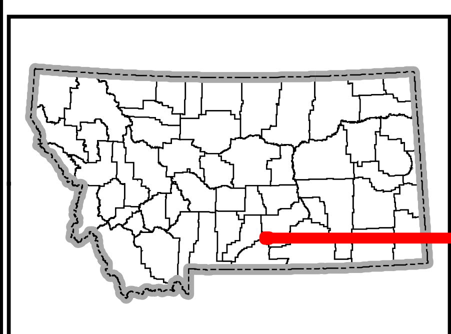
Montana Species of Concern
City of Laurel
Water Treatment Plant Intake
Wetlands



SPECIES OF CONCERN: A polygon feature representing only what is known from direct observation with a defined level of certainty regarding the spatial location of the feature.

Wetland Types

- Lake
- River
- Freshwater Pond
- Freshwater Emergent Wetland
- Freshwater Scrub-Shrub Wetland
- Freshwater Forested Wetland
- Riparian Emergent
- Riparian Scrub-Shrub
- Riparian Forested



Not all legend items may occur on the map.

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This map displays management status, which may vary from ownership.

Montana Natural Heritage Program

Natural Resource Information System, Montana State Library
1515 East Sixth Ave., Helena, MT 59620-1800

406 444-5354 http://mtnhp.org mtnhp@mt.gov

Map Document: K:\REQUESTS\Requests\13\PRVT\13prvt0148\13prvt0148.mxd (2/26/2013)

Montana Natural Heritage Program
Natural Resource Information System
Montana State Library
PO Box 201800
Helena, MT 59620-1800
(406)444-3009 mtnhp@mt.gov

Species of Concern Data Report

Visit http://mtnhp.org for additional information.

Report Date:
Tuesday, February 26, 2013

Ardea herodias

View Species in MT Field Guide

Common Name: Great Blue Heron
General Habitat: Riparian forest
Description: Birds
Mapping Delineation:

Confirmed nesting area buffered by a minimum distance of 6,500 meters in order to be conservative about encompassing the areas commonly used for foraging near the breeding colony and otherwise buffered by the locational uncertainty associated with the observation up to a maximum distance of 10,000 meters.

Species Status

Click Status for Explanations

Natural Heritage Ranks:
State: S3
Global: G5

FWP CFWCS Tier: 3

MT PIF Code:

Federal Agency Status:
U.S. Fish & Wildlife Service:
U.S. Forest Service:
U.S. Bureau of Land Management:

Species Occurrences

Species Occurence Map Label: 10017664

First Observation Date: 1988-04-28
Last Observation Date: 1988-07-28
SO Number: 186
Acreage: 32,633

Species Occurence Map Label: 10017663

First Observation Date: 1988-04-28
Last Observation Date: 1988-07-28
SO Number: 187
Acreage: 32,633

Haliaeetus leucocephalus

View Species in MT Field Guide

Common Name: Bald Eagle
General Habitat: Riparian forest
Description: Birds
Mapping Delineation:

Confirmed nesting area buffered by a minimum distance of 2,000 meters in order to be conservative about encompassing the breeding territory and area commonly used for renesting and otherwise buffered by the locational uncertainty associated with the observation up to a maximum distance of 10,000 meters.

Species Status

Click Status for Explanations

Natural Heritage Ranks:
State: S4
Global: G5

FWP CFWCS Tier: 1

MT PIF Code: 2

Federal Agency Status:
U.S. Fish & Wildlife Service: DM; BGEPA; MBTA; BCC
U.S. Forest Service: SENSITIVE
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10035270

First Observation Date:	2001-03-01	**SO Number:**	896
Last Observation Date:	2002-09-01	**Acreage:**	3,089

Species Occurence Map Label: 10035272

First Observation Date:	2003-03-01	**SO Number:**	772
Last Observation Date:	2003-09-01	**Acreage:**	3,089

Coccvzus americanus

View Species in MT Field Guide

Common Name: Yellow-billed Cuckoo

General Habitat: Prairie riparian forest

Description: Birds

Mapping Delineation:

Observations with evidence of breeding activity buffered by a minimum distance of 300 meters in order to encompass the maximum foraging area size reported for the species and otherwise is buffered by the locational uncertainty associated with the observation up to a maximum distance of 10,000 meters.

Species Status

Click Status for Explanations

Natural Heritage Ranks:

State: S3B
Global: G5

FWP CFWCS Tier: 2

MT PIF Code: 2

Federal Agency Status:

U.S. Fish & Wildlife Service: PS:C
U.S. Forest Service:
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10020247

First Observation Date:	1984-07-03	**SO Number:**	11
Last Observation Date:	1984-07-03	**Acreage:**	43,446

Ammodramus bairdii

View Species in MT Field Guide

Common Name: Baird's Sparrow

General Habitat: Grasslands

Description: Birds

Mapping Delineation:

Confirmed breeding area based on the presence of a nest, chicks, or territorial adults during the breeding season. Point observation location is buffered by a minimum distance of 100 meters in order to encompass the average breeding territory size of the species and otherwise is buffered by the locational uncertainty associated with the observation up to a maximum distance of 10,000 meters.

Species Status

Click Status for Explanations

Natural Heritage Ranks:

State: S3B
Global: G4

FWP CFWCS Tier: 2

MT PIF Code: 1

Federal Agency Status:

U.S. Fish & Wildlife Service:
U.S. Forest Service:
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10029477

First Observation Date: 1980-06-22
Last Observation Date: 1980-06-22
SO Number: 155
Acreage: 494

Oncorhvnchus clarkii bouvieri

View Species in MT Field Guide

Common Name: Yellowstone Cutthroat Trout
General Habitat: Mountain streams, rivers, lakes
Description: Fish

Mapping Delineation:

Stream reaches and standing water bodies where the species presence has been confirmed through direct capture or where they are believed to be present based on the professional judgement of a fisheries biologist due to confirmed presence in adjacent areas. In order to reflect the importance of adjacent terrestrial habitats to survival, stream reaches are buffered 100 meters, standing water bodies greater than 1 acre are buffered 50 meters, and standing water bodies less than 1 acre are buffered 30 meters into the terrestrial habitat based on PACFISH/INFISH Riparian Conservation Area standards.

Species Status

Click Status for Explanations

Natural Heritage Ranks:

State: S2
Global: G4T2

FWP CFWCS Tier: 1

MT PIF Code:

Federal Agency Status:

U.S. Fish & Wildlife Service:
U.S. Forest Service: SENSITIVE
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10046643

First Observation Date:
Last Observation Date:
SO Number:
Acreage: 37

Thvmallus arcticus

View Species in MT Field Guide

Common Name: Arctic Grayling
General Habitat: Mountain rivers, lakes
Description: Fish

Mapping Delineation:

Stream reaches and standing water bodies where the species presence has been confirmed through direct capture or where they are believed to be present based on the professional judgement of a fisheries biologist due to confirmed presence in adjacent areas. In order to reflect the importance of adjacent terrestrial habitats to survival, stream reaches are buffered 100 meters, standing water bodies greater than 1 acre are buffered 50 meters, and standing water bodies less than 1 acre are buffered 30 meters into the terrestrial habitat based on PACFISH/INFISH Riparian Conservation Area standards.

Species Status

Click Status for Explanations

Natural Heritage Ranks:

State: S1
Global: G5

FWP CFWCS Tier: 1

MT PIF Code:

Federal Agency Status:

U.S. Fish & Wildlife Service: C
U.S. Forest Service: SENSITIVE
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10039769

First Observation Date:
Last Observation Date:
SO Number:
Acreage: 222

Species Occurence Map Label: 10039770

First Observation Date:
Last Observation Date:
SO Number:
Acreage: 250

Sander canadensis

View Species in MT Field Guide

Common Name: Sauger
Description: Fish
General Habitat: Large prairie rivers

Mapping Delineation:

Stream reaches and standing water bodies where the species presence has been confirmed through direct capture or where they are believed to be present based on the professional judgement of a fisheries biologist due to confirmed presence in adjacent areas. In order to reflect the importance of adjacent terrestrial habitats to survival, stream reaches are buffered 100 meters, standing water bodies greater than 1 acre are buffered 50 meters, and standing water bodies less than 1 acre are buffered 30 meters into the terrestrial habitat based on PACFISH/INFISH Riparian Conservation Area standards.

Species Status

Click Status for Explanations

Natural Heritage Ranks:

State: S2
Global: G5

FWP CFWCS Tier: 1

MT PIF Code:

Federal Agency Status:

U.S. Fish & Wildlife Service:
U.S. Forest Service:
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10039206

First Observation Date:
Last Observation Date:
SO Number:
Acreage: 10,660

Cvnomvs ludovicianus

View Species in MT Field Guide

Common Name: Black-tailed Prairie Dog
General Habitat: Grasslands
Description: Mammals
Mapping Delineation:
Areas with recent evidence of activity (i.e. burrow entrances) visibile on the 2005 or 2009 National Agricultural Imagery Program (NAIP) aerial color photographic imagery that either contain or are within a distance of 200 meters of a definitive observation of the species.

Species Status

Click Status for Explanations

Natural Heritage Ranks:
State: S3
Global: G4
FWP CFWCS Tier: 1
MT PIF Code:

Federal Agency Status:
U.S. Fish & Wildlife Service:
U.S. Forest Service: SENSITIVE
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10024133

First Observation Date:
Last Observation Date:
SO Number: 1,821
Acreage: 17

Apalone spinifera

View Species in MT Field Guide

Common Name: Spiny Softshell
General Habitat: Prairie rivers and larger streams
Description: Reptiles
Mapping Delineation:
Stream reaches where the species presence has been confirmed through direct capture or where they are believed to be present based on the professional judgement of a biologist due to confirmed presence in adjacent areas. In order to reflect the importance of adjacent terrestrial habitats to survival, stream reaches are buffered 100 meters into the terrestrial habitat based on PACFISH/INFISH Riparian Conservation Area standards.

Species Status

Click Status for Explanations

Natural Heritage Ranks:
State: S3
Global: G5
FWP CFWCS Tier: 1
MT PIF Code:

Federal Agency Status:
U.S. Fish & Wildlife Service:
U.S. Forest Service:
U.S. Bureau of Land Management: SENSITIVE

Species Occurrences

Species Occurence Map Label: 10033204

First Observation Date: 2005-05-22
Last Observation Date: 2005-05-22
SO Number: 8
Acreage: 334

Jonathan Weaver

From: Berkley, Jim [Berkley.Jim@epa.gov]
Sent: Monday, April 22, 2013 2:56 PM
To: Jonathan Weaver
Cc: Hamilton, Karen
Subject: EPA Comments on Prescreening Analysis

Dear Jonathan:

Thank you for the opportunity to review, "City of Laurel Alternatives Prescreening Analysis: New Water Treatment Plant Intake." EPA has also been in communication with Montana Department of Environmental Quality (DEQ), U.S. Army Corps of Engineers-Billings Regulatory Office and Montana Fish Parks and Wildlife to understand their perspectives on the alternatives presented in the report. EPA has similar concerns described in the agencies' written communications to you about the alternatives and analyses and has described them below.

We understand that having a working water intake in this dynamic stretch of river is particularly challenging. We appreciate the range of alternatives considered but do think that it is important to consider more combinations and analysis of the alternatives presented to avoid, minimize and mitigate for unavoidable impacts, based on our evaluation criteria as provided in 40 CFR 230. In particular, the experience with weirs as mentioned in the March 5, 2013, DEQ letter, highlights the empirical high level of uncertainty associated with the success rate with weirs on the Yellowstone River. The relevance of this point is that the success rate can translate into whether an approach is sustainable for the long or short term. This is relevant to our assessment of the alternatives because, it is important for understanding what the probability is that another human caused major disturbance to the resource might be necessary in the future due to failure of some part of this solution in the short term. This concern goes to complying with the, "avoid and minimize" aspect of the Clean Water Act 404 (b) (1) regulations, by which we are required to evaluate proposals affecting Waters of the U.S.

Weirs can have significant impacts on aspects of aquatic resources, one of which is fish passage, as mentioned in both the Fish Parks and Wildlife and DEQ letters. When fish passage is considered in these structures the costs can move upwards significantly and once included may change the practicability of the particular alternative and other alternatives relative to it that were once eliminated because of cost. We do suggest that weir type structures be avoided as a part of the solution to the water supply problem. We suggest further exploration and analysis of a combination of the alternatives be presented to see if a combination is practicable and less environmentally damaging.

Again, thank you for the opportunity to review and provide input on your prescreening analysis. If you have any questions or I can provide clarification, please contact me.

Jim Berkley, PhD

Water Resources Engineer

Aquatic Resources Protection Unit

303-312-7102

MEMORANDUM

Date: February 25, 2013

To: Distribution

From: Jeremiah Theys, PE J.T.
Project Manager

Subject: City of Laurel Water Treatment Plant Intake Feasibility Study
Alternatives Preliminary Screening Analysis

Attached is the Alternatives Preliminary Screening Analysis for the City of Laurel Water Treatment Plant Intake Feasibility Study. This analysis is presented as part of the ongoing effort to find a long-term solution to the City's water supply problem, which was most recently caused by the flooding on the Yellowstone River in the spring of 2011. The long-term solution that will eventually be selected will be funded by FEMA under their Public Assistance (PA) Grant Program.

Every effort has been made to include and analyze all possible alternatives in order to ensure the highest probability of mitigating the City's water supply problem. If there are other possible alternatives or variations of the ones presented that you feel should be considered please provide that recommendation.

Also, as it pertains to your particular agency, please provide comments on the following:

- Wetlands
- Floodplains
- Air quality
- Water quality
- Fish, including threatened or endangered species or species of special concern
- Wildlife, including threatened or endangered species or species of special concern
- Archeological/historical/architectural concerns
- Funding eligibility
- Other environmental concerns
- Other issues

Please return your written comments to jtheys@greatwesteng.com or the following address:

Jeremiah Theys
Great West Engineering
P.O. Box 4817
Helena, MT 59604

Due to the expedited nature of this project, we would request receipt of your comments by no later than March 12, 2013. These comments will be taken into consideration and included in the feasibility study and environmental assessment (EA).

Since there are so many interests involved with this project, it may be beneficial to schedule a face-to-face meeting to facilitate better communication. If you feel this would be beneficial, please indicate so in your response. The meeting would likely be scheduled sometime during the third or fourth weeks of March.

Thank you for your time and consideration.

Distribution:

Tom Barnard, DHS/FEMA
Steve Hardegen, Regional Environmental Officer, DHS/FEMA
Tim Miller, Yellowstone County Floodplain Administrator
Todd Tillinger, State Program Manager, U.S. Army Corps of Engineers
Shannon Johnson, U.S. Army Corps of Engineers
Jeff Ryan, Environmental Science Specialist, Montana Department of Environmental Quality
David Leitheiser, Billings District Hydraulic Engineer, Montana Department of Transportation
Stefan Streeter, Billings District Administrator, Montana Department of Transportation
Ken Frazer, Fisheries Manager, Montana Fish, Wildlife, & Parks
Toney Ott, Environmental Scientist, U.S. Environmental Protection Agency
R. Mark Wilson, Field Supervisor, U.S. Fish & Wildlife Service
Damon Murdo, Cultural Records Manager, State Historic Preservation Office
Ronald G. Berry, Director of Bridge Engineering, BNSF Railway
Jeff Bollman, Planner, Montana Department of Natural Resources & Conservation
Martin P. Miller, Montana Natural Heritage Program

cc:

City of Laurel
Chad Hanson, Great West Engineering
Jeremiah Theys, Great West Engineering
Jonathan Weaver, Great West Engineering
Project File

City of Laurel

Alternatives Prescreening Analysis

New Water Treatment Plant Intake

February 25, 2013

Prepared by:

Great West engineering ®

MEETING MINUTES

Date: January 2, 2012

To: Meeting Attendees (see attached)

From: Great West Engineering

Subject: City of Laurel, 2011 Flood Damage Restoration & Mitigation Coordination Meeting

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A meeting was held on December 19, 2012 at the City of Laurel Public Library to discuss the restoration and mitigation projects surrounding flood damage that occurred on the Yellowstone River during the flooding of 2011. A record of the meeting follows. ***Note that action items are highlighted in bold, italicized font.***

Time	Notes
08:00	• Introduction of all parties • History of project

08:15	• Discussion of exposed water main
	   o Smaller than desired riprap was installed
	• Rock diversion dike & weir
	   o In August, 2012 the City measured 0.3' - 0.6' drop per day in water surface at intake
	   o Drop in water surface was compounded by substantial scour beneath bridge
	   o No return of irrigation flow in 2012
	   o Had to install weir, emergency declaration by Council
	   o Intake designed for 20 MGD, city couldn't get even 3 MGD
	   o Intake loses function when water surface drops 6" below top of intake

08:20	• Temporary ditch to old intake for redundancy during winter and low-flow months
	   o Some permits in-place
	   o Waiting for floodplain & encroachment from BNSF
	   o Talk to Zack Anderson with BNSF in Texas to expedite encroachment permit application. ***Yellowstone County will do this.*** BNSF is the holdup on completing this work.

08:30
- Permanent bank stabilization
    - Sheet pile is planned to be used for dewatering
    - Ryan Holm has coordinated with utilities
    - FEMA is concerned with impact to existing utilities by driving sheet pile
    - Permanent bank stabilization will not happen until next fall
    - Commissioner Kennedy concerned with what will happen this spring during low flows
    - CLOMR process will push bank stabilization to Fall 2013

08:35
- Boat ramp
    - Ideally incorporated into bank work for cost savings on construction
- Sediment removal
    - The current sediment plug concentrates flow, increases velocity, which results in further scour and erosion
    - Removal of sediment would also help with ice jamming and debris buildup

08:40
- Brief discussion of long-term solution

08:45-10:05
- Site visit

10:05
- Tom Barnard with FEMA
    - FEMA operates under Stafford Act
    - FEMA can fund either Loss of Function or Property Damage
    - Our project is dealing with Loss of Function
    - FEMA will restore to pre-disaster conditions
    - Mitigation can be done to ensure it doesn't happen again
    - Project must comply with local, state, federal regulations, otherwise can't fund
    - Office of Inspector General audits FEMA
        - Long process to insure that the City doesn't have to pay back funds
    - FEMA wants big picture to restore function

10:10
- FEMA does not want parts of the solution. They want the whole picture.
- Incorporate bank stabilization into boat ramp
- FEMA is OK to fund levee with COE approval
    - Shannon Johnson of the COE stated that the "non-levee embankment" is in the 404 permit. Therefore, FEMA can fund the work.
    - ***Will need to revise 404 permit to include sheet pile if used for dewatering***
    - Funding for boat ramp must go to FWP since they are the owners
- Ken Fraser of FWP stated that the paperwork just needs to be processed for the ***MOU between the City and FWP*** in order to incorporate the boat ramp into the bank stabilization work.
- Project Worksheet (PW) for boat ramp will go to FWP. FWP will then reimburse the City if the work is incorporated into one construction project.

10:30
- FWP is willing to match the difference if FEMA is not able to fund the entire amount for the boat ramp replacement.
- Has Cenex been approached for funding?

- FEMA stated that skewed design of the boat ramp is allowable and fundable. It is only when the quantities change that the work becomes "mitigation".
- Steve Hardegen of FEMA: Public notice is required with the CLOMR process
- Commissioner Kennedy: Has US DOT been contacted regarding the pipelines in the project vicinity?
  - He recommended to involve them early in order to avoid a hitch later in the project
  - Ryan Holm has thorough documentation from coordination with utilities
- Tim Thennis: Discussion of "improved project"
  - He stated that an "improved project" designation is probably not necessary for the boat ramp. Tom Barnard agreed.

10:45

- Shannon Johnson stated that the rock weir is potentially permittable through COE if it is part of the long-term solution. It must be demonstrated to be LEDPA (Least Environmentally Damaging Practicable Alternative)
- COE deadline for the removal of the "dike" is set for January 23, 2012
- Deadline for removal of "weir" is associated with a certain flow rate rather than a date

10:55

- If weir is part of long-term solution, then it would be permittable and fundable; if not, then it would not be permittable or fundable

11:00

- Temporary ditch
  - Tom Barnard stated that it is very likely fundable through FEMA through "emergency measures". This is typically only available for six months after a disaster declaration, but they would extend it in this case.
  - BNSF is the holdup on the installation of the temporary ditch
    - The review time for a temporary easement is four to six weeks
    - $3000 fee to expedite this process
    - Cynthia Daniels of BNSF indicated to Ryan Holm that if it comes to an emergency, BNSF will work with the City
  - ***Great West will provide reference and correspondence with BNSF to Liz Ching of Senator Baucus' office***
  - ***Great West will provide FEMA with alternatives narrative***
  - ***Tom Barnard will discuss with Tom Bush (who is currently out on the east coast because of hurricane Sandy) to see if they can write a PW for the emergency work***
  - Floodplain permit is currently in a public comment period

11:20

- Sediment removal
  - FEMA stated that this may be fundable if it is part of the long-term solution
  - Tom Barnard stated that whatever restores function is fundable; however, the solution must be "cost effective"

11:30

- Long-term solution discussion
  - Diversion dam is probably not an option

12:00
- Mayor Olson
  - Don't want to chase the river as it is a poor use of taxpayer dollars. There is substantial infrastructure invested in the current location of the intake.
  - Groundwater has been investigated throughout Yellowstone County; it has been found to be very alkaline and restrictive due to shallow bedrock

12:15-12:40
- Lunch provided by the City of Laurel

12:40
- Discussion of project timeline
  - Chan Hanson pointed out that the timeline will be affected depending on which alternative is selected
- Commissioner Kennedy
  - ***Senators Baucus and Tester will look into other funding sources***
  - Yellowstone County will be sure to coordinate regarding the floodplain permit
  - An alternative should be pursued that is not necessarily the cheapest, but one that will work it the long-term
  - The primary issue is providing water to the public
- The possibility of another coordination meeting at a later date was discussed and was seen as beneficial
- Jeremiah Theys: recommended to continue bi-weekly conference calls to discuss the progress of the project
- Misc. closing statements
- Heidi
  - ***Will provide a statement of non-reimbursable expenses for the project to the Yellowstone County Commission and the offices of the Senators***
  - Has already sent some invoices for project expenses to Tom Barnard
- ***Tom will write PW to assist City with engineering and other expenses***
  - Tom stated that the City will need to provide documentation on all hours worked on the project for final closeout
  - Noted the difference between "small" and "large" projects
    - Small projects: reimbursement upon project completion
    - Large projects: reimbursement throughout the project
- Commissioner Kennedy recommended that a face-to-face meeting with MDT take place to discuss the project
  - Great West noted that a meeting has already taken place with the Hydraulics Bureau
  - Commissioner Kennedy further suggested that the meeting should include himself, the mayor, and the Bureau Chief

1:30
- Meeting adjourned

City of Laurel
2011 Flood Damage Restoration & Mitigation Coordination Meeting
December 19, 2012

MEETING ATTENDEES

Name	Organization	Email	Phone
Tom Lutey	Billings Gazette	tlutey@billingsgazette.com	
Emelie Eaton	City of Laurel Ward 1 Alderwomen	deaton4626@aol.com	406-628-2164
Bruce McGee	City of Laurel Ward 2 Alderman	ward2B@laurel.mt.gov	406-321-0329
Heidi Jensen	City of Laurel, Chief Administrative Officer	hjensen@laurel.mt.gov	406-628-4796
Ken Olson	City of Laurel, Mayor	citymayor@laurel.mt.gov	406-628-8456
Kurt Markegard	City of Laurel, Public Works Director	kmarkegard@laurel.mt.gov	406-628-4796
Randy Welch	FEMA	randy.welch@fema.dhs.gov	
Tom Barnard	FEMA-Public Assistance	thomas.barnard@fema.dhs.gov	
Steve Hardegen	FEMA-Regional Environmental Officer	steven.hardegen@fema.dhs.gov	303 235-4714
Chad Hanson	Great West Engineering	chanson@greatwesteng.com	406-860-5145
Jeremiah Theys	Great West Engineering	jtheys@greatwesteng.com	406-495-6193
Jonathan Weaver	Great West Engineering	jweaver@greatwesteng.com	406-495-6171
Ryan Holm	Great West Engineering	rholm@greatwesteng.com	406-495-6183
Jennifer Ries	Laurel Outlook	news@laureloutlook.com	406-628-4412
Steve Knecht	MT DES, Chief of Operations	sknecht@mt.gov	406-324-4787
Jan Traynor	MT DES, Response and Recovery Bureau	jtraynor@mt.gov	406-324-4772
Tim Thennis	MT DES, Response and Recovery Bureau	tthennis@mt.gov	406-324-4783
Sam Johnson	MT DNRC, Civil Engineer	sam.johnson@mt.gov	406-247-4423
Ken Frazer	MT FWP, Fisheries Manager	kfrazer@mt.gov	406-247-2961
Kevin McDonnell	MT FWP, Project Manager	kemcdonnel@mt.gov	406-841-4010
Liz Ching	Sen. Baucus, Economic Development Director	elizabeth_ching@baucus.senate.gov	406-657-6790
Rachel Court	Sen. Tester, Regional Director	rachel_court@tester.senate.gov	406-252-0550
Shannon Johnson	US Army Corps of Engineers	shannon.L.johnson@usace.army.mil	406-657-5910
Bill Kennedy	Yellowstone County Commissioner	bkennedy@co.yellowstone.mt.gov	406-256-2701
John Ostlund	Yellowstone County Commissioner	jostlund@co.yellowstone.mt.gov	406-256-2701
Darin Swenson	Yellowstone County, Public Works	dswenson@co.yellowstone.mt.gov	406-256-2735
Tim Miller	Yellowstone County, Public Works Director	tmiller@yellowstone.mt.gov	406-256-2735

NEW WATER TREATMENT PLANT INTAKE

ALTERNATIVES PRESCREENING ANALYSIS

Prepared for:

City of Laurel, Montana

December 2012

Prepared by: Jonathan Weaver, E.I.

QA/QC: Jeremiah Theys, P.E.

Ryan Holm, E.I.

Great West Engineering, Inc.

2501 Belt View Drive

Helena, MT 59601

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

February 22, 2012

Ref: 8EPR-EP

Shannon Johnson, Project Officer
U.S. Army Corps of Engineers
Post Office Box 2256
Billings, Montana 59103

RE: City of Laurel, Montana, Yellowstone County Yellowstone River Bank Stabilization Riverside Park USACE Public Notice NWO-2011-02145-MTB

Dear Ms. Johnson:

U.S. Environmental Protection Agency Region 8 (EPA) has reviewed Public Notice Application NWO-2011-02145-MTB, for a project in Yellowstone County, Montana, requiring a permit under authority of the Secretary of the Army under Section 10 of the Rivers and Harbors Act of 1899 (30 Stat. 1151; 33 U.S.C. 403) and Section 404 of the Clean Water Act (33 USC 1344) (CWA). EPA requested and received additional information including additional information on the site plan for the proposed project, purpose and the impacts of the 2011 Yellowstone River flood.

The proposed activity is located in the Yellowstone River near the City of Laurel Riverside Park. The project will reconstruct and stabilize approximately 715 linear feet of riverbank extending from the existing Highway 212 Bridge southern abutment downstream of the former boat ramp. The riprap toe will be constructed approximately 45 feet into the new channel at the upstream end where erosion was most severe. The applicant has requested permission to fill and construct bank stabilization to an elevation approximately 2-3 feet above base flood elevations.

The second element of the proposed project is sediment removal beneath the adjacent railroad and highway bridges. The removal of fill is designed to improve hydraulic capacity under the bridges and lessen pressure on the south bank of the river.

The stated purpose of the proposed project is to prevent channel movement of the Yellowstone River toward the south bank and to prevent sedimentation impacts to the City of Laurel water intake. The water intake is downstream of the highway bridge. The area of the intake structure appears to be near an outside curve of the river that has developed a large island of sediment and appears relatively stable. The sediment deposition area was present when the new intake structure was constructed. The Corps did prepare a planning study for the City of Laurel to assist in the management of the intake structure and river. The City did not utilize river management techniques such weirs or wing dams to manage river lateral movement suggested in the Corps planning study.

The Yellowstone River is one of the last, large, free flowing rivers in the continental United States. Lack of mainstem impoundments allows spring peak flows and fall and winter low flows to influence a unique ecosystem and aesthetic resource. The Middle Yellowstone, which EPA Region 8 is defining as the reach from the Wyoming border to below Billings, Montana is currently undergoing significant development. The Middle Yellowstone watershed is known for its high ecosystem values in areas such as ecology, aesthetics, recreation, and agriculture. The area has increasing natural gas leasing within the floodplain of the Yellowstone and impacts from residential development.

EPA believes that the USACE needs to demonstrate permitted bank stabilization projects and other permitted activities on this reach of the Yellowstone River will not cumulatively impact this aquatic resource. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period. Evidence is increasing that the most devastating environmental effects may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time (Council of Environmental Quality 1997). Cumulative impacts can be defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (Thatcher 1990).

At the present EPA recommends the USACE deny the project as currently designed. EPA believes that the project applicant has not adequately addressed or provided adequate information to determine if the proposed project is the Least Environmentally Damaging Practicable Alternative (LEDPA). The project has the potential for unacceptable adverse effects to the aquatic environment, and lacks of an adequate mitigation plan. EPA believes that the hydrologic changes to the river that can be expected from the permit activities may negatively affect the chemical, biological and physical characteristics of this reach of the Yellowstone River. The project has the potential to adversely affect bank habitat; ability of the river to maintain river functions such as transport of sediment and bedload; transport pollutants associated with sediment; channel high flow; access the floodplain; effectively move within the natural meander zone. EPA also believes that the proposed fill and bank work may result in accelerated velocity of the river's flow and impact downstream properties.

EPA would like to receive any additional information on efforts of the applicant to avoid and minimize impacts, and demonstrating that the proposed project is the least environmentally damaging practical alternative. Specifically we would like to see hydrologic modeling completed to demonstrate the effectiveness of the current plan; an analysis of the proposed plan on the intake structure, downstream river habitat, riparian and floodplain ecosystem communities; and, mitigation plans for the proposed dredging, fill and bank stabilization work planned at Riverside Park.

Identification of the Least Environmentally Damaging Practicable Alternative (LEDPA) is achieved by performing an alternatives analysis that estimates the direct, secondary, and cumulative impacts to jurisdictional waters resulting from each alternative considered. Project alternatives that are not practicable and do not meet the project purpose are eliminated. The LEDPA is the remaining alternative with the fewest impacts to aquatic resources, so long as it does not have other significant adverse environmental consequences.

EPA has reason to believe the hydrologic changes to the river that can be expected from the permit activities may negatively affect the character of the river, access to the base elevation floodplain and restrict the natural meander behavior of the Yellowstone. EPA is concerned that this permit and additional permits for similar activities along the mainstem of the Yellowstone River may adversely affect warm-water species, and the associated aquatic ecosystem; may increase sediment, turbidity, pollutants associated with sediment; and velocity of the flow which would also be harmful to these aquatic species and the habitat. It appears the placement of the extended fill and bank hardening above the base flood elevation may cause accelerated velocity of the river's flow, increased scour, increase turbulence and erosion of the opposite and downstream banks and ephemeral islands opposite of the proposed fill project. The bank stabilization has the potential to raise the floodway elevation increasing the potential for flood damage downstream and in the areas where the river may backup and flood. A change in the flooding regime may impact the riparian and adjacent aquatic habitat of the river.

There is no proposed mitigation plan for the impacts of the proposed activities. Required mitigation information for the application of a CWA 404 permit is addressed by the mitigation rule under 33 CFR § 325.1 (d)(7) . Streams (and rivers) have a special designation and requirements under the mitigation rule as "difficult to replace" resources [33 CFR § 332.3 (e)(3)/40 CFR § 230.93(e)(3)]. EPA would like to receive, review and provide comment on a comprehensive mitigation plan if a permit is issued. 33 CFR § 325.1 (d)(7) requires the applicant to describe how impacts will be avoided and minimized. Mitigation measures are necessary for the immediate impacts to water quality and habitat characteristics of the river, and all secondary impacts.

Our initial review indicates that the proposed project may result in significant and unacceptable impacts to the Yellowstone River. The proposed permit does not comply with the Section 404(b)(1) Guidelines and USACE regulations for the following reasons:

1) The applicant has not clearly demonstrated that the proposed project is the least environmentally damaging practicable alternative (LEDPA) (40 CFR 230.10(a)); nor has the proponent demonstrated or provided information that the proposed project will accomplished the proposed purpose of this project;

2) The proposed project may cause or contribute to significant degradation of Yellowstone River aquatic resources (40 CFR 230.10(c));

3) Appropriate and practicable steps to minimize potential adverse impacts have not been taken (40 CFR 230.10(d));

4) The cumulative and secondary effects of the proposed project have not been adequately evaluated (40 CFR 230.11(g), (h)); and

5) There is not an appropriate "statement describing how impacts to waters of the United States are to be compensated for" (33 CFR § 325.1 (d)).

EPA suggests that the applicant provide information or hydrologic modeling results on the validity of the proposed actions to protect the intake structure. EPA also suggests that an assessment of the raised bank be evaluated for impacts to adjacent floodplain, and wetlands. The impacts of the increased velocity of the river on the physical and biological components of the river should be reviewed for a range of flows and the analysis submitted to the USACE.

We are requesting that the USACE work collaboratively with EPA and other involved agencies to resolve the issues raised during the follow-up to the permit review period. We would like to request that any additional information provided by the applicant to USACE be sent to Region 8 and that the USACE include EPA in future discussions and communications with the applicant. Any communication sent in regard to this permit should be sent to Region 8 project contact, Toney Ott, ott.toney@epa.gov, 303-312-6909.

Sincerely,

Toney Ott

Toney Ott
Environmental Scientist
Ecosystems Protection

CC: Jeff Ryan, Montana DEQ
Jim Darling, Montana FWP
Jeff Berglund, USFWS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
MONTANA FIELD OFFICE
100 N. PARK, SUITE 320
HELENA, MONTANA 59601
PHONE (406) 449-5225, FAX (406) 449-5339

M.06 COE Public Notices FY 2002 February 25, 2002

Mr. Gary Ewell
HKM Engineering, Inc.
222 North 32nd Street, Suite 700
P.O. Box 31318
Billings, Montana 59107-1318

Dear Mr. Ewell:

Thank you for your February 7, 2002 letter and revised Feasibility Study for mitigating the City of Laurel's Water Supply Problem. The US Fish and Wildlife Service's (Service) last written comments on this sedimentation problem was in August 2000 in response to US Army Corps of Engineers (Corps) Public Notice MT 200090388, concerning an application by the City of Laurel, Montana to construct four bendway weirs in the Yellowstone River. The Service offers the following comments on the revised Feasibility Study. These comments have been prepared under the authority of, and in accordance with, the provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et. seq.) and the Endangered Species Act (16 U.S.C. 1531 et. seq.).

For over a decade the Service has commented on the activities of the City of Laurel as they relate to the City's water intake in the Yellowstone River. We have consistently recommended a more permanent solution to the sediment problem at the intake site. In a letter to the Corps dated April 21, 1994 (in reference to Public Notice #199890097), the Service identified significant concerns to threatened, endangered, and candidate species, as well as increasing cumulative impacts affecting the physical, chemical, and biological dynamics of the Yellowstone River. The recurring activity by the City of Laurel in the Yellowstone River adds to these cumulative impacts and affects the threshold under which other activities proposed in the future will be critically examined.

Since the winter of 1998, Lou Hanebury, of my staff, has attended meetings with the City of Laurel and the Corps to find a more permanent solution to the sedimentation problem at the intake site. During this process, a study conducted by the Corps presented three alternatives designed to insure a more dependable water source for the city. Alternative Two consisted of constructing two spur dikes, 450 and 350 feet long, on the right bank of the river. Alternative Three consisted of constructing a new reinforced concrete water intake structure immediately downstream of the southern pier of the US Highway 212 bridge. The study's findings are described in an April, 2000 Omaha District, Corps report entitled, "Evaluation of the Sediment Deposition Problems along the Yellowstone River near Laurel, Montana." The Service indicated at the last meeting in Laurel that we preferred Alternative Three, the construction of the additional water intake downstream of the bridge. In a July 2000 letter, the Service additionally recommended that the Corps examine the applicability of constructing a modified low profile "W" weir in conjunction with, or in place of, Alternative Three. We regret that this recommendation was not considered in the new feasibility study.

Most recently, during a January 11, 2002 conference call to discuss the new feasibility study, the Service supported the additional intake as proposed (Alternative Three) as the least environmentally damaging alternative. The Service believes this proposed alternative will not likely adversely affect endangered, threatened, candidate, or proposed species. We applaud the City of Laurel for reconsidering its original proposals to construct bendway weirs in the Yellowstone River to solve their intake sedimentation problem, and for seeking a more permanent solution.

The above views constitute the report of the Department of the Interior. We appreciate your efforts to consider and conserve fish and wildlife resources, including threatened and endangered species, in your project planning. If you have questions regarding this letter, please contact Mr. Lou Hanebury of our Billings Suboffice at (406)247-7367.

Sincerely,

R. Mark Wilson

R. Mark Wilson
Field Supervisor

LRH/lrh

cc: Larry Robson, COE, Billings, MT
Jim Darling, MT Dept. of Fish, Wildlife and Parks, Billings, MT
Jeff Ryan, MT Dept. of Environmental Quality, Water Quality Bureau, Helena, MT
Christine Knutson, Environmental Protection Agency, Helena, MT
USFWS, Billings Suboffice

APPENDIX E – ENVIRONMENTAL DOCUMENTATION

Animal Species of Concern

Species List Last Updated **05/10/2013**

1 Special Status Species
35 Species of Concern
19 Potential Species of Concern
Filtered by the following criteria:
County = YELLOWSTONE

MONTANA Natural Heritage Program

A program of the Montana State Library's Natural Resource Information System operated by the University of Montana.

Introduction

The Montana Natural Heritage Program (MTNHP) serves as the state's information source for animals, plants, and plant communities with a focus on species and communities that are rare, threatened, and/or have declining trends and as a result are at risk or potentially at risk of extirpation in Montana.

This report on **Montana Animal Species of Concern** is produced jointly by the Montana Natural Heritage Program (MTNHP) and Montana Department of Fish, Wildlife, and Parks (MFWP). Montana Animal Species of Concern are native Montana animals that are considered to be "at risk" due to declining population trends, threats to their habitats, and/or restricted distribution.

Also included in this report are **Potential Animal Species of Concern** -- animals for which current, often limited, information suggests potential vulnerability or for which additional data are needed before an accurate status assessment can be made.

We also include **Special Status Species** which are species that have some legal protections in place, but are otherwise not recognized as federally listed under the Endangered Species Act and are not Montana Species of Concern. Bald Eagles are a Special Status Species because, although they are no longer protected under the Endangered Species Act and are also no longer a Montana Species of Concern, they are still protected under the Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. 668-668c).

Over the last 200 years, 5 species with historic breeding ranges in Montana have been extirpated from the state; Woodland Caribou (*Rangifer tarandus*), Greater Prairie-Chicken (*Tympanuchus cupido*), Passenger Pigeon (*Ectopistes migratorius*), Pilose Crayfish (*Pacifastacus gambelii*), and Rocky Mountain Locust (*Melanoplus spretus*). Designation as a Montana Animal Species of Concern or Potential Animal Species of Concern is not a statutory or regulatory classification. Instead, these designations provide a basis for resource managers and decision-makers to make proactive decisions regarding species conservation and data collection priorities in order to avoid additional extirpations.

Status determinations are made by MTNHP and MFWP biolgists in consultation with representatives of the Montana Chapter of the Wildlife Society, the Montana Chapter of the American Fisheries Society, and other experts. The process for evaluating and assigning status designations uses the Natural Heritage Program ranking system, described below, which forms the basis for identifying Montana Species of Concern.

How to Read the Lists

What Species are Included in this Report

Montana Species of Concern are defined as vertebrate animals with a state rank of S1, S2, or S3. Vertebrate species with a rank indicating uncertainty (SU), a "range rank" extending below the S3 cutoff (e.g., S3S4), or those ranked S4 for which there is limited baseline information on status are considered Potential Species of Concern. Because documentation for invertebrates is typically less complete than for vertebrates, only those ranked S1 or S2 are included as SOC. Invertebrates with a range rank extending below S2 (e.g., S2S3) are included as SOC only if their global ranks are G2G3 or G3, or if experts agree their occurrence in Montana has been adequately documented. Other invertebrates of concern with global ranks other than G1, G2, or G3 and with state ranks below S2 or range ranks extending below S2 (e.g., S3S4) are treated as Potential Species of Concern.

Organization of List

Both the list of Species of Concern and the list of Potential Species of Concern are grouped taxonomically in the following order: mammals, birds, reptiles, amphibians, fish, and various invertebrates. Within each taxonomic group you can sort species by common name or scientific name.

County Distribution

This column lists the documented county distribution for each species, including extant and historical occurrences. Any occurrences that cross county boundaries are counted for each county. Many older occurrence records and specimen collections are only known from vague location information and the area mapped as the potential area of observation may be quite large, leading to more than one county being counted.

Additions and Deletions

Species that have been added to or deleted from the SOC list due to changes in their state rank are reported in separate sections below; changes in global ranks are not tracked in this report.

Heritage Program Ranks

The international network of Natural Heritage Programs employs a standardized ranking system to denote **global** (range-wide) and **state** status (NatureServe 2006). Species are assigned numeric ranks ranging from 1 (highest risk, greatest concern) to 5 (demonstrably secure, least concern), reflecting the relative degree of risk to the species' viability, based upon available information. Global ranks are assigned by scientists at NatureServe (the international affiliate organization for the heritage network) in consultation with biologists in the natural heritage programs and other taxonomic experts.

A number of factors are considered in assigning state ranks — population size, area of occupancy in Montana, short and long-term population trends, threats, intrinsic vulnerability, and specificity to environment. Based on these factors, a preliminary rank is calculated and is reviewed by members of the Montana Chapter of the Wildlife Society and Montana Chapter of the American Fisheries Society or other key experts. A committee of biologists from MNHP and MFWP then review these rankings for consistent documentation and application of the criteria. Detailed documentation of the criteria and assessment process are available on the MTNHP website at: **http://mtnhp.org/animal/2004_SOC_Criteria.pdf**

Among other things, the combination of global and state ranks often helps describe the proportion of a species' range and/or total population occurring in Montana. For instance, a rank of G3 S3 often indicates that Montana comprises most or a very significant portion of an animal's total population. In contrast, an animal ranked G5 S1 often occurs in Montana at the periphery of its much larger range; thus, the state supports a relatively small portion of its total population.

Rank		Definition
G1	**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.
G2	**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.
G3	**S3**	Potentially at risk because of **limited** and/or **declining** numbers, range and/or habitat, even though it may be abundant in some areas.
G4	**S4**	Apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining.
G5	**S5**	Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.
GX	**SX**	Presumed Extinct or Extirpated - Species is believed to be extinct throughout its range or extirpated in Montana. Not located despite intensive searches of historical sites and other appropriate habitat, and small likelihood that it will ever be rediscovered.
GH	**SH**	Historical, known only from records usually 40 or more years old; may be rediscovered.
GNR	**SNR**	Not Ranked as of yet.
GU	**SU**	Unrankable - Species currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
GNA	**SNA**	A conservation status rank is not applicable for one of the following reasons: 1) The taxa is of Hybrid Origin; is Exotic or Introduced; is Accidental or 2) is Not Confidently Present in the state. (see other codes below)

Combination or Range Ranks

G#G# or **S#S#**	Indicates a range of uncertainty about the status of the species. *e.g. G1G3 = Global Rank ranges between G1 and G3 inclusive*

Sub-rank

T# Rank of a subspecies or variety. Appended to the global rank of the full species, *e.g. G4T3*

Qualifiers

Q	**Questionable** taxonomy that may reduce conservation priority-Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank. Appended to the global rank, *e.g. G3Q*
?	**Inexact Numeric Rank** - Denotes uncertainty; inexactness.
A	**Accidental** - Species is accidental or casual in Montana, in other words, infrequent and outside usual range. Includes species (usually birds or butterflies) recorded once or only a few times at a location. A few of these species may have bred on the few occasions they were recorded.
B	**Breeding** - Rank refers to the breeding population of the species in Montana. Appended to the state rank, *e.g. S2**B**,S5N = At risk during breeding season, but common in the winter*
N	**Nonbreeding** - Rank refers to the non-breeding population of the species in Montana. Appended to the state rank, *e.g. S5B,S2**N** = Common during breeding season, but at risk in the winter*
M	**Migratory** - Species occurs in Montana only during migration.

Federal Status

Designations in this column reflect the status of a species under the U.S. Endangered Species Act (ESA), or as "sensitive" by the U.S. Forest Service (USFS) or Bureau of Land Management (BLM).

U.S. Fish and Wildlife Service (Endangered Species Act)

Status, if any, of a taxon under the federal Endangered Species Act of 1973 (16 U.S.C.A. § 1531-1543 (Supp. 1996)) is noted.

Designation Descriptions

LE	**Listed endangered:** Any species in danger of extinction throughout all or a significant portion of its range (16 U.S.C. 1532(6)).
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)).
C	**Candidate:** Those taxa for which sufficient information on biological status and threats exists to propose to list them as threatened or endangered. We encourage their consideration in environmental planning and partnerships; however, none of the substantive or procedural provisions of the Act apply to candidate species.
DM	**Recovered, delisted, and being monitored** - Any previously listed species that is now recovered, has been delisted, and is being monitored.
NL	**Not listed** - No designation.
XE	**Experimental - Essential population** - An experimental population whose loss would be likely to appreciably reduce the likelihood of the survival of the species in the wild.
XN	**Experimental - Nonessential population** - An experimental population of a listed species reintroduced into a specific area that receives more flexible management under the Act.
CH	**Critical Habitat** - The specific areas (i) within the geographic area occupied by a species, at the time it is listed, on which are found those physical or biological features (I) essential to conserve the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by the species at the time it is listed upon determination that such areas are essential to conserve the species.
PS	**Partial status** - status in only a portion of the species' range. Typically indicated in a "full" species record where an infraspecific taxon or population, that has a record in the database has USESA status, but the entire species does not.
PS:value	**Partial status** - status in only a portion of the species' range. The value of that status appears in parentheses because the entity with status is not recognized as a valid taxon by Central Sciences (usually a population defined by geopolitical boundaries or defined administratively, such as experimental populations.) For example, Yellow-billed Cuckoo (*Coccyzus americanus*) is ranked **PS:C**. Partial Status - Candidate. Designated as a Candidate in the Western U.S. Distinct Population Segment (DPS) (subspecies *occidentalis*)
BGEPA	**The Bald and Golden Eagle Protection Act of 1940 (BGEPA)** - (16 U.S.C. 668-668c) prohibits anyone, without a permit issued by the Secretary of the Interior, from taking bald or golden eagles, including their parts, nests, or eggs. The BGEPA provides criminal and civil penalties for persons who take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle ... [or any golden eagle], alive or dead, or any part, nest, or egg thereof. The BGEPA defines take as pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb. "Disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. In addition to immediate impacts, this definition also covers impacts that result from human-induced alterations initiated around a previously used nest site during a time when eagles are not present, if, upon the eagles return, such alterations agitate or bother an eagle to a degree that injures an eagle or substantially interferes with normal breeding, feeding, or sheltering habits and causes, or is likely to cause, a loss of productivity or nest abandonment.
MBTA	**The Migratory Bird Treaty Act (MBTA)** - (16 U.S.C. §§ 703-712, July 3, 1918, as amended 1936, 1960, 1968, 1969, 1974, 1978, 1986 and 1989) implements four treaties that provide for international protection of migratory birds. The statute's language is clear that actions resulting in a "taking" or possession (permanent or temporary) of a protected species, in the absence of a U.S. Fish and Wildlife Service (USFWS) permit or regulatory authorization, are a violation of the MBTA. The MBTA states, "Unless and except as permitted by regulations ... it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill ... possess, offer for sale, sell ... purchase ... ship, export, import ... transport or cause to be transported ... any migratory bird, any part, nest, or eggs of any such bird .... [The Act] prohibits the taking, killing, possession, transportation, import and export of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." The word "take" is defined by regulation as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." The USFWS maintains a **list of species protected by the MBTA** at 50 CFR 10.13. This list includes over one thousand species of migratory birds, including eagles and other raptors, waterfowl, shorebirds, seabirds, wading birds, and passerines. The USFWS also maintains a **list of species not protected by the MBTA**. MBTA does not protect species that are not native to the United States or species groups not explicitly covered under the MBTA; these include species such as the house (English) sparrow, European starling, rock dove (pigeon), Eurasian collared-dove, and non-migratory upland game birds.
BCC	The 1988 amendment to the Fish and Wildlife Conservation Act mandates the U.S. Fish and Wildlife Service to identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act. **Birds of Conservation Concern 2008 (BCC 2008)** is the most recent effort to carry out this mandate. The overall goal of this report is to accurately identify the migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent the Service's highest conservation priorities.

Bureau of Land Management

BLM Sensitive Species are defined by the BLM 6840 Manual as those that normally occur on BLM administered lands for which BLM has the capability to significantly affect the conservation status of the species through management. Such species should be managed to the level of protection required by State laws or under the BLM policy for candidate species, whichever would provide better opportunity for its conservation. The State Director may designate additional categories of special status species as appropriate and applicable to his or her state's needs. The sensitive species designation, for species other than federally listed, proposed, or candidate species, may include such native species as those that:

1. could become endangered in or extirpated from a state, or within a significant portion of its distribution in the foreseeable future.
2. are under status review by the U.S. Fish and Wildlife Service and/or National Marine Fisheries Service,
3. are undergoing significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution,
4. are undergoing significant current or predicted downward trends in population or density such that federally listed, proposed, candidate, or State listed status may become necessary,
5. have typically small and widely dispersed populations,
6. are inhabiting ecological refugia, specialized or unique habitats, or
7. are State listed but which may be better conserved through application of BLM sensitive species status.

Designation Descriptions

Sensitive	Denotes species listed as sensitive on BLM lands

Special Status Denotes species that are listed as Endangered or Threatened under the Endangered Species Act

U.S. Forest Service

U.S. Forest Service Manual (2670.22) defines Sensitive Species on Forest Service lands as those for which population viability is a concern as evidenced by a significant downward trend in population or a significant downward trend in habitat capacity. The Regional Forester (Northern Region) designates Sensitive species on National Forests in Montana. These designations were last updated in 2007 and they apply only on USFS-administered lands.

Designation Descriptions

Sensitive Listed as a Sensitive Species by USFS Northern Region (R1)

Endangered Listed as Endangered under the Endangered Species Act

Threatened Listed as Threatened under the Endangered Species Act

Acknowledgements

MTNHP and MFWP staff work together on a daily basis to manage information used to evaluate the status of Montana's animal species. We extend our thanks to these individuals and professional biologists that study and work to conserve species across Montana. We also thank a number of private citizens that spend a great deal of their free time contributing valuable information to statewide databases so that species can be better understood and managed.

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Contact Information

For questions or comments specific to this publication or for specific zoology related questions, please contact:

Bryce A. Maxell
Senior Zoologist
bmaxell@mt.gov
(406) 444-3655

For general questions and zoology-related data requests please use the Information Request function on our website **(www.mtnhp.org)** or the general MTNHP contact info below.

Montana Natural Heritage Program
P.O. Box 201800 Phone: (406) 444-3290
1515 E. 6th Ave. Fax: (406) 444-0581
Helena, MT 59620-1800 E-mail: mtnhp@mt.gov

Species of Concern

35 Species

Filtered by the following criteria:

County = YELLOWSTONE

MAMMALS (MAMMALIA)

4 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:

COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Corynorhinus townsendii Townsend's Big-eared Bat	**Vespertilionidae** Bats	G3G4	S3		SENSITIVE	SENSITIVE	1	5%	87%	Caves in forested habitats
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Fergus, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Lincoln, Madison, Mineral, Missoula, Musselshell, Phillips, Powder River, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Silver Bow, Yellowstone								
Cynomys ludovicianus Black-tailed Prairie Dog	**Sciuridae** Squirrels	G4	S3		SENSITIVE	SENSITIVE	1	15%	71%	Grasslands
		Species verified in these Counties: Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Fallon, Fergus, Garfield, Golden Valley, Hill, Jefferson, Judith Basin, Lewis and Clark, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Rosebud, Stillwater, Sweet Grass, Toole, Treasure, Valley, Wheatland, Yellowstone								
Euderma maculatum Spotted Bat	**Vespertilionidae** Bats	G4	S3		SENSITIVE	SENSITIVE	1	5%	27%	Cliffs with rock crevices
		Species verified in these Counties: Big Horn, Carbon, Cascade, Lewis and Clark, Yellowstone								
Lasiurus cinereus Hoary Bat	**Vespertilionidae** Bats	G5	S3				2	2%	100%	Riparian and forest
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Powder River, Powell, Prairie, Ravalli, Richland, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wibaux, Yellowstone								

BIRDS (AVES)

22 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:

COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Ammodramus bairdii Baird's Sparrow	**Emberizidae** Sparrows	G4	S3B			SENSITIVE	2	27%	67%	Grasslands
		Species verified in these Counties: Blaine, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Glacier, Hill, Lewis and Clark, Liberty, McCone, Meagher, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone **State Rank Reason:** Montana populations were declining until recently and the species is declining in most or the surrounding states and provinces.								
Aquila chrysaetos Golden Eagle	**Accipitridae** Hawks / Kites / Eagles	G5	S3	BGEPA; MBTA; BCC		SENSITIVE	2	3%	100%	Grasslands
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Custer, Deer Lodge, Fallon, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Lake, Lewis and Clark, Madison, McCone, Musselshell, Petroleum, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Roosevelt, Rosebud, Sanders, Sheridan, Silver Bow, Stillwater, Teton, Toole, Valley, Wheatland, Yellowstone								
Ardea herodias Great Blue Heron	**Ardeidae** Bitterns / Egrets / Herons / Night-Herons	G5	S3				3	3%	100%	Riparian forest
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Mineral, Missoula, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Silver Bow, Stillwater, Sweet Grass, Teton, Treasure, Valley, Wheatland, Wibaux, Yellowstone **State Rank Reason:** Small breeding population size, evidence of recent declines, and declining regeneration of riparian cottonwood forests due to altered hydrology and grazing.								

Athene cunicularia Burrowing Owl	**Strigidae** Owls	G4	S3B		SENSITIVE	SENSITIVE	1	2%	82%	Grasslands
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Fallon, Fergus, Gallatin, Garfield, Golden Valley, Hill, Jefferson, Lewis and Clark, Liberty, Madison, McCone, Musselshell, Petroleum, Phillips, Pondera, Powder River, Prairie, Roosevelt, Rosebud, Sheridan, Stillwater, Teton, Toole, Treasure, Valley, Wheatland, Yellowstone **State Rank Reason:** Species has a negative short-term population trend.								
Botaurus lentiginosus American Bittern	**Ardeidae** Bitterns / Egrets / Herons / Night-Herons	G4	S3B				2	4%	100%	Wetlands
		Species verified in these Counties: Blaine, Carter, Cascade, Chouteau, Fergus, Flathead, Glacier, Golden Valley, Lake, Missoula, Phillips, Powell, Ravalli, Roosevelt, Sanders, Sheridan, Teton, Yellowstone								
Buteo regalis Ferruginous Hawk	**Accipitridae** Hawks / Kites / Eagles	G4	S3B			SENSITIVE	2	11%	95%	Sagebrush grassland
		Species verified in these Counties: Beaverhead, Blaine, Broadwater, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Gallatin, Garfield, Glacier, Golden Valley, Hill, Jefferson, Judith Basin, Lewis and Clark, Liberty, Madison, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Prairie, Roosevelt, Rosebud, Sheridan, Stillwater, Teton, Toole, Valley, Wheatland, Yellowstone								
Calcarius ornatus Chestnut-collared Longspur	**Calcariidae** Longspurs and Snow Buntings	G5	S2B			SENSITIVE	3	32%	67%	Grasslands
		Species verified in these Counties: Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Glacier, Golden Valley, Hill, Lewis and Clark, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Valley, Wheatland, Wibaux, Yellowstone **State Rank Reason:** Species has a negative short-term population trend and faces threats from loss of native prairie grassland habitats and altered frequency, intensity, and spatial distribution of grazing and fire regimes it is dependent on.								
Catharus fuscescens Veery	**Turdidae** Thrushes	G5	S3B				2	6%	100%	Riparian forest
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Cascade, Chouteau, Custer, Deer Lodge, Fergus, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Liberty, Lincoln, Madison, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Wheatland, Yellowstone								
Centrocercus urophasianus Greater Sage-Grouse	**Phasianidae** Upland Game Birds	G3G4	S2	C	SENSITIVE	SENSITIVE	1	17%	75%	Sagebrush
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Carbon, Carter, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Gallatin, Garfield, Golden Valley, Hill, Liberty, Madison, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Powder River, Prairie, Roosevelt, Rosebud, Silver Bow, Stillwater, Sweet Grass, Treasure, Valley, Wheatland, Wibaux, Yellowstone								
Chlidonias niger Black Tern	**Laridae** Gulls / Terns	G4	S3B			SENSITIVE	1	7%	100%	Wetlands
		Species verified in these Counties: Blaine, Carter, Cascade, Chouteau, Daniels, Flathead, Glacier, Golden Valley, Lake, Madison, Missoula, Phillips, Pondera, Powell, Roosevelt, Sheridan, Teton, Yellowstone **State Rank Reason:** Species has a small breeding population size and negative short-term population trends.								
Coccyzus americanus Yellow-billed Cuckoo	**Cuculidae** Cuckoos	G5	S3B	PS:C		SENSITIVE	2	1%	50%	Prairie riparian forest
		Species verified in these Counties: Big Horn, Carbon, Carter, Custer, Gallatin, Madison, Rosebud, Stillwater, Yellowstone								
Coccyzus erythropthalmus Black-billed Cuckoo	**Cuculidae** Cuckoos	G5	S3B				2	4%	95%	Riparian forest
		Species verified in these Counties: Big Horn, Cascade, Chouteau, Dawson, Fallon, Garfield, McCone, Musselshell, Petroleum, Prairie, Richland, Roosevelt, Stillwater, Valley, Wibaux, Yellowstone								
Dolichonyx oryzivorus Bobolink	**Icteridae** Blackbirds	G5	S3B			SENSITIVE	3	9%	100%	Moist grasslands
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Flathead, Gallatin, Granite, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Madison, Meagher, Missoula, Park, Petroleum, Phillips, Powell, Ravalli, Richland, Roosevelt, Sanders, Sheridan, Stillwater, Sweet Grass, Teton, Valley, Wibaux, Yellowstone **State Rank Reason:** Species has undergone recent large population declines in Montana and a patchwork of declines and increases have been documented in surrounding states and provinces.								
Falco peregrinus Peregrine Falcon	**Falconidae** Falcons	G4	S3	DM	SENSITIVE	SENSITIVE	2	2%	100%	Cliffs / canyons
		Species verified in these Counties: Beaverhead, Big Horn, Broadwater, Carbon, Cascade, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Park, Pondera, Powell, Prairie, Ravalli, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Yellowstone								
Gymnorhinus cyanocephalus Pinyon Jay	**Corvidae** Jays / Crows / Magpies	G5	S3				2	5%	55%	Open conifer forest
		Species verified in these Counties: Big Horn, Blaine, Broadwater, Carbon, Carter, Chouteau, Custer, Fergus, Gallatin, Garfield, Jefferson, Lewis and Clark, Musselshell, Park, Petroleum, Phillips, Powder River, Rosebud, Stillwater, Sweet Grass, Wheatland, Yellowstone								
Haemorhous cassinii Cassin's Finch	**Fringillidae** Finches	G5	S3				3	11%	62%	Drier conifer forest
		Species verified in these Counties: Beaverhead, Big Horn, Broadwater, Carbon, Cascade, Chouteau, Custer, Deer Lodge, Fergus, Flathead, Gallatin, Glacier, Golden Valley, Granite, Jefferson, Judith Basin, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Powder River, Powell, Ravalli, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Wheatland, Yellowstone								
Himantopus mexicanus	**Recurvirostridae** Avocets	G5	S3B				3	1%	8%	Wetlands
		Species verified in these Counties: Cascade, Gallatin, Golden Valley, Lake, Lewis and Clark, Phillips, Stillwater, Teton, Yellowstone								

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Black-necked Stilt										
Lanius ludovicianus Loggerhead Shrike	**Laniidae** Shrikes	G4	S3B			SENSITIVE	2	4%	100%	Shrubland
		Species verified in these Counties: Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Fallon, Fergus, Garfield, Golden Valley, Hill, Jefferson, Liberty, McCone, Meagher, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Teton, Toole, Valley, Wheatland, Wibaux, Yellowstone								
Melanerpes erythrocephalus Red-headed Woodpecker	**Picidae** Woodpeckers	G5	S3B			SENSITIVE	2	4%	60%	Riparian forest
		Species verified in these Counties: Carter, Custer, Fallon, Musselshell, Petroleum, Powder River, Prairie, Richland, Roosevelt, Rosebud, Valley, Wibaux, Yellowstone								
Numenius americanus Long-billed Curlew	**Scolopacidae** Sandpipers	G5	S3B			SENSITIVE	1	19%	100%	Grasslands
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Deer Lodge, Fallon, Fergus, Gallatin, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Madison, McCone, Meagher, Missoula, Musselshell, Petroleum, Phillips, Powder River, Powell, Prairie, Ravalli, Roosevelt, Rosebud, Sanders, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone								
Rhynchophanes mccownii McCown's Longspur	**Calcariidae** Longspurs and Snow Buntings	G4	S3B			SENSITIVE	2	41%	79%	Grasslands
		Species verified in these Counties: Beaverhead, Blaine, Broadwater, Cascade, Chouteau, Daniels, Glacier, Golden Valley, Hill, Lewis and Clark, Liberty, Madison, McCone, Musselshell, Petroleum, Phillips, Pondera, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Valley, Wheatland, Yellowstone **State Rank Reason:** Species faces threats from covertype conversion and altered grazing and fire regimes and although populations in the core of their breeding range in northeast Montana appear to be relatively stable, declines are occuring in much of the species global breeding range.								
Spizella breweri Brewer's Sparrow	**Emberizidae** Sparrows	G5	S3B			SENSITIVE	2	12%	100%	Sagebrush
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Chouteau, Custer, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Hill, Jefferson, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Powder River, Powell, Prairie, Ravalli, Rosebud, Sanders, Silver Bow, Stillwater, Teton, Toole, Valley, Wheatland, Yellowstone **State Rank Reason:** Species faces threats from loss of sagebrush habitats it is dependent on as a result of habitat covertype conversion for agriculture and increased frequency of fire as a result of weed encroachment and drought.								

REPTILES (REPTILIA)

5 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Apalone spinifera Spiny Softshell	**Trionychidae** Softshell Turtles	G5	S3			SENSITIVE	1	2%	26%	Prairie rivers and larger streams
		Species verified in these Counties: Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Fergus, Garfield, Golden Valley, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Rosebud, Teton, Toole, Treasure, Wheatland, Wibaux, Yellowstone								
Chelydra serpentina Snapping Turtle	**Chelydridae** Snapping Turtles	G5	S3			SENSITIVE	1	1%	26%	Prairie rivers and streams
		Species verified in these Counties: Big Horn, Carter, Custer, Dawson, Fallon, Powder River, Rosebud, Wibaux, Yellowstone								
Heterodon nasicus Western Hog-nosed Snake	**Colubridae** Colubrid Snakes	G5	S2		SENSITIVE	SENSITIVE	1	8%	63%	Friable soils
		Species verified in these Counties: Big Horn, Blaine, Carter, Cascade, Custer, Dawson, Fallon, Garfield, Hill, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Toole, Treasure, Valley, Yellowstone								
Lampropeltis triangulum Milksnake	**Colubridae** Colubrid Snakes	G5	S2		SENSITIVE	SENSITIVE	1	2%	51%	Rock outcrops
		Species verified in these Counties: Big Horn, Carbon, Custer, Dawson, Fergus, Garfield, Musselshell, Phillips, Powder River, Rosebud, Yellowstone								
Phrynosoma hernandesi Greater Short-horned Lizard	**Phrynosomatidae** Sagebush / Spiny Lizards	G5	S3		SENSITIVE	SENSITIVE	2	19%	66%	Sandy / gravelly soils
		Species verified in these Counties: Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Gallatin, Garfield, Glacier, Golden Valley, Hill, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Rosebud, Stillwater, Sweet Grass, Teton, Toole, Valley, Wheatland, Wibaux, Yellowstone								

AMPHIBIANS (AMPHIBIA)

1 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Spea bombifrons Plains Spadefoot	**Scaphiopodidae** Spadefoots	G5	S3		SENSITIVE	SENSITIVE	2	12%	73%	Wetlands, floodplain pools
		Species verified in these Counties: Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Custer, Fergus, Gallatin, Garfield, Golden Valley, Lewis and Clark, Musselshell, Petroleum, Powder River, Prairie, Rosebud, Sheridan, Stillwater, Toole, Treasure, Valley, Yellowstone								

FISH (ACTINOPTERYGII)

3 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Oncorhynchus clarkii bouvieri Yellowstone Cutthroat Trout	**Salmonidae** Trout	G4T2	S2		SENSITIVE	SENSITIVE	1		12%	Mountain streams, rivers, lakes
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Madison, Meagher, Mineral, Missoula, Park, Pondera, Powell, Ravalli, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Wheatland, Yellowstone								
Sander canadensis Sauger	**Percidae** Perches	G5	S2			SENSITIVE	1	1%	15%	Large prairie rivers
		Species verified in these Counties: Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Fallon, Fergus, Garfield, Hill, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Stillwater, Teton, Treasure, Valley, Wibaux, Yellowstone								
Thymallus arcticus Arctic Grayling	**Salmonidae** Trout	G5	S1	C	SENSITIVE	SENSITIVE	1		5%	Mountain rivers, lakes
		Species verified in these Counties: Beaverhead, Big Horn, Broadwater, Carbon, Cascade, Dawson, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Judith Basin, Lake, Lewis and Clark, Lincoln, Madison, Missoula, Park, Powell, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Yellowstone								

Potential Species of Concern

19 Species
Filtered by the following criteria:
County = YELLOWSTONE

MAMMALS (MAMMALIA)

3 SPECIES
FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Erethizon dorsatum Porcupine	**Erethizontidae** Porcupines	G5	S4				3	3%	100%	Mixed forest
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Lincoln, Madison, McCone, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone								
Peromyscus leucopus White-footed Mouse	**Muridae** Mice / Voles / Lemmings / Rats	G5	S4				2	2%	58%	Riparian shrub
		Species verified in these Counties: Big Horn, Carbon, Cascade, Chouteau, Custer, Dawson, Fergus, Garfield, Hill, Judith Basin, McCone, Meagher, Phillips, Powder River, Richland, Rosebud, Treasure, Valley, Yellowstone								
Sorex haydeni Hayden's Shrew	**Soricidae** Shrews	G4	S3S4				2	5%	65%	Grasslands
		Species verified in these Counties: Big Horn, Carter, Chouteau, Dawson, Fergus, Gallatin, Lewis and Clark, Musselshell, Park, Phillips, Pondera, Richland, Roosevelt, Sheridan, Sweet Grass, Teton, Treasure, Valley, Wibaux, Yellowstone								

BIRDS (AVES)

5 SPECIES
FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Asio flammeus Short-eared Owl	**Strigidae** Owls	G5	S4				3	2%	100%	Grasslands
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Madison, McCone, Meagher, Missoula, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wibaux, Yellowstone								
Lophodytes cucullatus Hooded Merganser	**Anatidae** Swans / Geese / Ducks	G5	S4				2	2%	100%	Rivers / Riparian Wetland
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Cascade, Chouteau, Custer, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Mineral, Missoula, Musselshell, Park, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Roosevelt, Rosebud, Sanders, Sheridan, Silver Bow, Teton, Valley, Yellowstone								
Megascops asio Eastern Screech-Owl	**Strigidae** Owls	G5	S3S4				3	4%	74%	Riparian forest
		Species verified in these Counties: Big Horn, Carbon, Cascade, Chouteau, Custer, Fallon, Fergus, Liberty, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Valley, Wibaux, Yellowstone								
Phalaenoptilus nuttallii Common Poorwill	**Caprimulgidae** Nighthawks	G5	S4B				3	4%	100%	Shrub grassland
		Species verified in these Counties: Beaverhead, Big Horn, Carbon, Carter, Chouteau, Custer, Fergus, Jefferson, Lake, McCone, Missoula, Musselshell, Petroleum, Phillips, Powder River, Rosebud, Yellowstone **State Rank Reason:** Although species lacks monitoring data, populations are assumed to be stable, habitats seem to be intact, and threats are not believed to be significant at the present time.								
Vireo plumbeus Plumbeous Vireo	**Vireonidae** Vireos	G5	S3S4B				3	1%	31%	Conifer forest
		Species verified in these Counties: Big Horn, Carbon, Carter, Custer, Fergus, Musselshell, Park, Petroleum, Phillips, Powder River, Rosebud, Silver Bow, Stillwater, Sweet Grass, Yellowstone								

FISH (ACTINOPTERYGII)

5 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME / COMMON NAME / TAXA SORT	FAMILY (SCIENTIFIC) / FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
Culaea inconstans Brook Stickleback	**Gasterosteidae** Sticklebacks	G5	S4				3		27%	Small prairie rivers
		Species verified in these Counties: Big Horn, Blaine, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Flathead, Garfield, Glacier, Hill, Lake, Liberty, McCone, Missoula, Park, Petroleum, Phillips, Pondera, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wibaux, Yellowstone								
Hybognathus hankinsoni Brassy Minnow	**Cyprinidae** Minnows	G5	S4				3	6%	26%	Small prairie rivers
		Species verified in these Counties: Big Horn, Blaine, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Garfield, Glacier, Golden Valley, Hill, Judith Basin, Lewis and Clark, Liberty, McCone, Musselshell, Petroleum, Phillips, Pondera, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Stillwater, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone								
Hybognathus placitus Plains Minnow	**Cyprinidae** Minnows	G4	S4				3	10%	8%	Small and large prairie rivers
		Species verified in these Counties: Blaine, Carter, Chouteau, Custer, Daniels, Dawson, Fallon, Fergus, Garfield, Hill, Judith Basin, Liberty, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Teton, Toole, Treasure, Valley, Wibaux, Yellowstone								
Lota lota Burbot	**Gadidae** Burbot	G5	S4				1	1%	20%	Large rivers, lakes
		Species verified in these Counties: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fergus, Flathead, Garfield, Glacier, Golden Valley, Hill, Jefferson, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Petroleum, Phillips, Pondera, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone								
Semotilus atromaculatus Creek Chub	**Cyprinidae** Minnows	G5	S4				3	1%	17%	Small prairie rivers
		Species verified in these Counties: Big Horn, Blaine, Carter, Custer, Daniels, Dawson, Fallon, Fergus, Garfield, McCone, Musselshell, Petroleum, Phillips, Powder River, Prairie, Richland, Rosebud, Treasure, Valley, Wibaux, Yellowstone								

INVERTEBRATES - INSECTS

6 SPECIES

FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME / COMMON NAME / TAXA SORT	FAMILY (SCIENTIFIC) / FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	CFWCS TIER ID	% OF GLOBAL BREEDING RANGE IN MT	% OF MT THAT IS BREEDING RANGE	HABITAT
DAMSELFLIES										
Argia emma Emma's Dancer	**Coenagrionidae** Narrow-winged Damselflies	G5	S3S5						74%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Blaine, Custer, Dawson, Flathead, Garfield, Hill, Lincoln, Missoula, Musselshell, Petroleum, Phillips, Powder River, Prairie, Rosebud, Teton, Valley, Yellowstone								
Enallagma civile Familiar Bluet	**Coenagrionidae** Narrow-winged Damselflies	G5	S2S4						45%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Beaverhead, Big Horn, Carter, Custer, Dawson, Fergus, Garfield, Meagher, Petroleum, Phillips, Powder River, Richland, Roosevelt, Rosebud, Yellowstone								
Enallagma praevarum Arroyo Bluet	**Coenagrionidae** Narrow-winged Damselflies	G5	S3S5						42%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Big Horn, Carter, Custer, Daniels, Dawson, Fergus, Garfield, Musselshell, Petroleum, Phillips, Powder River, Rosebud, Yellowstone								
DRAGONFLIES										
Rhionaeschna californica California Darner	**Aeshnidae** Darner Dragonflies	G5	S3S5						69%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Broadwater, Carbon, Carter, Cascade, Chouteau, Deer Lodge, Fergus, Flathead, Gallatin, Golden Valley, Granite, Hill, Jefferson, Lewis and Clark, Madison, Meagher, Missoula, Park, Petroleum, Phillips, Powell, Stillwater, Sweet Grass, Yellowstone								

Rhionaeschna multicolor Blue-eyed Darner	**Aeshnidae** Darner Dragonflies	G5	S2S4						84%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Big Horn, Blaine, Carter, Cascade, Custer, Deer Lodge, Flathead, Granite, Hill, Lewis and Clark, Liberty, Lincoln, Madison, Missoula, Powder River, Silver Bow, Yellowstone								
Sympetrum madidum Red-veined Meadowhawk	**Libellulidae** Skimmer Dragonflies	G4	S2S3						100%	Wetlands / lakes with emergent veg
		Species verified in these Counties: Beaverhead, Big Horn, Carter, Chouteau, Deer Lodge, Flathead, Glacier, Hill, Jefferson, Lake, Lewis and Clark, Lincoln, Madison, Missoula, Petroleum, Pondera, Powder River, Powell, Rosebud, Valley, Yellowstone								

Plant Species of Concern

4 Species of Concern
Filtered by the following criteria:
County = YELLOWSTONE

Species List Last Updated **04/02/2013**

MONTANA Natural Heritage Program

A program of the Montana State Library's
Natural Resource Information System
operated by the University of Montana.

Introduction

The Montana Natural Heritage Program (MTNHP) serves as the state's information source for Species of Concern (SOC) -- plants and animals that are rare, threatened, and/or have declining populations and as a result are at risk or potentially at risk of extirpation in Montana. This report is based on information gathered from field inventories, publications, reports, herbaria specimens, and the knowledge of botanists and other taxonomic experts. Taxa in the SOC category generally include all vascular plant taxa ranked S1, S2, S3 or SH. Nonvascular taxa (bryophytes and lichens) which are not as well documented or studied as vascular plant taxa in the state, are listed as SOC using similar criteria as vascular taxa but are more strictly limited to those taxa which are believed to be the rarest or most vulnerable to extirpation based on current information.

Designation as a Species of Concern is not a statutory or regulatory classification. Instead, these designations provide a basis for resource managers and decision-makers to make proactive decisions regarding species conservation and data collection priorities in order to maintain viable populations and avoid extirpation of species from the state. MTNHP may designate additional taxa as Potential Species of Concern (PSOC). Taxa in this designation include species or subspecies which may be rare, have a restricted range in the state or are otherwise vulnerable to extirpation in at least part of their range but otherwise do not meet the criteria for inclusion as a SOC. An additional designation of Status Under Review is used for those taxa for which additional information is needed to accurately assign a status rank or for which conflicting information exists. Taxa designated as Status Under Review are not included in this document but can be found in the on-line **Fieldguide (http://fieldguide.mt.gov/)**.

This web-based report, which replaces the 2006 Plant Species of Concern publication, identifies vascular plant Species of Concern (SOC), bryophyte SOC and lichen SOC in Montana. The MTNHP continuously reviews and updates status ranks as new information and data become available through field surveys, research, and submitted observations. Status ranks and information supporting them are reviewed by botanists and resource specialists. If you wish to comment or contribute information to this process please contact the MTNHP Botanist. The information we receive from botanists and others throughout the state is essential in this process, and contributes to more accurate assessments of species' status. We continue to ask that all observations for SOC, PSOC and Review Status plants be reported to the Heritage Program. A copy of the field survey form specifying the information that should be submitted is available on our **website (http://mtnhp.org/)**.

Information concerning plant species contained on the SOC, PSOC or Review lists may be viewed on the MTNHP's on-line Montana Plant Field Guide. The Field Guide provides information for vascular and non-vascular plants, including species' characteristics, identification, habitat, distribution, state rank reasons and references, as well as technical illustrations and photographs of the plants and their habitats. For each species, a link to the NatureServe website (http://www.natureserve.org/) provides access to information on the status of the species throughout North America, assembled from state and provincial Natural Heritage databases. Information in the Montana Field Guide is continuously updated and expanded, so please check it often for current species' information. If you have questions concerning the field guide or find errors or omissions please contact the MTNHP.

Status lists of SOC plants may be queried on-line by county and/or township; taxonomic group or one of several rank/status criteria. More detailed information or additional assistance can be requested from MTNHP using the Information Request function on our **website**, or by phone, e-mail or mail.

How to Read the Lists

The SOC list is organized alphabetically by scientific name (Genus and specific epithet followed by subspecific epithet if any) within the major groups of Vascular Plants, Bryophytes (Mosses and Liverworts) and Lichens. Vascular plants are further sorted by the subgroups: Ferns and Fern Allies, Gymnosperms (if any), Flowering Plants-Dicots and Flowering Plants-Monocots. The list can also be sorted alphabetically by the common name. Additional scientific names as well as the Family name are included in adjacent columns for each species. The nomenclature and taxonomy for many groups of plants continues to change as new research is conducted and published, and as a result no one nomenclatural reference is followed. Publications and web resources which are most relevant to Montana plants include Vascular Plants of Montana (Dorn 1984), NatureServe Explorer, The USDA PLANTS database, Flora of North America (1993-), Grasses of Montana (Lavin and Seibert 2011) and Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). Additionally, an abundance of scientific literature pertinent to Montana plants is available and indispensable in the process of determining the nomenclature and taxonomic concepts used in this report.

Species that have been added to or deleted from the SOC list due to changes in their global or state rank are reported in separate sections below. These changes are also reflected in the date displayed at the top of the report which shows when an addition or deletion to the list last occurred.

County Distribution

Montana counties of record are listed alphabetically with each species. County records of occurrence are determined directly from mapped species occurrences (SO's) in MTNHP databases. A record of occurrence for a particular county may be based on a historical observation which may no longer be extant. Additionally, some plant observations with vague locality information are not mapped in MTNHP databases and as result would not be included in the county distribution for that particular species.

Heritage Program Ranks

The international network of Natural Heritage Programs employs a standardized ranking system to denote **global** (range-wide) and **state** status (NatureServe 2006). Species are assigned numeric ranks ranging from 1 (highest risk, greatest concern) to 5 (demonstrably secure, least concern), reflecting the relative degree of risk to the species' viability, based upon available information. Global ranks are assigned by biologists at NatureServe (the international affiliate organization for the heritage network) in consultation with biologists in the natural heritage programs and other taxonomic experts, or by the MTNHP Botanist, who has the responsibility for reviewing and assigning global ranks for approximately 50 plant species that are either endemic to Montana or in which a large portion of the species' global range or population is within the state.

A number of factors are considered in assigning state ranks — the number, size and quality of known occurrences or populations, distribution, trends (if known), life history traits, habitat specificity, and definable threats. The process of assigning state ranks for each taxon relies heavily on factors of abundance (# of occurrences, population size and area of occupancy), viability of occurrences, threats to viability and trends in population size. The "State Rank Reason" field in the *Montana Field Guide* provides additional information on the reasons for a particular species' rank. The ranking process being used by MTNHP for plant species relies heavily on IUCN (2001) methodology and NatureServe/Heritage Network methodology presented in Master et al (2009), Faber-Langendoen et al (2009) and previously in Regan, Master and Hammerson (2004).

Rank definitions given below reflect some changes in terminology from that used by NatureServe. However, the meaning and criteria for ranks remain unchanged, to maintain consistency with international standards.

Rank		Definition
G1	**S1**	At very high risk of extinction or extirpation in the state due to **extremely limited** and/or **rapidly declining** population numbers, range and/or habitat. or extirpation in the state.
G2	**S2**	At high risk of extinction or extirpation in the state due to **very limited** and/or **declining** population numbers, range and/or habitat. or extirpation in the state.
G3	**S3**	At risk of extinction or extirpation in the state due to **limited** and/or **declining** numbers, range and/or habitat, even though it may be abundant in some areas.
G4	**S4**	Apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining.
G5	**S5**	Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range.
GX	**SX**	Presumed Extinct or Extirpated - Species is believed to be extinct throughout its range or extirpated in Montana. Not located despite intensive searches of historical sites and other appropriate habitat, and small likelihood that it will ever be rediscovered.
GH	**SH**	Historical, known only from records usually 40 or more years old; may be rediscovered.
GNR	**SNR**	Not Ranked as of yet.
GU	**SU**	Unrankable - Species currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
GNA	**SNA**	A conservation status rank is not applicable for one of the following reasons: 1) The taxa is of Hybrid Origin; is Exotic or Introduced; is Accidental or 2) is Not Confidently Present in the state. (see other codes below)

Combination or Range Ranks

G#G# or **S#S#** Indicates a range of uncertainty about the status of the species.
e.g. G1G3 = Global Rank ranges between G1 and G3 inclusive

Sub-rank

T# Rank of a subspecies or variety. Appended to the global rank of the full species, *e.g. G4T3*

Qualifiers

Q **Questionable** taxonomy that may reduce conservation priority-Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank. Appended to the global rank, *e.g. G3Q*

? Inexact Numeric Rank - Denotes uncertainty; inexactness.

Federal Status

Designations in these columns reflect the status of a species under the U.S. Endangered Species Act (ESA), or as "sensitive" by the U.S. Forest Service (USFS) or the Bureau of Land Management (BLM).

U.S. Fish and Wildlife Service (Endangered Species Act)

Status, if any of a taxon under the federal Endangered Species Act of 1973 (16 U.S.C.A. § 1531-1543 (Supp. 1996)) is noted. Regulatory aspects of the Endangered Species Act affect plants only when they occur on federal lands or may be affected by federal actions. Currently, 3 plants in Montana have designations under the U.S. Endangered Species Act.

Designation Descriptions

LE	**Listed endangered:** Any species in danger of extinction throughout all or a significant portion of its range (16 U.S.C. 1532(6)).
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)).
C	**Candidate:** Those taxa for which sufficient information on biological status and threats exists to propose to list them as threatened or endangered. We encourage their consideration in environmental planning and partnerships; however, none of the substantive or procedural provisions of the Act apply to candidate species.
DM	**Recovered, delisted, and being monitored** - Any previously listed species that is now recovered, has been delisted, and is being monitored.

Bureau of Land Management

BLM Sensitive Species are defined by the BLM 6840 Manual as those that normally occur on Bureau administered lands for which BLM has the capability to significantly affect the conservation status of the species through management. The State Director may designate additional categories of special status species as appropriate and applicable to his or her state's needs. The sensitive species designation, for species other than federally listed, proposed, or candidate species, may include such native species as those that:

1. could become endangered in or extirpated from a state, or within a significant portion of its distribution in the foreseeable future,
2. are under status review by FWS and/or NMFS,
3. are undergoing significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution,
4. are undergoing significant current or predicted downward trends in population or density such that federally listed, proposed, candidate, or State listed status may become necessary,
5. have typically small and widely dispersed populations,
6. are inhabiting ecological refugia, specialized or unique habitats, or
7. are State listed but which may be better conserved through application of BLM sensitive species status. Such species should be managed to the level of protection required by State laws or under the BLM policy for candidate species, whichever would provide better opportunity for its conservation.

Designation Descriptions

Sensitive	Denotes species listed as sensitive on BLM lands
Special Status	Denotes species that are listed as Endangered or Threatened under the Endangered Species Act

U.S. Forest Service

U.S. Forest Service Manual (2670.22) defines Sensitive Species on Forest Service lands as those for which population viability is a concern as evidenced by a significant downward trend in population or a significant downward trend in habitat capacity. The Regional Forester (Northern Region) designates Sensitive species on National Forests in Montana. These designations were last updated in 2007 and they apply only on USFS-administered lands.

Designation Descriptions

Endangered	Listed as Endangered (LE) under the U.S. Endangered Species Act.
Threatened	Listed as Threatened (LT) under the U.S. Endangered Species Act.
Sensitive	Listed as a Sensitive Species by USFS Northern Region (R1).

Acknowledgements

We would like to gratefully acknowledge the many people who contributed information on plant species' occurrences and distribution throughout Montana over the years -- those contributions are the building blocks of the MTNHP databases and this publication. We encourage you to continue submitting data for SOC, PSOC and Under Review taxa so that status ranks and this document are as accurate and comprehensive as possible.

Selected References

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- USDA, NRCS. *The PLANTS Database* (**http://plants.usda.gov**). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Contact Information

For questions or comments specific to this publication or for specific plant related questions, please contact:

Scott Mincemoyer
Program Botanist
smincemoyer@mt.gov
(406) 444-2817

For general questions and botany-related data requests please use the Information Request function on our website **(www.mtnhp.org)** or the general MTNHP contact info below.

Montana Natural Heritage Program	
P.O. Box 201800	Phone: (406) 444-5354
1515 E. 6th Ave.	Fax: (406) 444-0581
Helena, MT 59620-1800	E-mail: mtnhp@mt.gov

Species of Concern
4 Species
Filtered by the following criteria:
County = YELLOWSTONE

FLOWERING PLANTS - DICOTS (MAGNOLIOPSIDA)

4 SPECIES
FILTERED BY THE FOLLOWING CRITERIA:
COUNTY = YELLOWSTONE

SCIENTIFIC NAME COMMON NAME TAXA SORT	OTHER NAMES	FAMILY (SCIENTIFIC) FAMILY (COMMON)	GLOBAL RANK	STATE RANK	USFWS	USFS	BLM	MNPS THREAT CATEGORY	HABITAT
Ammannia robusta Scarlet Ammannia	**Ammannia coccinea ssp. robusta**	**Lythraceae** Loosestrife Family	G5	S2					Wetland/Riparian
			Species verified in these Counties: Phillips, Valley, Yellowstone **State Rank Reason:** Known from a few extant populations and a historical collection in northeastern Montana. Likely occurs in additional wetlands in Montana east of the Continental Divide, though many of these would be on private lands and are unlikely to be surveyed for its presence.						
Bacopa rotundifolia Roundleaf Water-hyssop		**Plantaginaceae** Plantain Family	G5	S3?				3	Wetland/Riparian
			Species verified in these Counties: Cascade, Fergus, Garfield, Phillips, Yellowstone **State Rank Reason:** A rare species known in Montana from only a few observations in the central and eastern portions of the state. However, the species is widely distributed and appears tolerant of brackish waters as well as some degree of nutrient enrichment. As such, it is unclear to what extent the species' viability is at risk in the state and whether it responds negatively to human-induced impacts to water quality. Additional populations of the species are likely to occur in Montana.						
Ipomoea leptophylla Bush morning-glory		**Convolvulaceae** Morning-glory Family	G3G5	S1S2					Prairie
			Species verified in these Counties: Big Horn, Rosebud, Treasure, Yellowstone **State Rank Reason:** Known in Montana from only a few collections in the southeastern part of the state, only 1 of these collections was in the last 2 decades. This is a very conspicuous, attractive species, so it is probably not undercollected.						
Rorippa calycina Persistent-sepal Yellow-cress		**Brassicaceae** Mustards	G3	SH			SENSITIVE		Wetland/Riparian
			Species verified in these Counties: Big Horn, Custer, McCone, Rosebud, Treasure, Yellowstone **State Rank Reason:** *Rorippa calycina* is a regional endemic currently known only from four Montana records. The species was last observed in Montana more than 30 years ago. Surveys are needed.						

Potential Species of Concern

0 Species

Filtered by the following criteria:

County = YELLOWSTONE

Jonathan Weaver

From: James Boyd [james_boyd@fws.gov]
Sent: Thursday, May 09, 2013 11:29 AM
To: Jonathan Weaver
Subject: T&E species list for Yellowstone County

Jonathan–

Here is the latest list of T&E (and candidate) species for Yellowstone County. These species are known to occur within the boundaries of Yellowstone County; however, there appears to be no suitable habitat for any of these species within your project area. Thus, no adverse impacts from your project are expected for any of these species. Let me know if you need anything else. Thanks.

YELLOWSTONE COUNTY		
Mustela nigripes	Black-footed Ferret	LE
Grus americana	Whooping Crane	LE
Centrocercus urophasianus	Greater Sage-Grouse	C
Anthus spragueii	Sprague's Pipit	C

LE=Listed as Endangered, C=Candidate species (candidate for federal listing)

James Boyd
Fish and Wildlife Biologist
Listing and Recovery
USFWS, Helena Field Office, MT
406-449-5225 ex. 216
james_boyd@fws.gov

U.S. Fish and Wildlife Service

National Wetlands Inventory

Laurel WTP Intake, EA

May 31, 2013

Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

Riparian

- Herbaceous
- Forested/Shrub

Riparian Status

- Digital Data

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

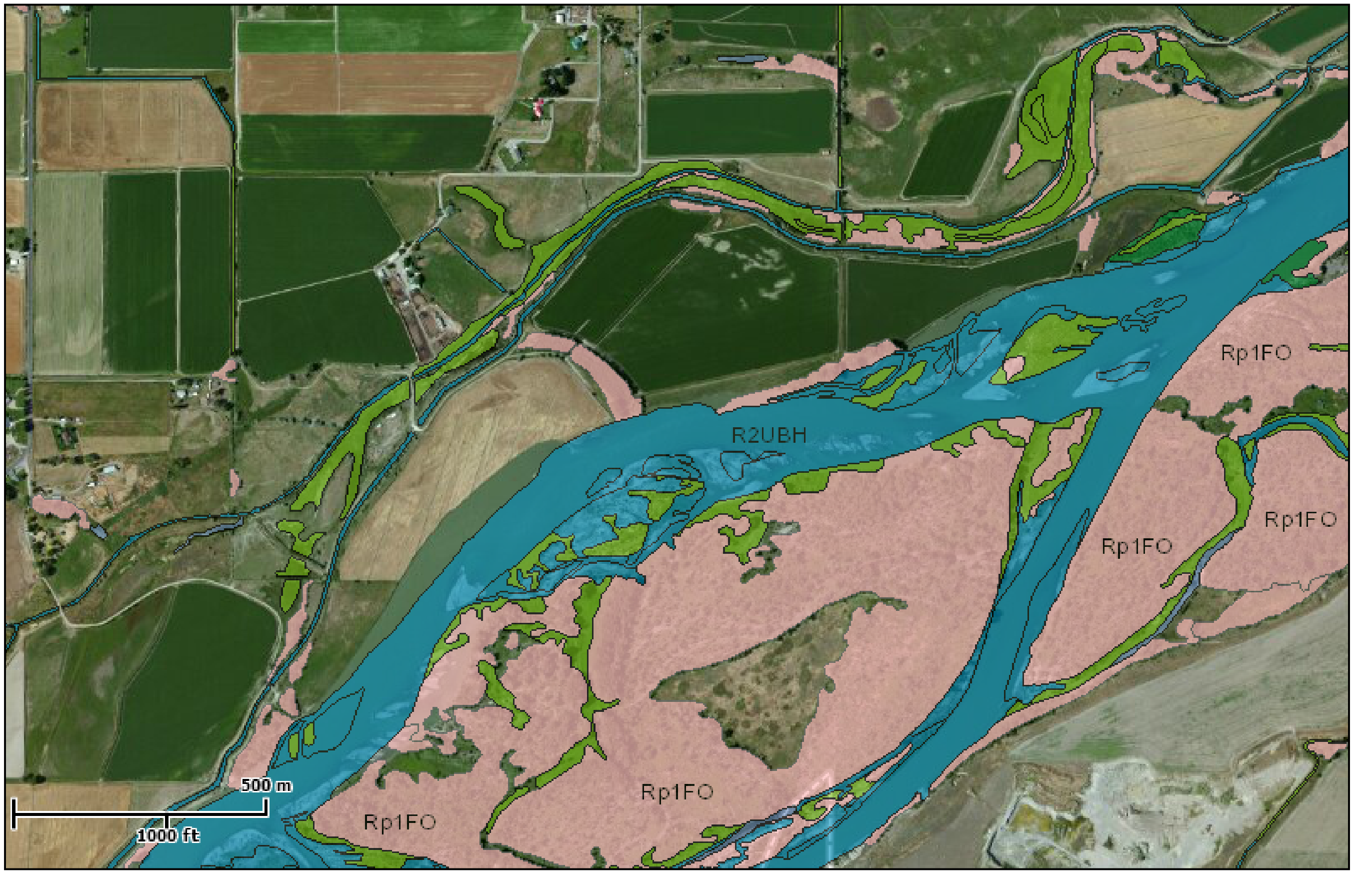
User Remarks:

U.S. Fish and Wildlife Service

National Wetlands Inventory

Laurel WTP Intake, EA

May 31, 2013



Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

Riparian

- Herbaceous
- Forested/Shrub

Riparian Status

- Digital Data

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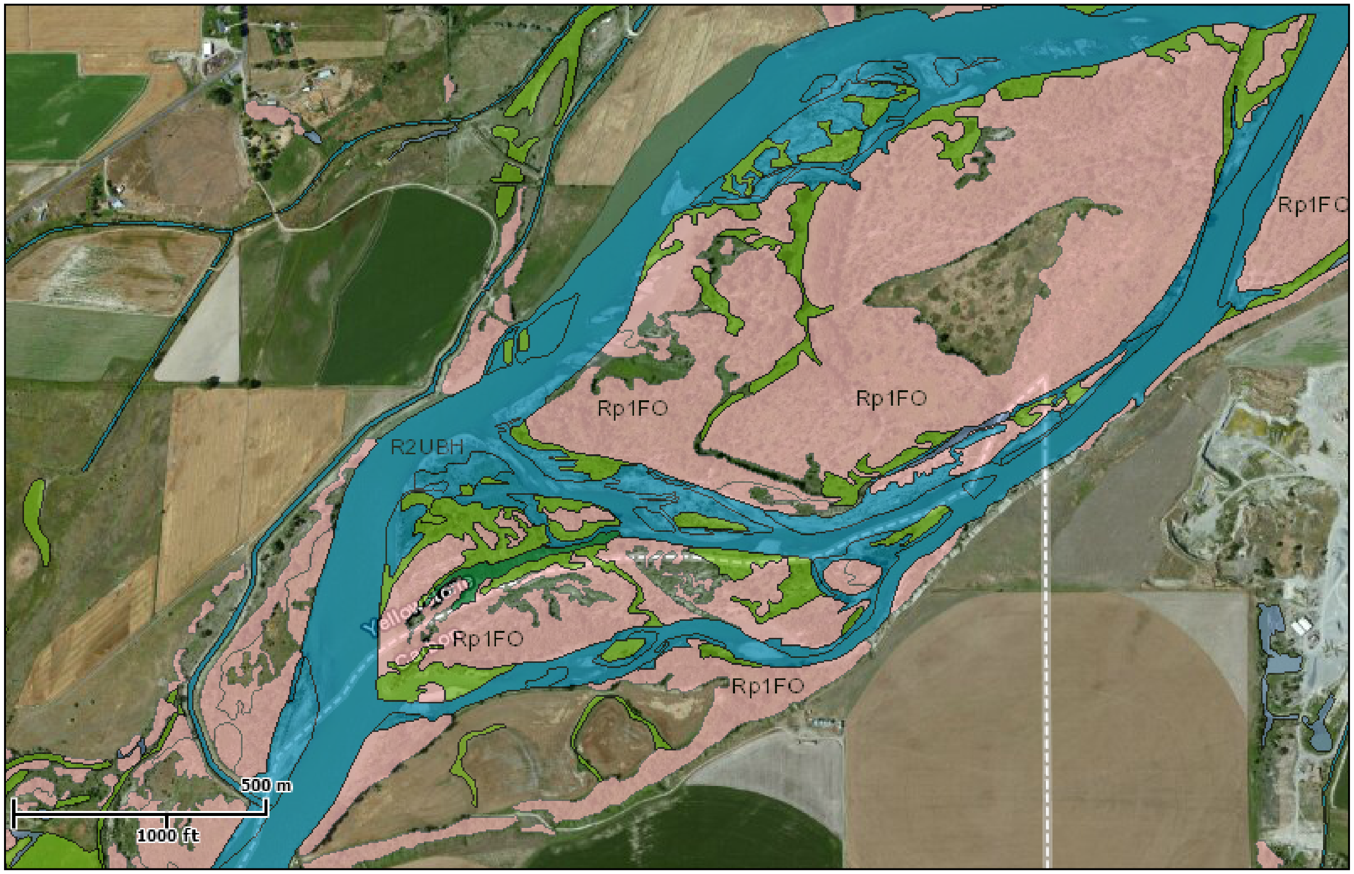
User Remarks:

U.S. Fish and Wildlife Service

National Wetlands Inventory

Laurel WTP Intake, EA

May 31, 2013



Wetlands

- Freshwater Emergent
- Freshwater Forested/Shrub
- Estuarine and Marine Deepwater
- Estuarine and Marine
- Freshwater Pond
- Lake
- Riverine
- Other

Riparian

- Herbaceous
- Forested/Shrub

Riparian Status

- Digital Data

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

User Remarks:

Laurel (city), Montana

People QuickFacts	Laurel	Montana
Population, 2012 estimate	6,931	1,005,141
Population, 2010 (April 1) estimates base	6,718	989,417
Population, percent change, April 1, 2010 to July 1, 2012	3.2%	1.6%
Population, 2010	6,718	989,415
Persons under 5 years, percent, 2010	7.2%	6.3%
Persons under 18 years, percent, 2010	25.3%	22.6%
Persons 65 years and over, percent, 2010	15.9%	14.8%
Female persons, percent, 2010	52.0%	49.8%
White persons, percent, 2010 (a)	95.3%	89.4%
Black persons, percent, 2010 (a)	0.4%	0.4%
American Indian and Alaska Native persons, percent, 2010 (a)	1.5%	6.3%
Asian persons, percent, 2010 (a)	0.4%	0.6%
Native Hawaiian and Other Pacific Islander, percent, 2010 (a)	Z	0.1%
Persons reporting two or more races, percent, 2010	2.1%	2.5%
Persons of Hispanic or Latino origin, percent, 2010 (b)	3.0%	2.9%
White persons not Hispanic, percent, 2010	93.0%	87.8%
Living in same house 1 year & over, percent, 2007-2011	88.5%	83.7%
Foreign born persons, percent, 2007-2011	0.7%	2.0%
Language other than English spoken at home, percent age 5+, 2007-2011	0.9%	4.6%
High school graduate or higher, percent of persons age 25+, 2007-2011	88.1%	91.4%
Bachelor's degree or higher, percent of persons age 25+, 2007-2011	21.2%	28.2%
Veterans, 2007-2011	533	99,163
Mean travel time to work (minutes), workers age 16+, 2007-2011	18.3	17.9
Housing units, 2010	2,943	482,825
Homeownership rate, 2007-2011	69.9%	68.9%
Housing units in multi-unit structures, percent, 2007-2011	21.5%	16.3%
Median value of owner-occupied housing units, 2007-2011	$150,000	$179,900
Households, 2007-2011	2,760	403,495
Persons per household, 2007-2011	2.39	2.36
Per capita money income in the past 12 months (2011 dollars), 2007-2011	$21,631	$24,640
Median household income, 2007-2011	$46,530	$45,324
Persons below poverty level, percent, 2007-2011	11.5%	14.6%

Business QuickFacts	Laurel	Montana
Total number of firms, 2007	700	114,398
Black-owned firms, percent, 2007	F	0.2%
American Indian- and Alaska Native-owned firms, percent, 2007	F	2.0%
Asian-owned firms, percent, 2007	F	0.6%
Native Hawaiian and Other Pacific Islander-owned firms, percent, 2007	F	S
Hispanic-owned firms, percent, 2007	F	1.0%
Women-owned firms, percent, 2007	S	24.6%
Manufacturers shipments, 2007 ($1000)	NA	10,638,145
Merchant wholesaler sales, 2007 ($1000)	D	8,202,782
Retail sales, 2007 ($1000)	124,096	14,686,854
Retail sales per capita, 2007	$18,978	$15,343
Accommodation and food services sales, 2007 ($1000)	11,591	2,079,426

Geography QuickFacts	Laurel	Montana
Land area in square miles, 2010	2.14	145,545.80
Persons per square mile, 2010	3,133.4	6.8
FIPS Code	42700	30
Counties		

(a) Includes persons reporting only one race.
(b) Hispanics may be of any race, so also are included in applicable race categories.

D: Suppressed to avoid disclosure of confidential information
F: Fewer than 25 firms
FN: Footnote on this item for this area in place of data
NA: Not available
S: Suppressed; does not meet publication standards

X: Not applicable
Z: Value greater than zero but less than half unit of measure shown

Source U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, County Business Patterns, Economic Census, Survey of Business Owners, Building Permits, Census of Governments
Last Revised: Tuesday, 28-May-2013 09:47:58 EDT

mt.gov Montana's Official State Website (http://mt.gov/)

DEPARTMENT OF ENVIRONMENTAL QUALITY (/)

(#ctl00_SiteMapPath1_SkipLink) Home (/default.mcpx) » Hazardous Waste (/hazwaste/default.mcpx) » RCRA Permitted Sites (/hazwaste/RCRA/default.mcpx) » RCRA Permitted Facilities Fact Sheets (/hazwaste /RCRA/RCRAFactSheets/default.mcpx) » CHS Laurel Refinery (/hazwaste/RCRA/RCRAFactSheets /CHS/default.mcpx) » CHS Incorporated Laurel Refinery Fact Sheet

Waste and Underground Tank Management Bureau

CHS Inc. Laurel Refinery
Laurel, Montana

FACILITY FACT SHEET

(/HazWaste/RCRA/RCRA_Fact_Sheets/CHS/RCRA_CHS_Map.htm) Location Map (/HazWaste/RCRA/RCRA_Fact_Sheets/CHS/RCRA_CHS_Map.htm)

(../../../images/RCRA_CHS_COKER.jpg)

View across the CAMU towards construction of the refinery coker (2007)

(../../../images /RCRA_CHS_GROUNDWATER_SAMPLING.jpg)

Groundwater Sampling


(../../../images/RCRA_CHS_LNAPL.jpg)

LNAPL Recovery from a CAMU Monitoring Well

FACILITY BACKGROUND

CHS owns and operates a 42,000 barrel per day refinery in Laurel. The refinery has been in operation since the 1930s. Fuel products include propane, gasoline, burner fuel, diesel fuel, asphalt propane de-asphalted pitch, and road oil.

The original owner and operator of the Laurel Refinery was Independent Refining Company. Farmer Union Central Exchange, Inc. (CENEX) purchased the refinery in the 1940's. In 1998, CENEX merged with Harvest States Grain to form Cenex Harvest States Cooperatives, the current owner of the refinery. Subsequently, Cenex Harvest States Cooperatives was shortened to CHS, Inc.

Top (#top)

REGULATORY BACKGROUND

The Resource Conservation and Recovery Act (RCRA (/HazWaste/Glossary.mcpx#Resource Conservation and Recovery Act (RCRA))) is the federal law which requires proper management and disposal of hazardous waste. Hazardous waste permits are required for on-site units that are used t treat, store or dispose of hazardous waste. Hazardous waste permits must also include provisions requiring facility-wide investigation and remediation of releases of hazardous waste or hazardous constituents. The Montana Hazardous Waste Act (MHWA) is the State equivalent of RCRA.

The State of Montana issued a hazardous waste permit to CHS, Inc. in 1991 for the closure and post-closure care of the facility's two inactive land treatment units. In addition, because the State o Montana was not yet authorized by EPA to implement facility-wide corrective action, EPA issued a federal permit to CHS that same year. The EPA permit required facility-wide investigation of releases and potential releases of hazardous waste or hazardous constituents.

In 2000, the State was approved by EPA to implement facility-wide corrective action. This enabled Montana Department of Environmental Quality (MDEQ) to combine requirements for closure and post-closure care of the land treatment unit with requirements for facility-wide corrective action in a single permit, which was issued in 2002.

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CURRENT STATUS

Facility-Wide Corrective Action

EPA conducted a RCRA facility assessment (RFA (/HazWaste/Glossary.mcpx#RCRA Facility Assessment (RFA))) at the Laurel refinery in 1989. The RFA identified 32 areas needing further investigation for potential contamination in soils and groundwater. CHS conducted a RCRA Facility Investigation (RFI (/hazwaste/Glossary.mcpx#RCRA Facility Investigation (RFI))) from 1991 to

2006, which identified the nature and extent of hazardous constituents in soils and both ground and surface water at the facility. In addition, a baseline risk assessment was conducted to determine the areas of contamination at the facility which posed risk to human and ecological health.

Concurrent to the RFI work, CHS implemented Interim Measures (IM (/HazWaste/Glossary.mcpx#Interim Measures (IM))) at the refinery boundary to halt off-site migration of contaminants in groundwater. The IM technologies include air sparging fences, pump and treat well systems, and a slurry wall barrier. CHS also implemented measures, in the form of a pump and trea system, to stabilize and remove Light Non-aqueous Phase Liquid (LNAPL (/hazwaste/Glossary.mcpx#Light Non-Aqueous Phase Liquid (LNAPL))) from the groundwater in the refinery interior.

CHS conducted a Corrective Measures Study (CMS (/HazWaste/Glossary.mcpx#Corrective Measures Study (CMS))) to evaluate remedial technologies and approaches for remediating contaminated media at the facility. CHS then submitted a CMS report to the MDEQ, which is currently under review. Following review of the CMS report, the MDEQ will choose a remedy for the facility and develop a draft Statement of Basis which will outline the corrective measures CHS must take to implement a remedy for contamination at the facility. The draft Statement of Basis and Environmental Assessment will be issued for public comment. After consideration of comments, the MDEQ will finalize selection of a remedy and will modify the CHS hazardous waste permit to include requirements for implementing the remedy. CHS will then implement the remedy through a Corrective Measure Implementation work plan.

Regulated Units

An area in the southwestern portion of the refinery was used from 1965 to 1988 to treat refinery wastes. This area is comprised of two land treatment units, the Old Landfarm (OLF) and the New Landfarm (NLF). The OLF was approximately 14.5 acres and was used from 1964 through 1981. The NLF was approximately 8 acres and used from 1981 through 1988.

CHS began closure of both land treatment units in 1991, following the closure requirements as outlined in the closure/post-closure permit. The permit established standards for allowable concentrations of hydrocarbon and metal constituents in the soils. Soils with constituents above the standard were excavated in phases and placed on areas of the units where soil standards had been met. Each excavated soil volume (or 'lift') was then land treated until standards were met for that lift. In 2002, MDEQ, at the request of CHS, designated the OLF as a Corrective Action Management Unit (CAMU (/hazwaste/Glossary.mcpx#Corrective Action Management Unit (CAMU))). The NLF wa clean-closed in 2006.

Groundwater Corrective Action At the CAMU, Light Non-aqueous Phase Liquid (LNAPL) is present on the surface of the groundwater beneath the CAMU. The LNAPL consists of hydrocarbons which migrated through the land treatment soils into the groundwater. The LNAPL 'floats' on the groundwater surface and can be recovered through pumping.

As a corrective measure to address the LNAPL, CHS installed a barrier wall system to contain the contamination. The barrier wall system is composed of a bentonite slurry wall two feet wide and 15 feet deep at the downgradient edge of the CAMU. The barrier wall stops off-site contaminant migration and ponds the LNAPL along the upgradient edge of the wall. The LNAPL is pumped into recovery wells and recycled back into the refinery's petroleum refining process. Monitoring wells are located south (down gradient) of the barrier wall and are sampled regularly.

Corrective Action Management Unit (CAMU) CAMUs are physically distinct geographic areas within a facility designated for managing, treating or disposing remediation wastes generated by corrective action or cleanup at a facility. CAMU rules are found in 40 CFR 264.552 and are incorporated by reference in ARM 17.53.801.

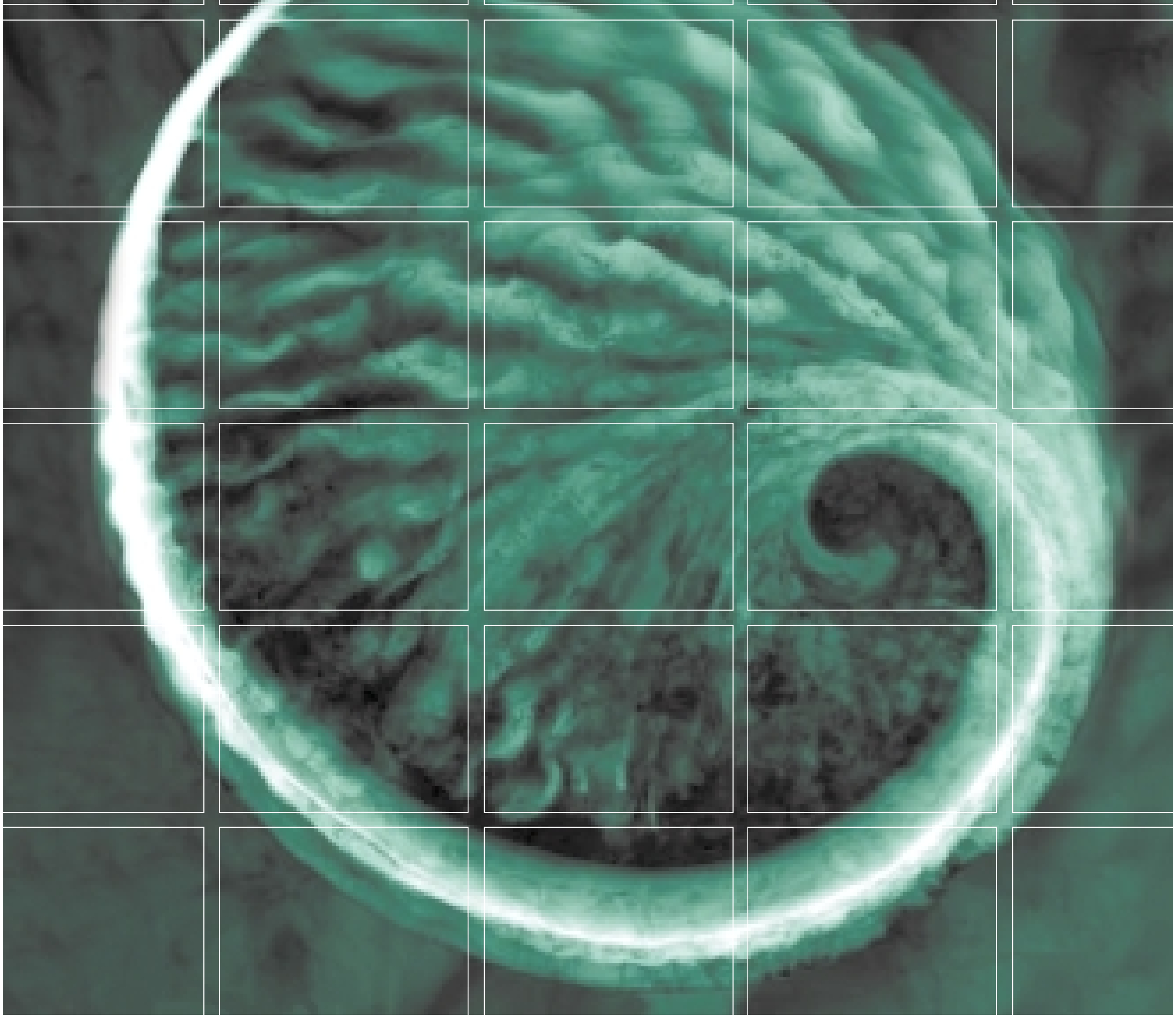
The CAMU at the CHS refinery may be used to land treat and dispose of petroleum-contaminated soi generated during corrective action activities. Types of contaminated soil expected to be treated include soils from corrective measures required by facility-wide corrective action, and soils from remediation of spills and/or excavation of contaminated soils found during facility construction or maintenance activities.

The CHS hazardous waste permit places conditions on how CHS must operate and maintain the CAMU. Concentration limits of hazardous constituents are designated for contaminated media and CAMU soils. In addition, soil nutrients (specifically carbon, nitrogen, potassium, and phosphorous) and pH must be kept within certain limits. The permit also sets requirements for tillage, as well as weed and blowing soils control and minimization. Soil and groundwater monitoring must be conducted to guard against migration of contaminants into deeper soils or groundwater. The permit also contains requirements that guard against migration of contamination into deeper soils or groundwater.

Top (#top)

FOR MORE INFORMATION

DEQ Contact:
Becky Holmes, Environmental Science Specialist
Montana Department of Environmental Quality
P.O. Box 200901
Helena, Montana 59620-0901
406-444-2876
e-mail: rholmes@mt.gov (mailto:rholmes@mt.gov)



2012 Annual Effectiveness Monitoring and Interim Stabilization Measures Report

CHS Inc.
Interim Measures Areas and South Tank Farm
CHS Refinery, Laurel, Montana

November 15, 2012

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ERM

CHS Inc.

2012 Annual Effectiveness Monitoring and Interim Stabilization Measures Report

November 15, 2012

Project No. 0153285

Interim Measures Areas and South Tank Farm
CHS Refinery, Laurel, Montana

Peter J. Gagnon, P.E. (Montana), BCEE
Partner-in-Charge

Michael L. Ross, P.G. (Texas)
Project Consultant

Drew Hisey, P.E. (Texas)
Project Manager

Rebecca S. Comeaux
Project Geologist

Environmental Resources Management
15810 Park Ten Place, Suite 300
Houston, Texas 77084-5140
T: 281-600-1000
F: 281-600-1001

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NOTES:

1. UPDATED REFINERY PROPERTY BOUNDARY BASED ON PLOT PLAN DRAWING NO. 001-MS-GEN-001-A PREPARED BY COMMON GROUND INDUSTRIES (CGI) AND RECEIVED FROM CHS IN JANUARY 2012.
2. AOC-17 INCLUDED WITHIN THE SOUTH TANK FARM.

NON-PROCESS AREA OF LAUREL REFINERY PROPERTY EXTENDS TO THE SOUTHWEST ALONG NORTH BANK OF RIVER

LEGEND

- PROGRAM AREA
- CHS REFINERY PROPERTY BOUNDARY
- RT-14 MONITOR WELL NOT IN MONITORING PROGRAM
- RW-8 RECOVERY WELL LOCATIONS
- RT-29 PROGRAM MONITOR WELL
- CEN-27 POINT OF COMPLIANCE MONITOR WELL/PIEZOMETER
- SP-1A SPARGE POINT
- OB-3 PLUGGED AND ABANDONED WELL LOCATION

Environmental Resources Management

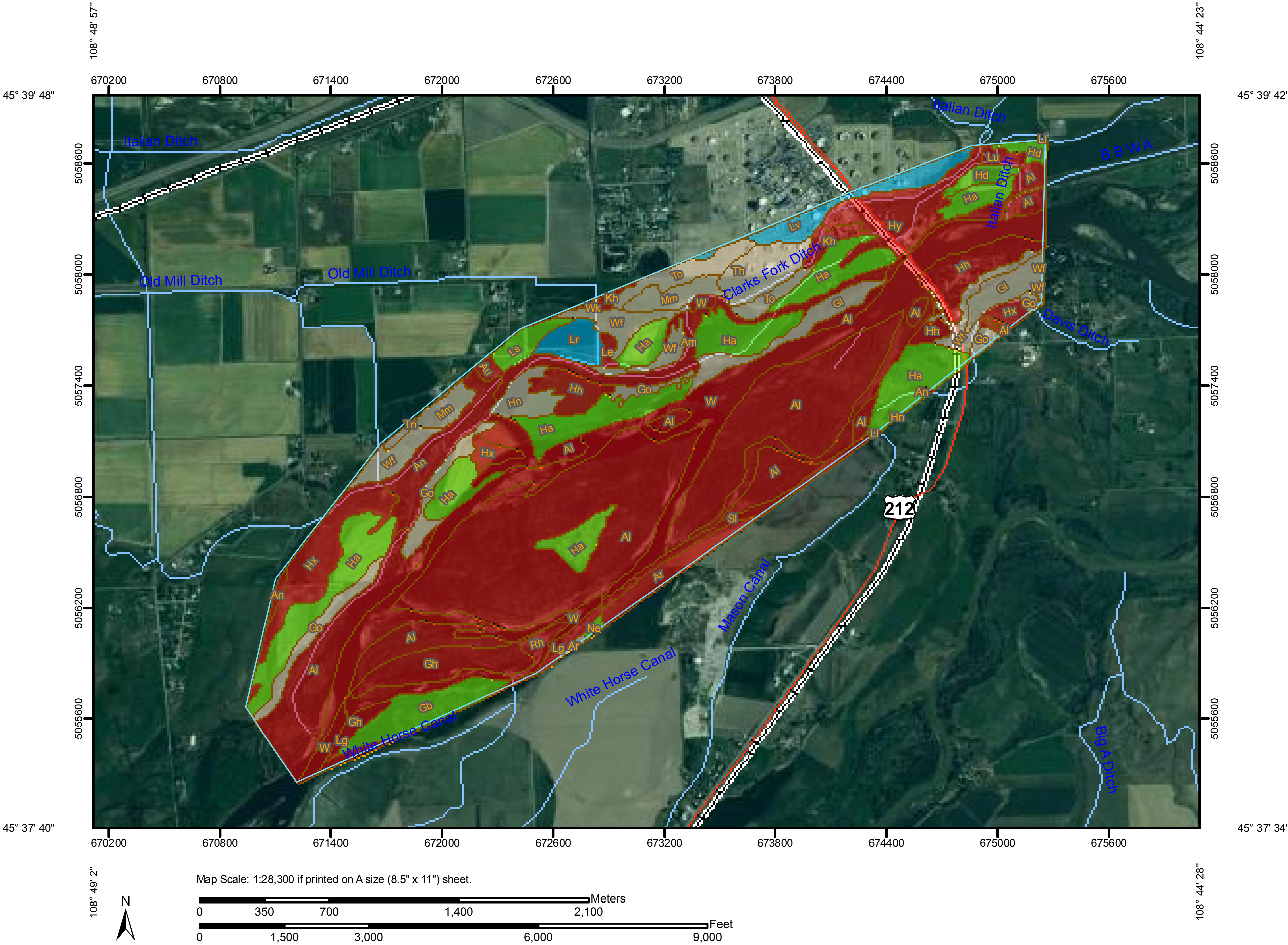
PLATE 1
SITE LOCATION MAP
CHS Refinery
Laurel, Montana

ERM

DESIGN: RSC	DRAWN: CAK	CHKD.: DH	SHEET NO.
DATE: 11/12/2012	SCALE: AS SHOWN	REV.:	1 of 1
W.O.NO.: H:\DWG\K12\0153285c215.dwg, 11/12/2012 4:57:18 PM			

ERM-Southwest, Inc. TX PE Firm No. 2393

Farmland Classification—Carbon County Area, Montana, and Yellowstone County, Montana
(Laurel, WTP Intake EA)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of local importance
- Farmland of unique importance
- Not rated or not available

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:28,300 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Carbon County Area, Montana
Survey Area Data: Version 10, May 31, 2012

Soil Survey Area: Yellowstone County, Montana
Survey Area Data: Version 11, Jan 17, 2012

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 7/12/2005; 7/8/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Farmland Classification

Farmland Classification— Summary by Map Unit — Carbon County Area, Montana (MT611)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ar	Alice fine sandy loam, 0 to 8 percent slopes	Prime farmland if irrigated	1.2	0.1%
Gb	Glenberg loam, gravel substratum	Farmland of statewide importance	31.1	2.0%
Gh	Glenberg-Haverson complex	Not prime farmland	40.2	2.6%
Lg	Larim gravelly sandy loam, 8 to 15 percent slopes	Not prime farmland	12.5	0.8%
Ne	Nelson fine sandy loam, 4 to 8 percent slopes	Farmland of statewide importance	1.7	0.1%
Rh	Riverwash	Not prime farmland	20.0	1.3%
W	Water	Not prime farmland	12.2	0.8%
Subtotals for Soil Survey Area			**118.9**	**7.6%**
Totals for Area of Interest			**1,574.4**	**100.0%**

Farmland Classification— Summary by Map Unit — Yellowstone County, Montana (MT111)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Al	Alluvial land, mixed	Not prime farmland	480.0	30.5%
Am	Alluvial land, seeped	Not prime farmland	37.3	2.4%
An	Alluvial land, wet	Not prime farmland	51.9	3.3%
Ar	Apron loamy fine sand, 4 to 7 percent slopes	Not prime farmland	20.9	1.3%
Au	Arvada clay loam, 0 to 1 percent slopes	Not prime farmland	2.9	0.2%
Gl	Glenberg loam, 0 to 1 percent slopes	Prime farmland if irrigated	38.2	2.4%
Go	Glenberg loam, 0 to 1 percent slopes	Prime farmland if irrigated	38.2	2.4%
Ha	Haverson loam, 0 to 1 percent slopes	Farmland of statewide importance	200.2	12.7%
Hd	Haverson silty clay loam, 0 to 1 percent slopes	Farmland of statewide importance	13.0	0.8%
Hh	Haverson-Hysham loams, 0 to 1 percent slopes	Not prime farmland	49.1	3.1%
Hn	Haverson loam, gravelly variant, 0 to 1 percent slopes	Prime farmland if irrigated	14.8	0.9%
Hx	Hysham-Laurel loams, 0 to 2 percent slopes	Not prime farmland	54.8	3.5%
Hy	Hysham-Laurel silty clay loams, 0 to 2 percent slopes	Not prime farmland	43.5	2.8%

Farmland Classification— Summary by Map Unit — Yellowstone County, Montana (MT111)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Kh	Keiser and Hesper silty clay loams, 0 to 1 percent slopes	Not prime farmland	9.7	0.6%
Le	Larim loam, 0 to 4 percent slopes	Not prime farmland	3.2	0.2%
Ll	Larim gravelly loam, 15 to 35 percent slopes	Not prime farmland	0.5	0.0%
Lr	Lohmiller silty clay, 0 to 1 percent slopes	Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60	15.9	1.0%
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	Farmland of statewide importance	11.6	0.7%
Lu	Lohmiller-Hysham silty clay loams, 0 to 1 percent slopes	Not prime farmland	5.1	0.3%
Lv	Lohmiller silty clay, gravelly variant, 0 to 1 percent slopes	Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60	25.8	1.6%
Mm	McRae loam, 0 to 1 percent slopes	Prime farmland if irrigated	24.1	1.5%
Sl	Shale outcrop	Not prime farmland	14.1	0.9%
Th	Toluca clay loam, 1 to 4 percent slopes	Prime farmland if irrigated	26.0	1.7%
Tn	Toluca and Wanetta clay loams, 0 to 2 percent slopes	Prime farmland if irrigated	3.2	0.2%
To	Toluca and Wanetta clay loams, 2 to 4 percent slopes	Prime farmland if irrigated	25.7	1.6%
W	Water	Not prime farmland	193.3	12.3%
Wf	Wanetta clay loam, 0 to 1 percent slopes	Prime farmland if irrigated	50.6	3.2%
Wk	Wanetta-Larim clay loams, 1 to 4 percent slopes	Not prime farmland	1.8	0.1%
Subtotals for Soil Survey Area			**1,455.5**	**92.4%**
Totals for Area of Interest			**1,574.4**	**100.0%**

Description

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Rating Options

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

United States Department of Agriculture

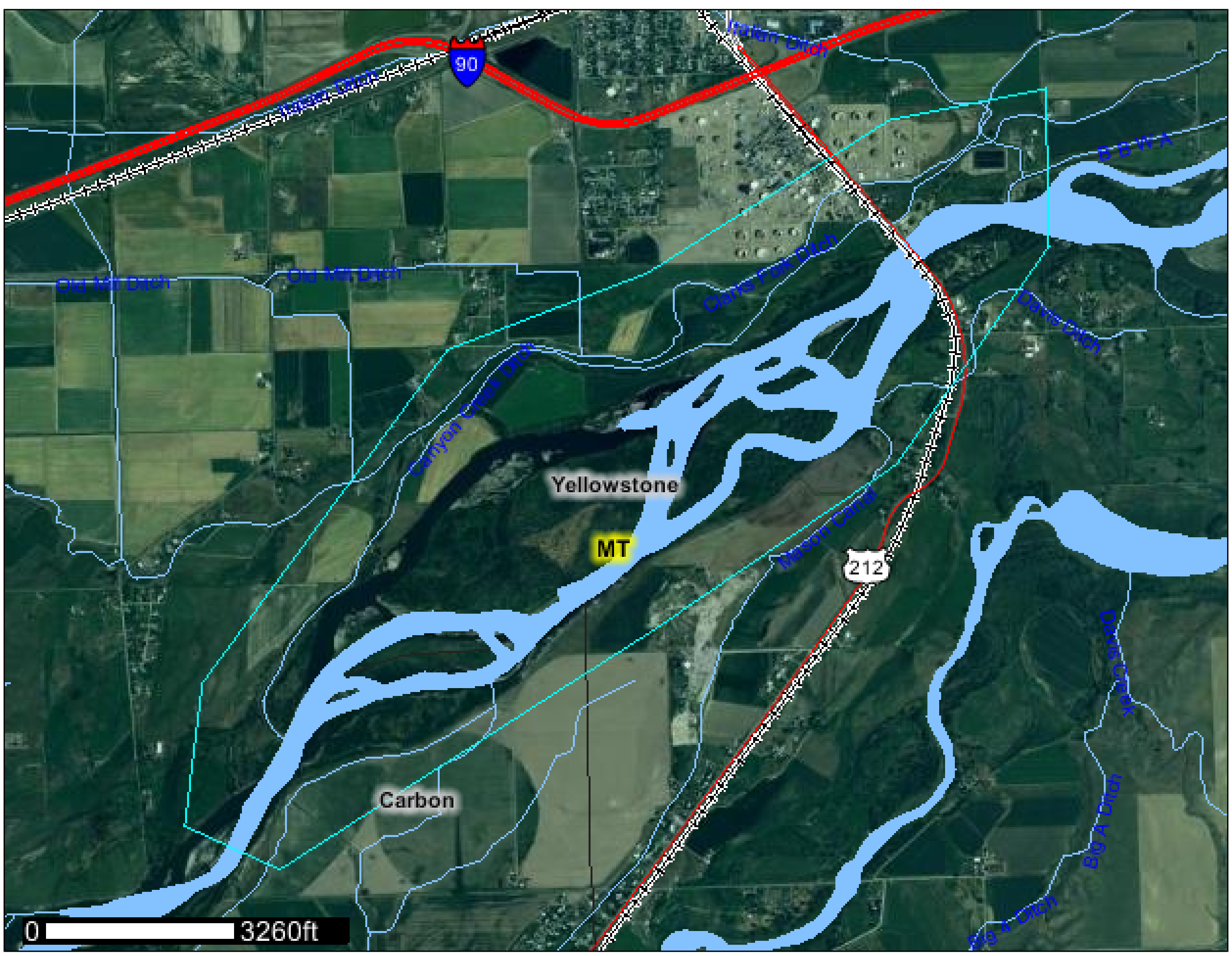
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Carbon County Area, Montana, and Yellowstone County, Montana

Laurel-WTP Intake EA



June 4, 2013

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

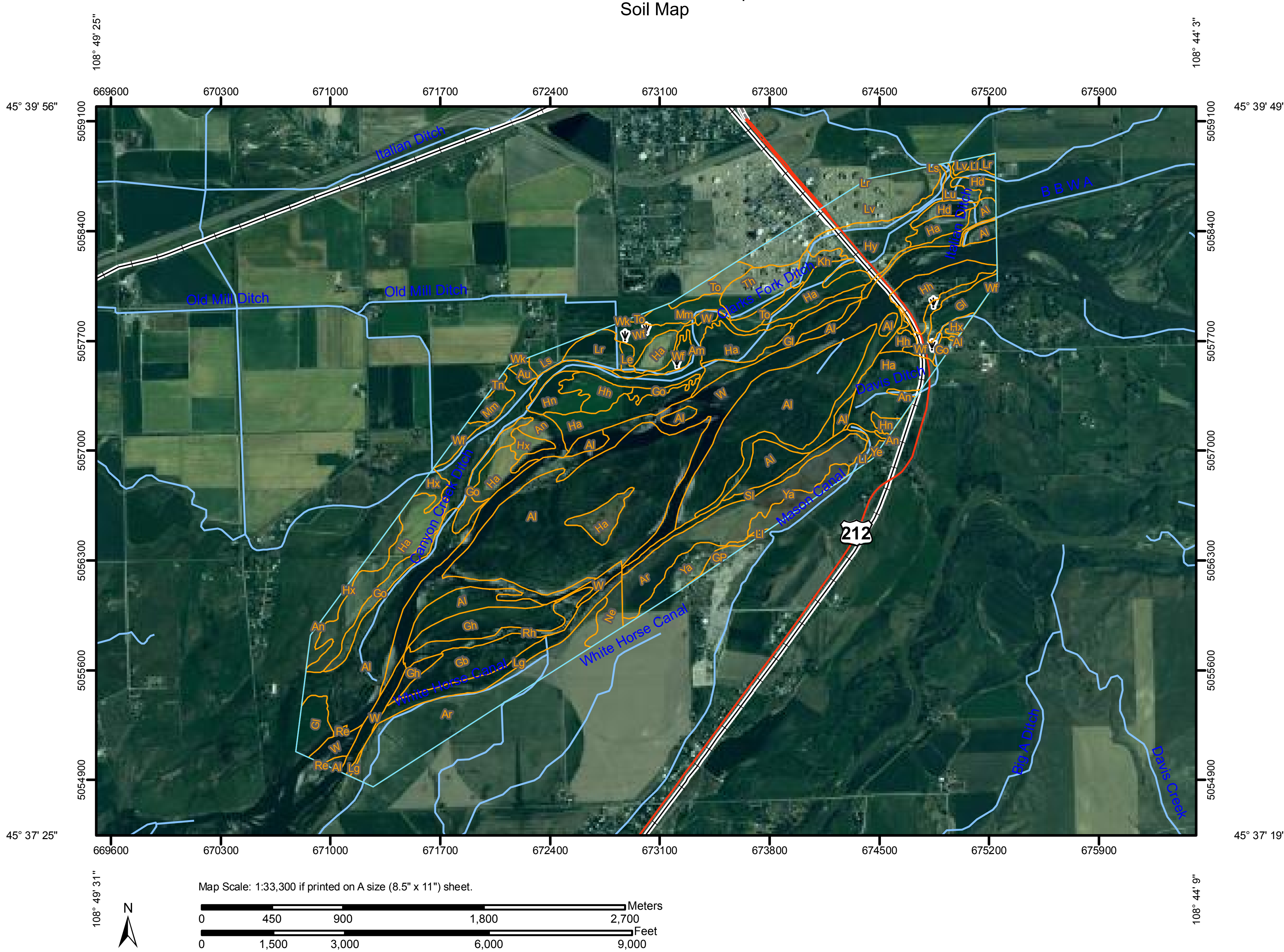
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


108° 49' 25"
108° 44' 3"
669600
670300
671000
671700
672400
673100
673800
674500
675200
675900
45° 39' 56"
45° 39' 49"
5059100
5058400
5057700
5057000
5056300
5055600
5054900
45° 37' 25"
45° 37' 19"
108° 49' 31"
108° 44' 9"
Italian Ditch
Old Mill Ditch
Old Mill Ditch
B B W A
Clarks Fork Ditch
Italian Ditch
Davis Ditch
Canyon Creek Ditch
Mason Canal
White Horse Canal
White Horse Canal
Big A Ditch
Davis Creek
212
Map Scale: 1:33,300 if printed on A size (8.5" x 11") sheet.
N
Meters
0
450
900
1,800
2,700
Feet
0
1,500
3,000
6,000
9,000

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Gully

Short Steep Slope

Other

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:33,300 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Carbon County Area, Montana
Survey Area Data: Version 10, May 31, 2012

Soil Survey Area: Yellowstone County, Montana
Survey Area Data: Version 11, Jan 17, 2012

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 7/12/2005; 7/8/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Carbon County Area, Montana (MT611)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ar	Alice fine sandy loam, 0 to 8 percent slopes	90.6	4.9%
Gb	Glenberg loam, gravel substratum	33.9	1.8%
Gh	Glenberg-Haverson complex	40.2	2.2%
Lg	Larim gravelly sandy loam, 8 to 15 percent slopes	31.3	1.7%
Ne	Nelson fine sandy loam, 4 to 8 percent slopes	11.2	0.6%
Rh	Riverwash	20.0	1.1%
W	Water	18.0	1.0%
Subtotals for Soil Survey Area		**245.3**	**13.2%**
Totals for Area of Interest		**1,863.2**	**100.0%**

Yellowstone County, Montana (MT111)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Al	Alluvial land, mixed	498.9	26.8%
Am	Alluvial land, seeped	37.3	2.0%
An	Alluvial land, wet	51.3	2.8%
Ar	Apron loamy fine sand, 4 to 7 percent slopes	70.9	3.8%
Au	Arvada clay loam, 0 to 1 percent slopes	3.5	0.2%
Gl	Glenberg loam, 0 to 1 percent slopes	52.6	2.8%
Go	Glenberg loam, 0 to 1 percent slopes	35.9	1.9%
GP	Gravel pit	4.2	0.2%
Ha	Haverson loam, 0 to 1 percent slopes	213.8	11.5%
Hd	Haverson silty clay loam, 0 to 1 percent slopes	13.9	0.7%
Hh	Haverson-Hysham loams, 0 to 1 percent slopes	49.2	2.6%
Hn	Haverson loam, gravelly variant, 0 to 1 percent slopes	18.2	1.0%
Hx	Hysham-Laurel loams, 0 to 2 percent slopes	34.1	1.8%
Hy	Hysham-Laurel silty clay loams, 0 to 2 percent slopes	44.5	2.4%
Kh	Keiser and Hesper silty clay loams, 0 to 1 percent slopes	8.0	0.4%
Le	Larim loam, 0 to 4 percent slopes	3.2	0.2%
Ll	Larim gravelly loam, 15 to 35 percent slopes	9.8	0.5%
Lr	Lohmiller silty clay, 0 to 1 percent slopes	19.3	1.0%
Ls	Lohmiller soils, seeped, 0 to 2 percent slopes	8.0	0.4%

Yellowstone County, Montana (MT111)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Lu	Lohmiller-Hysham silty clay loams, 0 to 1 percent slopes	6.4	0.3%
Lv	Lohmiller silty clay, gravelly variant, 0 to 1 percent slopes	67.3	3.6%
Mm	McRae loam, 0 to 1 percent slopes	22.4	1.2%
Re	Riverwash	0.3	0.0%
Sl	Shale outcrop	16.6	0.9%
Th	Toluca clay loam, 1 to 4 percent slopes	26.0	1.4%
Tn	Toluca and Wanetta clay loams, 0 to 2 percent slopes	1.3	0.1%
To	Toluca and Wanetta clay loams, 2 to 4 percent slopes	19.8	1.1%
W	Water	202.1	10.8%
Wf	Wanetta clay loam, 0 to 1 percent slopes	40.1	2.2%
Wk	Wanetta-Larim clay loams, 1 to 4 percent slopes	1.0	0.1%
Ya	Yegen sandy loam, 0 to 1 percent slopes	37.0	2.0%
Ye	Yegen sandy loam, 4 to 10 percent slopes	1.1	0.1%
Subtotals for Soil Survey Area		**1,617.9**	**86.8%**
Totals for Area of Interest		**1,863.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used.

Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Carbon County Area, Montana

Ar—Alice fine sandy loam, 0 to 8 percent slopes

Map Unit Setting

Elevation: 1,800 to 6,500 feet
Mean annual precipitation: 10 to 19 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 90 to 120 days

Map Unit Composition

Alice and similar soils: 95 percent
Minor components: 5 percent

Description of Alice

Setting

Landform: Plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Limy residuum weathered from sandstone

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 6.8 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: Sandy (Sy) RRU 46-S 15-19" p.z. (R046XS106MT)

Typical profile

0 to 7 inches: Fine sandy loam
7 to 45 inches: Fine sandy loam
45 to 60 inches: Loamy fine sand

Minor Components

Rentsac

Percent of map unit: 3 percent
Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Shallow (Sw) RRU 46-S 13-19" p.z. (R046XS114MT)

Cabba

Percent of map unit: 2 percent

Landform: Plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Shallow (Sw) RRU 46-S 13-19" p.z. (R046XS114MT)

Gb—Glenberg loam, gravel substratum

Map Unit Setting

Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 125 to 130 days

Map Unit Composition

Glenberg and similar soils: 85 percent
Minor components: 15 percent

Description of Glenberg

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 5.2 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B

Typical profile

0 to 6 inches: Loam
6 to 24 inches: Stratified very fine sandy loam to silt loam
24 to 60 inches: Very gravelly sand

Minor Components

Heldt

Percent of map unit: 8 percent
Landform: Alluvial fans, stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Haverson

Percent of map unit: 7 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear

Gh—Glenberg-Haverson complex

Map Unit Setting

Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 125 to 130 days

Map Unit Composition

Glenberg and similar soils: 50 percent
Haverson and similar soils: 40 percent
Minor components: 10 percent

Description of Glenberg

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Low (about 5.2 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B

Typical profile

0 to 6 inches: Loam
6 to 24 inches: Stratified very fine sandy loam to silt loam
24 to 60 inches: Very gravelly sand

Description of Haverson

Setting

Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4e
Land capability (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 10 inches: Silty clay loam
10 to 60 inches: Stratified fine sandy loam to clay loam

Minor Components

Heldt

Percent of map unit: 10 percent
Landform: Alluvial fans, stream terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Lg—Larim gravelly sandy loam, 8 to 15 percent slopes

Map Unit Setting

Elevation: 2,400 to 5,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 110 to 120 days

Map Unit Composition

Larim and similar soils: 95 percent
Minor components: 5 percent

Description of Larim

Setting

Landform: Scarps on terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly alluvium

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy (Sy) RRU 58A-C 11-14" p.z. (R058AC042MT)

Typical profile

0 to 4 inches: Gravelly sandy loam
4 to 10 inches: Very gravelly clay loam
10 to 60 inches: Very gravelly sand

Minor Components

Olney

Percent of map unit: 3 percent
Landform: Outwash terraces

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Sandy (Sy) RRU 58A-C 11-14" p.z. (R058AC042MT)

Midway

Percent of map unit: 2 percent
Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow (Sw) RRU 58A-C 11-14" p.z. (R058AC057MT)

Ne—Nelson fine sandy loam, 4 to 8 percent slopes

Map Unit Setting

Elevation: 2,900 to 5,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 110 to 120 days

Map Unit Composition

Nelson and similar soils: 95 percent
Minor components: 5 percent

Description of Nelson

Setting

Landform: Plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 4 to 8 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 4e
Land capability (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy (Sy) RRU 58A-C 11-14" p.z. (R058AC042MT)

Typical profile

0 to 6 inches: Fine sandy loam

6 to 30 inches: Fine sandy loam
30 to 60 inches: Unweathered bedrock

Minor Components

Travessilla
Percent of map unit: 5 percent
Landform: Plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow (Sw) RRU 58A-C 11-14" p.z. (R058AC057MT)

Rh—Riverwash

Map Unit Setting
Elevation: 2,400 to 6,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 110 to 120 days

Map Unit Composition
Riverwash: 90 percent
Minor components: 10 percent

Minor Components

Flooded soils
Percent of map unit: 10 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) 9-14" p.z. (R044XS338MT)

W—Water

Map Unit Setting
Mean annual precipitation: 12 to 14 inches
Frost-free period: 120 to 135 days

Map Unit Composition
Water: 100 percent

Yellowstone County, Montana

Al—Alluvial land, mixed

Map Unit Setting

Landscape: Valleys
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Alluvial land and similar soils: 98 percent
Minor components: 2 percent

Description of Alluvial Land

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 to 42 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 2.3 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 6w
Hydrologic Soil Group: B/D
Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Typical profile

0 to 5 inches: Gravelly loam
5 to 60 inches: Extremely gravelly sand

Minor Components

Havre

Percent of map unit: 2 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-E 10-14" p.z. (R058AE001MT)

Am—Alluvial land, seeped

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Alluvial land and similar soils: 85 percent
Minor components: 15 percent

Description of Alluvial Land

Setting

Landform: Terraces, fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: High (about 10.2 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 6 inches: Clay loam
6 to 60 inches: Clay loam

Minor Components

Haverson

Percent of map unit: 8 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Glenberg

Percent of map unit: 7 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

An—Alluvial land, wet

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Alluvial land and similar soils: 90 percent
Minor components: 10 percent

Description of Alluvial Land

Setting

Landform: Channels
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 6.8 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 3w
Land capability (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: Wet Meadow (WM) RRU 58A-C 11-14" p.z. (R058AC043MT)

Typical profile

0 to 10 inches: Loam
10 to 40 inches: Gravelly loam
40 to 60 inches: Very gravelly loamy sand

Minor Components

Haverson

Percent of map unit: 5 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Glenberg

Percent of map unit: 5 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Ar—Apron loamy fine sand, 4 to 7 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 5,000 feet
Mean annual precipitation: 11 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Apron and similar soils: 80 percent
Minor components: 20 percent

Description of Apron

Setting

Landform: Hills
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from calcareous sandstone

Properties and qualities

Slope: 4 to 7 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Sands (Sa) RRU 58A-C 11-14" p.z. (R058AC056MT)

Typical profile

0 to 2 inches: Loamy fine sand
2 to 60 inches: Loamy sand

Minor Components

Worland

Percent of map unit: 8 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Sandy (Sy) RRU 58A-C 11-14" p.z. (R058AC042MT)

Travessilla

Percent of map unit: 6 percent
Landform: Hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Shallow Limy (SwLy) RRU 58A-C 10-14" p.z. (R058AC641MT)

Blown-out land

Percent of map unit: 6 percent

Au—Arvada clay loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 2,500 to 4,500 feet
Mean annual precipitation: 12 to 15 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 115 to 135 days

Map Unit Composition

Arvada and similar soils: 80 percent
Minor components: 20 percent

Description of Arvada

Setting

Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: 0 to 8 inches to natric
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 30.0
Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 6s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 4 inches: Loam
4 to 28 inches: Clay
28 to 60 inches: Clay loam

Minor Components

Bone

Percent of map unit: 12 percent
Landform: Fans, terraces, lakebeds (relict)
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Saline Upland (SU) RRU 58A-C 11-14" p.z. (R058AC050MT)

Hydro

Percent of map unit: 8 percent
Landform: Low hills, fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear

Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Gl—Glenberg loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Glenberg and similar soils: 80 percent
Minor components: 20 percent

Description of Glenberg

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm)
Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 10 inches: Sandy loam
10 to 48 inches: Loamy fine sand
48 to 60 inches: Very gravelly loamy sand

Minor Components

Haverson

Percent of map unit: 10 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Lohmiller

Percent of map unit: 10 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Go—Glenberg loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Glenberg and similar soils: 80 percent
Minor components: 20 percent

Description of Glenberg

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)

Available water capacity: Moderate (about 6.0 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 6 inches: Loam
6 to 30 inches: Loamy sand
30 to 60 inches: Very gravelly sand

Minor Components

Haverson

Percent of map unit: 10 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Lohmiller

Percent of map unit: 10 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

GP—Gravel pit

Map Unit Composition

Pits, gravel: 100 percent

Ha—Haverson loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Haverson and similar soils: 80 percent
Minor components: 20 percent

Description of Haverson

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.7 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 5 inches: Loam
5 to 68 inches: Stratified fine sandy loam to clay loam

Minor Components

Glenberg

Percent of map unit: 10 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Lohmiller

Percent of map unit: 10 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Hd—Haverson silty clay loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Haverson and similar soils: 85 percent
Minor components: 15 percent

Description of Haverson

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.6 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 12 inches: Clay loam
12 to 68 inches: Stratified fine sandy loam to clay loam

Minor Components

Haverson

Percent of map unit: 9 percent

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Lohmiller
Percent of map unit: 6 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Hh—Haverson-Hysham loams, 0 to 1 percent slopes

Map Unit Setting
Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition
Haverson and similar soils: 60 percent
Hysham and similar soils: 30 percent
Minor components: 10 percent

Description of Haverson

Setting
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities
Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.7 inches)

Interpretive groups
Farmland classification: Not prime farmland

Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 5 inches: Loam
5 to 68 inches: Stratified fine sandy loam to clay loam

Description of Hysham

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 36 to 72 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Stratified fine sandy loam to clay loam

Minor Components

Lohmiller

Percent of map unit: 6 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Glenberg

Percent of map unit: 4 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave

Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Hn—Haverson loam, gravelly variant, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Haverson and similar soils: 85 percent
Minor components: 15 percent

Description of Haverson

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 36 to 72 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Available water capacity: Moderate (about 6.0 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B

Typical profile

0 to 5 inches: Loam
5 to 30 inches: Stratified very fine sandy loam to silt loam
30 to 60 inches: Extremely gravelly sand

Minor Components

Haverson

Percent of map unit: 9 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Glenberg

Percent of map unit: 6 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Hx—Hysham-Laurel loams, 0 to 2 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 34 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Hysham and similar soils: 60 percent
Laurel and similar soils: 30 percent
Minor components: 10 percent

Description of Hysham

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Calcium carbonate, maximum content: 5 percent
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 6s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Stratified fine sandy loam to clay loam

Description of Laurel

Setting

Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (16.0 to 32.0 mmhos/cm)
Sodium adsorption ratio, maximum: 30.0
Available water capacity: Low (about 5.4 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 7w
Hydrologic Soil Group: C
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Typical profile

0 to 10 inches: Loam
10 to 60 inches: Stratified loam to fine sandy loam

Minor Components

Lohmiller

Percent of map unit: 5 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Haverson

Percent of map unit: 4 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Lallie

Percent of map unit: 1 percent
Landform: Oxbows
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Subirrigated (Sb) RRU 58A-E 10-14" p.z. (R058AE008MT)

Hy—Hysham-Laurel silty clay loams, 0 to 2 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Hysham and similar soils: 55 percent
Laurel and similar soils: 35 percent
Minor components: 10 percent

Description of Hysham

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)

Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 6s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Typical profile

0 to 7 inches: Loam
7 to 60 inches: Stratified fine sandy loam to clay loam

Description of Laurel

Setting

Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (16.0 to 32.0 mmhos/cm)
Sodium adsorption ratio, maximum: 30.0
Available water capacity: Low (about 5.4 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 7w
Hydrologic Soil Group: C
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Typical profile

0 to 10 inches: Loam
10 to 60 inches: Stratified loam to fine sandy loam

Minor Components

Lohmiller

Percent of map unit: 5 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Haverson

Percent of map unit: 5 percent

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Kh—Keiser and Hesper silty clay loams, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 4,500 feet
Mean annual precipitation: 11 to 14 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Hesper and similar soils: 45 percent
Keiser and similar soils: 45 percent
Minor components: 10 percent

Description of Keiser

Setting

Landform: Low hills, terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)
Available water capacity: High (about 10.1 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 3 inches: Silt loam
3 to 9 inches: Silty clay
9 to 23 inches: Silty clay loam
23 to 60 inches: Silt loam

Description of Hesper

Setting

Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 9.8 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 2 inches: Silt loam
2 to 17 inches: Silty clay loam
17 to 44 inches: Clay loam
44 to 60 inches: Very fine sandy loam

Minor Components

Lambert

Percent of map unit: 4 percent
Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Clapper

Percent of map unit: 4 percent
Landform: Terraces, fans
Landform position (three-dimensional): Riser
Down-slope shape: Convex, linear
Across-slope shape: Linear

Ecological site: Saline Upland (SU) RRU 58A-C 11-14" p.z. (R058AC050MT)

Wanetta

Percent of map unit: 2 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Le—Larim loam, 0 to 4 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,600 to 3,400 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 34 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Larim and similar soils: 85 percent
Minor components: 15 percent

Description of Larim

Setting

Landform: Terraces, terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Convex, linear
Across-slope shape: Linear
Parent material: Gravelly alluvium

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B

Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Typical profile

0 to 5 inches: Loam
5 to 16 inches: Gravelly clay loam
16 to 60 inches: Extremely gravelly loamy sand

Minor Components

Wanetta

Percent of map unit: 13 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Mckenzie

Percent of map unit: 2 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Overflow (Ov) RRU 58A-C 11-14" p.z. (R058AC045MT)

Ll—Larim gravelly loam, 15 to 35 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 4,500 feet
Mean annual precipitation: 11 to 14 inches
Mean annual air temperature: 39 to 50 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Larim and similar soils: 80 percent
Minor components: 20 percent

Description of Larim

Setting

Landform: Terraces, terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Convex, linear
Across-slope shape: Linear
Parent material: Gravelly alluvium

Properties and qualities

Slope: 15 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Very low (about 2.3 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Typical profile

0 to 10 inches: Gravelly loam
10 to 60 inches: Extremely gravelly sand

Minor Components

Clapper

Percent of map unit: 8 percent
Landform: Terraces, fans
Landform position (three-dimensional): Riser
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: Thin Silty (TSi) RRU 46-S 15-19" p.z. (R046XS110MT)

Bainville

Percent of map unit: 8 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Steep 11-14" p.z. Deleted. Refer to site: R058AC049MT (R058AC046MT)

Elso

Percent of map unit: 4 percent
Landform: Hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Clayey-Steep (CyStp) RRU 58A-C 11-14" p.z. Deleted. Refer to site: R058A (R058AC047MT)

Lr—Lohmiller silty clay, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet

Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Lohmiller and similar soils: 85 percent
Minor components: 15 percent

Description of Lohmiller

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water capacity: High (about 9.0 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 4s
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 9 inches: Silty clay
9 to 42 inches: Stratified clay to silty clay loam
42 to 60 inches: Stratified silty clay loam to fine sandy loam

Minor Components

Haverson

Percent of map unit: 6 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Hysham

Percent of map unit: 5 percent
Landform: Flood plains, terraces

Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear

Glenberg

Percent of map unit: 4 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Ls—Lohmiller soils, seeped, 0 to 2 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 34 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Lohmiller and similar soils: 80 percent
Minor components: 20 percent

Description of Lohmiller

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 48 to 60 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (2.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.6 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 4w
Land capability (nonirrigated): 4w

Hydrologic Soil Group: C

Typical profile

0 to 3 inches: Silty clay loam
3 to 60 inches: Stratified silty clay to silty clay loam

Minor Components

Haverson

Percent of map unit: 15 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Hydro

Percent of map unit: 3 percent
Landform: Low hills, fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Lallie

Percent of map unit: 2 percent
Landform: Oxbows
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Subirrigated (Sb) RRU 58A-E 10-14" p.z. (R058AE008MT)

Lu—Lohmiller-Hysham silty clay loams, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Lohmiller and similar soils: 50 percent
Hysham and similar soils: 45 percent
Minor components: 5 percent

Description of Lohmiller

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread

Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Very slightly saline to slightly saline (4.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 20.0
Available water capacity: Moderate (about 8.7 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 4e
Hydrologic Soil Group: C

Typical profile

0 to 9 inches: Silty clay loam
9 to 60 inches: Silty clay loam

Description of Hysham

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Slightly saline to moderately saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 13.0
Available water capacity: Moderate (about 6.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B

Typical profile

0 to 7 inches: Loam

7 to 60 inches: Stratified fine sandy loam to clay loam

Minor Components

Haverson

Percent of map unit: 5 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Lv—Lohmiller silty clay, gravelly variant, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 34 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Lohmiller and similar soils: 80 percent
Haverson and similar soils: 18 percent
Minor components: 2 percent

Description of Lohmiller

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 9 inches: Silty clay
9 to 35 inches: Silty clay
35 to 60 inches: Gravelly loamy fine sand

Description of Haverson

Setting

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 9.6 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 12 inches: Clay loam
12 to 68 inches: Stratified fine sandy loam to clay loam

Minor Components

Lallie

Percent of map unit: 2 percent
Landform: Oxbows
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Subirrigated (Sb) RRU 58A-E 10-14" p.z. (R058AE008MT)

Mm—McRae loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Foothills, plains
Elevation: 1,900 to 6,600 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 36 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Mcrae and similar soils: 85 percent
Minor components: 15 percent

Description of Mcrae

Setting

Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear
Parent material: Loamy alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 10.3 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 5 inches: Loam
5 to 11 inches: Loam
11 to 60 inches: Loam

Minor Components

Fort collins

Percent of map unit: 9 percent
Landform: Terraces, fans
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Hysham

Percent of map unit: 6 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Concave, linear
Ecological site: Saline Lowland (SL) RRU 58A-C 11-14" p.z. (R058AC051MT)

Re—Riverwash

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 6,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Riverwash: 90 percent
Minor components: 10 percent

Minor Components

Havre

Percent of map unit: 5 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-E 10-14" p.z. (R058AE001MT)

Haverson

Percent of map unit: 3 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Silty (Si) RRU 58A-E 10-14" p.z. (R058AE001MT)

Glenberg

Percent of map unit: 2 percent

Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, concave
Ecological site: Sandy (Sy) RRU 58A-E 10-14" p.z. (R058AE003MT)

Sl—Shale outcrop

Map Unit Setting

Landscape: Plains
Mean annual precipitation: 12 to 14 inches
Frost-free period: 120 to 135 days

Map Unit Composition

Rock outcrop, shale: 90 percent
Minor components: 10 percent

Minor Components

Lismas

Percent of map unit: 10 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Shale (Sh) RRU 58A-C 11-14" p.z. (R058AC052MT)

Th—Toluca clay loam, 1 to 4 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 1,900 to 4,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Toluca and similar soils: 85 percent
Minor components: 15 percent

Description of Toluca

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities
Slope: 1 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups
Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 3e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile
0 to 5 inches: Clay loam
5 to 12 inches: Clay loam
12 to 35 inches: Loam
35 to 60 inches: Stratified very gravelly loam to very gravelly sand

Minor Components

Wanetta
Percent of map unit: 9 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Lambert
Percent of map unit: 6 percent
Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Tn—Toluca and Wanetta clay loams, 0 to 2 percent slopes

Map Unit Setting
Landscape: Plains

Elevation: 3,000 to 4,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 45 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Wanetta and similar soils: 85 percent
Minor components: 15 percent

Description of Wanetta

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 6.4 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B

Typical profile

0 to 5 inches: Clay loam
5 to 12 inches: Clay loam
12 to 32 inches: Loam
32 to 60 inches: Very gravelly loamy sand

Minor Components

Keiser

Percent of map unit: 15 percent
Landform: Low hills, terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

To—Toluca and Wanetta clay loams, 2 to 4 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 3,000 to 4,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 45 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Wanetta and similar soils: 85 percent
Minor components: 15 percent

Description of Wanetta

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 2 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 5 inches: Clay loam
5 to 12 inches: Clay loam
12 to 38 inches: Loam
38 to 60 inches: Very gravelly loamy sand

Minor Components

Keiser

Percent of map unit: 15 percent
Landform: Low hills, terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

W—Water

Map Unit Setting

Mean annual precipitation: 12 to 14 inches
Frost-free period: 120 to 135 days

Map Unit Composition

Water: 100 percent

Wf—Wanetta clay loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 2,400 to 5,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 39 to 50 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Wanetta and similar soils: 80 percent
Minor components: 20 percent

Description of Wanetta

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Typical profile

0 to 8 inches: Clay loam
8 to 17 inches: Clay loam
17 to 26 inches: Loam
26 to 60 inches: Very gravelly loamy sand

Minor Components

Bew

Percent of map unit: 7 percent
Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey (Cy) RRU 58A-C 11-14" p.z. (R058AC041MT)

Larim

Percent of map unit: 7 percent
Landform: Terraces, terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Toluca

Percent of map unit: 6 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Wk—Wanetta-Larim clay loams, 1 to 4 percent slopes

Map Unit Setting

Landscape: Plains
Elevation: 2,400 to 5,000 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 39 to 48 degrees F
Frost-free period: 120 to 135 days

Map Unit Composition

Wanetta and similar soils: 70 percent
Larim and similar soils: 25 percent
Minor components: 5 percent

Description of Wanetta

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 1 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 2e
Land capability (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: Silty (Si) RRU 58A-C 11-14" p.z. (R058AC040MT)

Typical profile

0 to 8 inches: Clay loam
8 to 17 inches: Clay loam
17 to 26 inches: Loam
26 to 60 inches: Very gravelly loamy sand

Description of Larim

Setting

Landform: Terraces, terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Convex, linear
Across-slope shape: Linear
Parent material: Gravelly alluvium

Properties and qualities

Slope: 3 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability classification (irrigated): 4s
Land capability (nonirrigated): 6s
Hydrologic Soil Group: B
Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Typical profile

0 to 5 inches: Loam
5 to 16 inches: Gravelly clay loam
16 to 60 inches: Extremely gravelly loamy sand

Minor Components

Larim

Percent of map unit: 5 percent
Landform: Terraces, terraces
Landform position (three-dimensional): Riser, tread
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: Shallow to Gravel (SwGr) RRU 58A-C 11-14" p.z. (R058AC194MT)

Ya—Yegen sandy loam, 0 to 1 percent slopes

Map Unit Setting

Landscape: Foothills
Elevation: 1,900 to 5,000 feet

Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 110 to 125 days

Map Unit Composition

Yegen and similar soils: 85 percent
Minor components: 15 percent

Description of Yegen

Setting

Landform: Fans, hills, terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear, concave
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.7 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance
Land capability classification (irrigated): 4e
Land capability (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy (Sy) RRU 46-S 15-19" p.z. (R046XS106MT)

Typical profile

0 to 6 inches: Sandy loam
6 to 23 inches: Sandy clay loam
23 to 64 inches: Sandy loam

Minor Components

Danvers

Percent of map unit: 6 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Silty (Si) RRU 46-S 13-19" p.z. (R046XS104MT)

Work

Percent of map unit: 6 percent
Landform: Fans, terraces
Landform position (three-dimensional): Tread

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Silty (Si) RRU 46-S 13-19" p.z. (R046XS104MT)

Absarokee

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Silty (Si) RRU 46-S 13-19" p.z. (R046XS104MT)

Ye—Yegen sandy loam, 4 to 10 percent slopes

Map Unit Setting

Landscape: Foothills
Elevation: 1,900 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 39 to 45 degrees F
Frost-free period: 110 to 125 days

Map Unit Composition

Yegen and similar soils: 80 percent
Minor components: 20 percent

Description of Yegen

Setting

Landform: Fans, hills, terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear, concave
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 4 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.7 inches)

Interpretive groups

Farmland classification: Farmland of statewide importance

Land capability classification (irrigated): 4e
Land capability (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy (Sy) RRU 46-S 15-19" p.z. (R046XS106MT)

Typical profile

0 to 6 inches: Sandy loam
6 to 23 inches: Sandy clay loam
23 to 64 inches: Sandy loam

Minor Components

Absarokee

Percent of map unit: 9 percent
Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Silty (Si) RRU 46-S 13-19" p.z. (R046XS104MT)

Work

Percent of map unit: 6 percent
Landform: Fans, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Draft Silty (Si) RRU 46-S 13-19" p.z. (R046XS104MT)

Rock outcrop

Percent of map unit: 5 percent

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APPENDIX F – WESTERN GROUNDWATER SERVICES. FEBRUARY 2014. GROUNDWATER ALTERNATIVES ANALYSIS, CITY OF LAUREL, MONTANA

Great West Engineering, Inc.

Groundwater Alternatives Analysis

City of Laurel
Laurel, Montana

WESTERN
GROUNDWATER
SERVICES

Western Groundwater Services, LLC
6595 Bear Claw Lane
Bozeman, MT 59715
Tel (406) 585-5947

GROUNDWATER ALTERNATIVES ANALYSIS
CITY OF LAUREL, MONTANA

Prepared for:

Great West Engineering, Inc.
Helena, Montana

MONTANA
MARK CUNNANE
12340PE
REGISTERED
PROFESSIONAL ENGINEER

February 10, 2014

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1 INTRODUCTION

The City of Laurel operates a public water system sourced from the Yellowstone River. Due to scouring of the riverbed and the subsequent loss of water surface elevation caused by the flooding of 2011, the existing intake can lose capacity resulting in water shortages. Engineered alterations to the channel as a means to improve the water intake are faced with environmental challenges. Given these circumstances, the development of groundwater in hydraulic connection with the river channel may be a viable option to restore or at least augment source capacity.

This report evaluates selected alternatives for development of a source water intake through groundwater adjacent to and in hydraulic connection with the Yellowstone River. The target capacity for a groundwater source intake is 20 million gallons per day (MGD), the equivalent of the City's existing intake when originally constructed.

A completely new source of water for the City developed from groundwater away from the Yellowstone River is not considered feasible, and so was not included in the alternatives analysis. There are no viable aquifers in proximity to Laurel away from the river channel and which could meet the design requirements. The City also owns water rights on the Yellowstone River which can be applied to a new intake location from this same source, but likely cannot be applied to a different source water. Should a viable groundwater source exist elsewhere, the City likely could obtain water rights only by purchase or lease from existing appropriators. It is therefore most sensible that the City remain sourced from the Yellowstone River.

Great West Engineering, Inc. is the City's consulting engineer tasked with identifying viable alternatives for the source water intake. Western Groundwater Services, LLC completed this groundwater alternatives analysis as a subconsultant to Great West Engineering.

2 HYDROGEOLOGY

Work completed to assess groundwater conditions in the vicinity of Laurel was entirely based on existing data obtained from published reports and maps, and State well log records.

2.1 Geology

The Billings-Laurel area local groundwater occurs within what are called terrace alluvial deposits designated as Qal, Qt1, Qt2, and Qt3, and shown on the geologic map of Figure 2-1. The terraces formed from ancestral Yellowstone River deposits as the river was down cutting. The contacts have associated scarps, as the younger terrace was deposited at lower elevation than the next older terrace (i.e., terrace Qt1 is lower than Qt2 which is lower than Qt3). The Qal unit represents the modern deposits of the present day river.

By this mode of deposition, the terrace deposits, and the associated aquifers tend to be isolated from one another. One exception to this isolation is the Qt1 and Qal contact, which is considered to be hydraulically continuous (Olson and Reiten 2002). The cross section shown on Figure 2-2 illustrates these relations.

This information indicates that groundwater source intakes must be located in the Qt1/Qal aquifer, as this aquifer has direct hydraulic connection to the Yellowstone River. The Qt2 and Qt3 aquifers are not directly connected to the river. The Qt1/Qal aquifer is outlined on Figure 2-1. The thickness of the aquifer and the permeability of the materials are of critical concern for site selection of a groundwater source.

2.2 Regional Studies

Prior work in the Laurel area has been completed by Gosling and Pashley (1973), Hutchinson (1983), and Olson and Reiten (2002). These studies were reviewed for specific data pertaining to aquifer hydraulic properties and saturated thickness.

Aquifer saturated thickness determinations were made using contours of the water table and the bedrock surface underlying the aquifer, as shown on Figures 2-3 and 2-4. Contours were digitized into AutoCad and subsequently imported into ArcGIS where they were converted to raster images and clipped to the extent of the Qt1/Qal aquifer. Raster math was applied to obtain the saturated thickness of the aquifer, shown by shading. The results of this analysis proved unfruitful as the data were found to be inconsistent with well logs to a large degree. The analysis shown on Figure 2-4 even includes negative thicknesses.

There was very limited compilation of aquifer hydraulic properties in the regional studies. Data reported and considered relevant are shown on Figure 2-5. Although some of these data are from the Qt2 and Qt3 terraces, it is generally considered that the three terraces have similar hydraulic properties (Olson and Reiten 2002).

Billings 1:100,000 Quadrangle Map from MBMG website

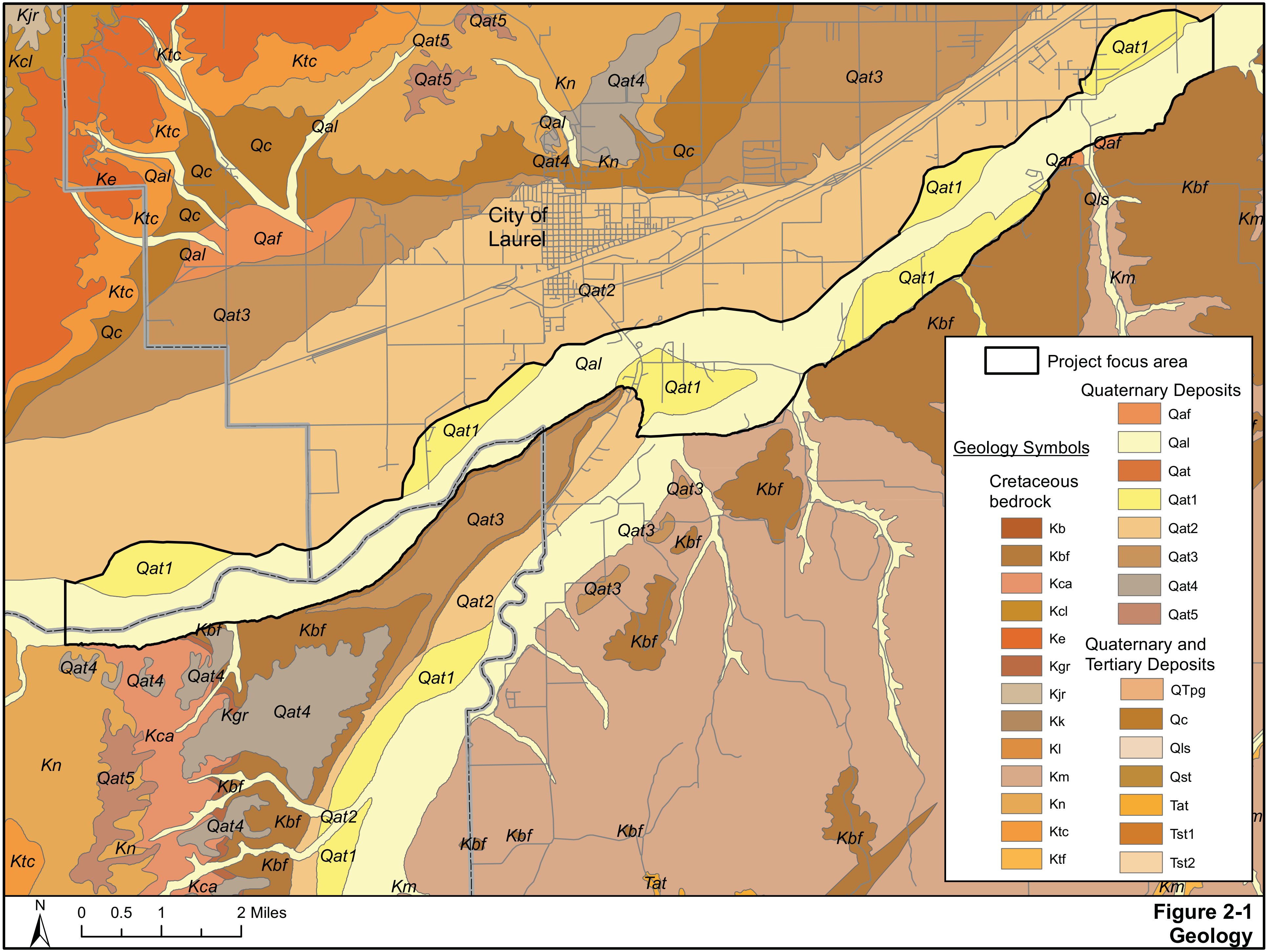


Figure 2-1
Geology

Western Groundwater Services

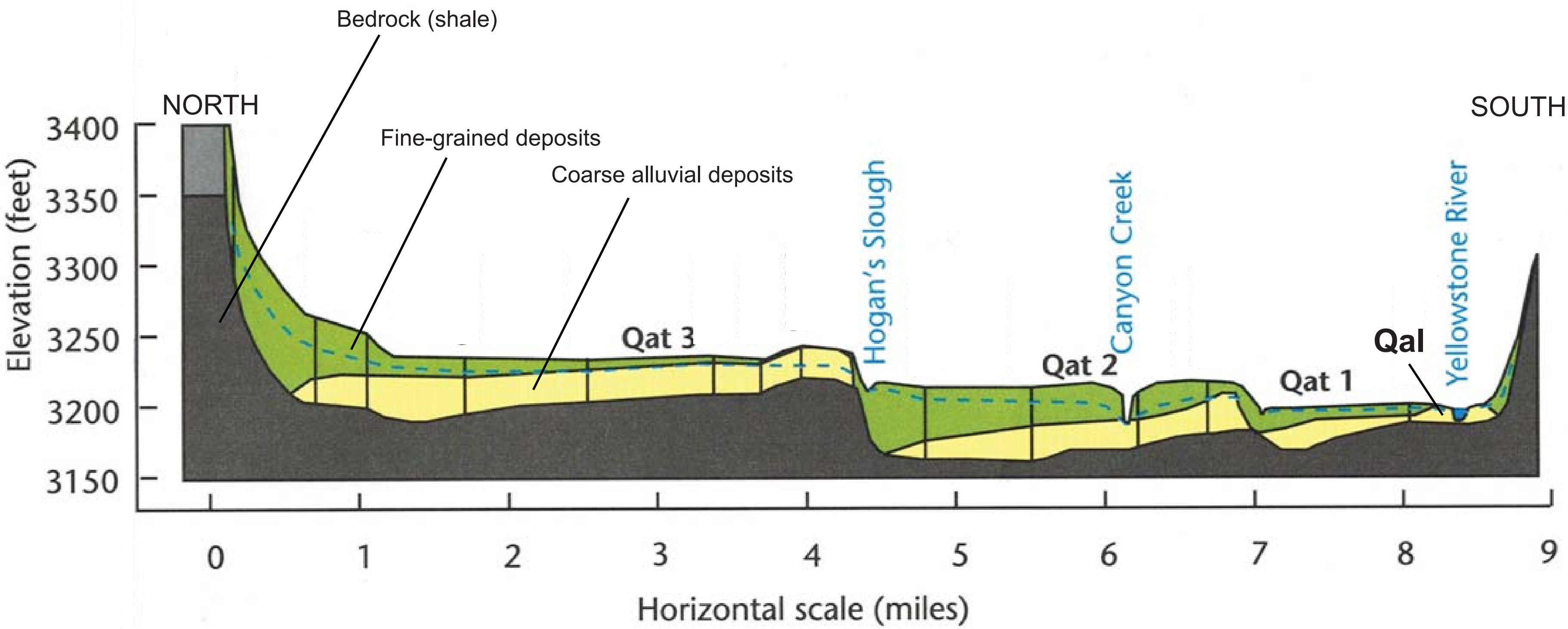


Illustration is from MBMG RI-10 Hydrogeologic Cross Section A-A',
located approximately 7-miles east of Laurel (Olson and Reiten 2002).

Figure 2-2
Hydrogeologic Cross Section

USGS HA-454, Gosling and Pashley (1973)

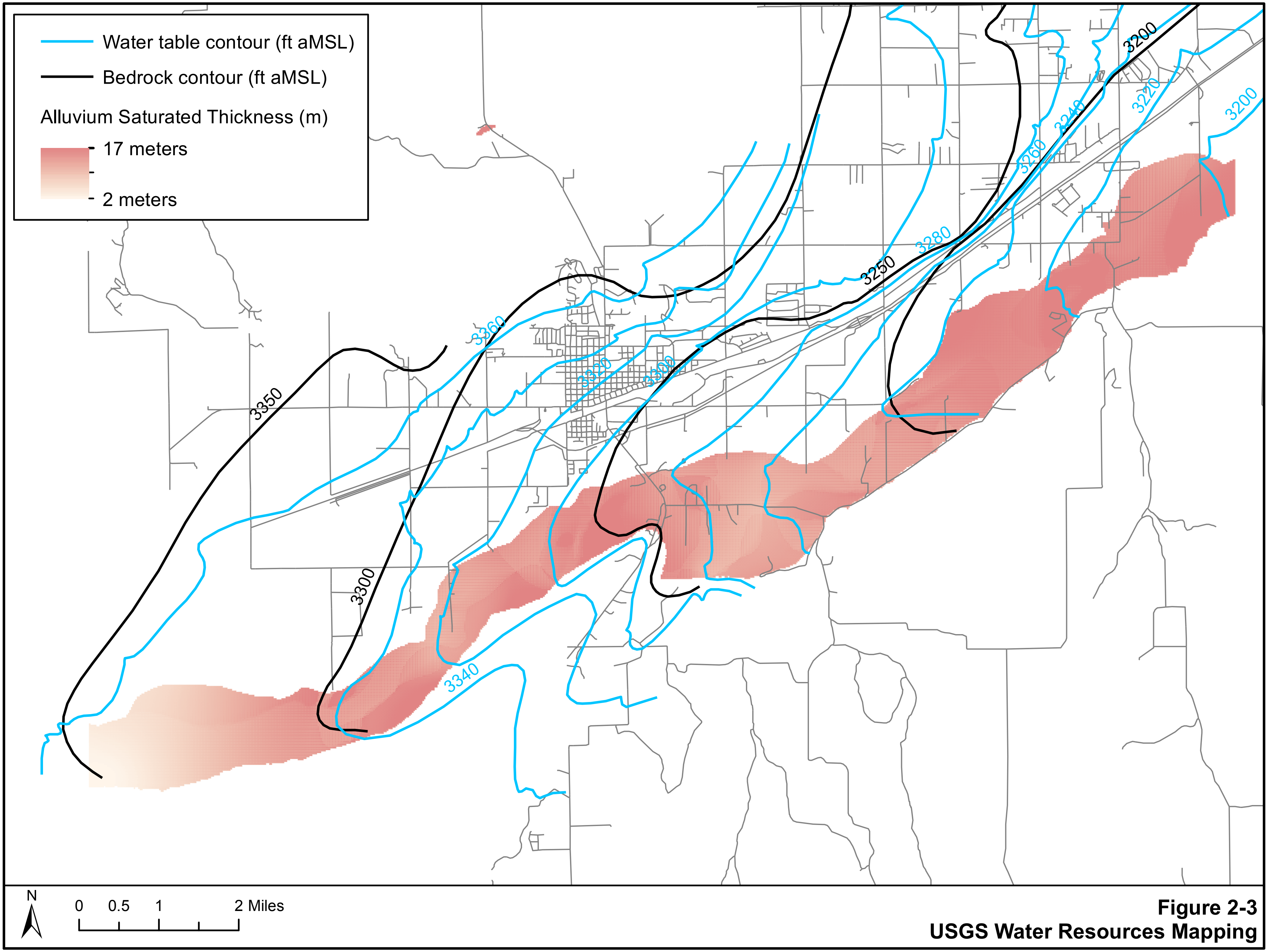


Figure 2-3
USGS Water Resources Mapping

MBMG Hydrogeologic Map 6, Hutchinson (1983)

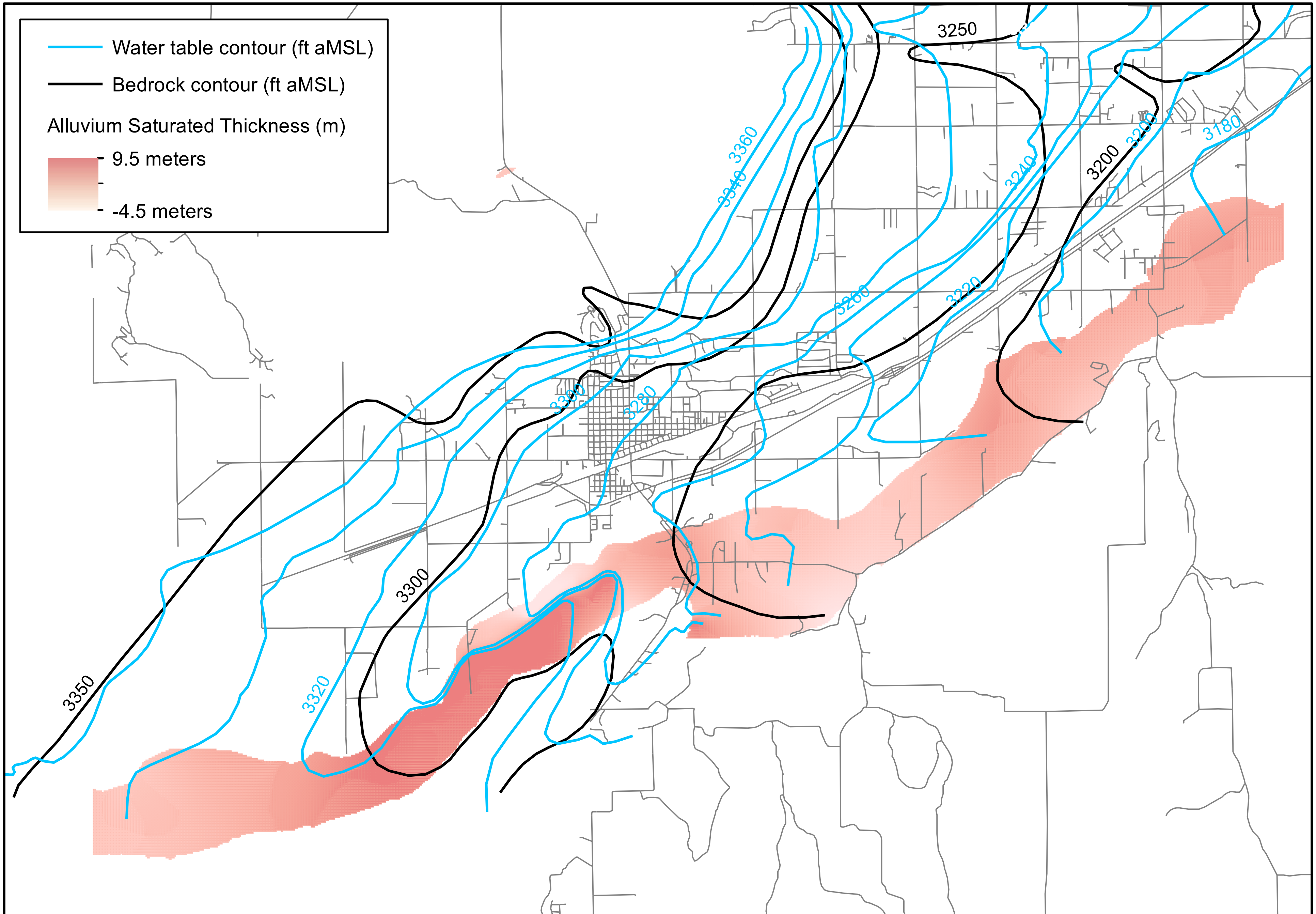


Figure 2-4
MBMG Water Resources Mapping

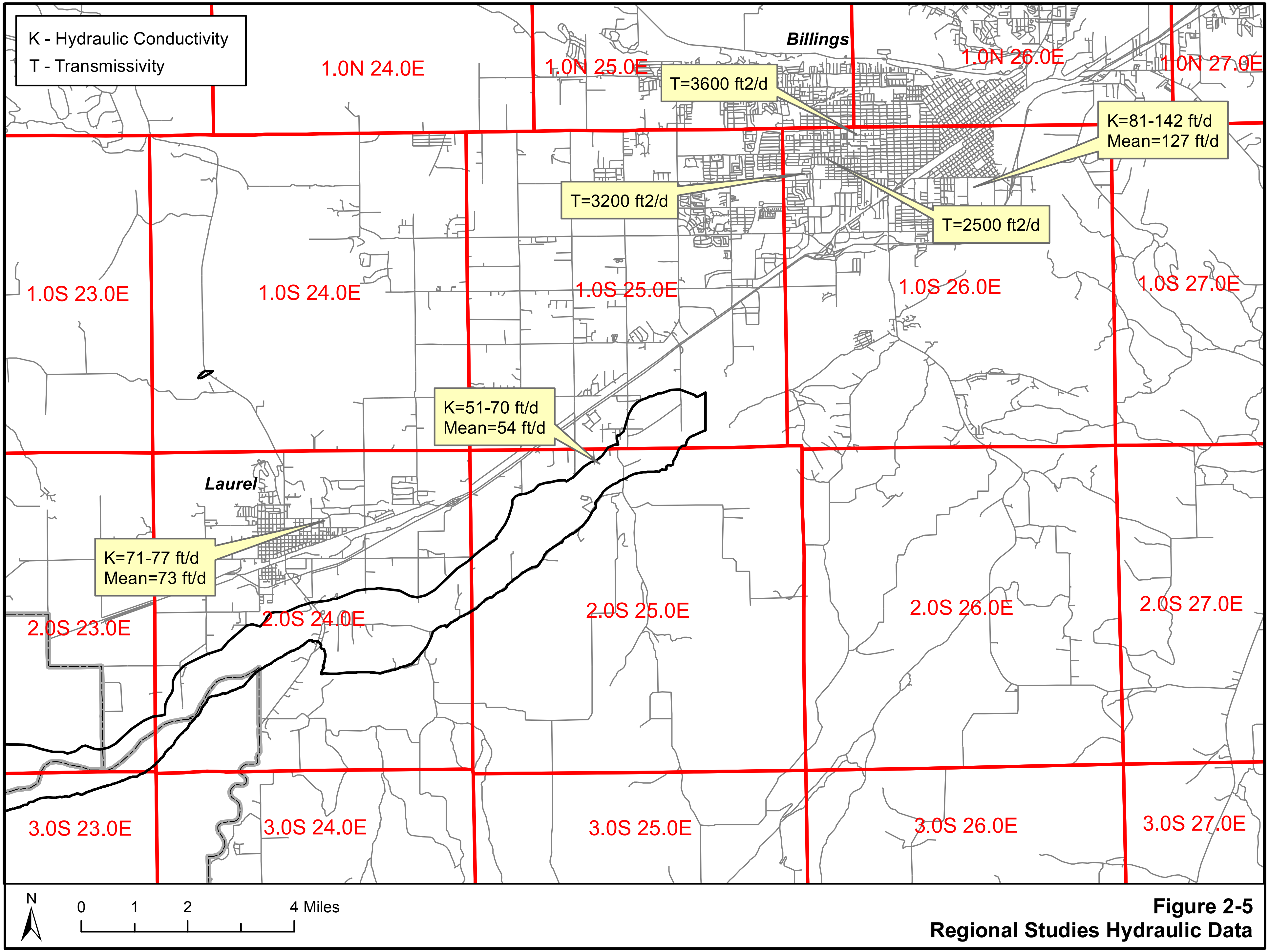


Figure 2-5
Regional Studies Hydraulic Data

2.3 Well Logs

Well log data was accessed from the Montana Bureau of Mines and Geology Ground Water Information Center (GWIC) and the State's Natural Resources Information System (NRIS). These websites provide access to the State's well log records and provided the most critical data for the groundwater alternatives analysis.

A review of well data was conducted for the locations shown on Figure 2-6, which include 406 individual wells. Many of the well locations correspond to multiple wells, an unfortunate occurrence due to how the location was designated on the well log. The location data were obtained from the NRIS website. Additional lithology data for each location was also obtained from the GWIC website. The lithology data were processed to create a database of depth to top of shale for each well location, enabling posting of alluvium- and saturated-thickness. These data were examined on-screen as a guide in the identification of possible groundwater source locations discussed below. More work could be done to process these data in relation to specific sites should a groundwater source be selected as a preferred alternative.

Because the Qt1/Qal aquifer is in proximity to the Yellowstone River channel there is generally a situation where most well logs are outside of the aquifer, producing groundwater from the Qt2 aquifer. One exception is a cluster of wells located on the west side of the project area, where shown on Figure 2-7. This group of 52 wells pertains to relatively recent development and is considered to provide generally accurate well locations and data. A similar well cluster occurs on the east side of the project area, however, these locations pertain to older wells and were deemed less reliable. Statistical analysis of data obtained from the 52 wells is presented on Figure 2-8. Key information obtained from these data are as follows.

- Total thickness of alluvium from land surface to the underlying shale bedrock averaged 21 feet. The range was from 12- to 31-ft.

- Saturated thickness measured from the water table to the top of the shale bedrock averaged 9.5 feet, with a range from 2- to 22-ft.

- Hydraulic conductivity was determined to have a geometric mean value of 510 ft/d, with a range from 30- to 4,890 ft/d.

Hydraulic conductivity was determined from well test data reported on the well logs for 18 locations. This analysis used a standard formula to convert specific capacity to transmissivity (T)[1], which in turn was divided by saturated thickness (h_0) to determine hydraulic conductivity ($K = T/h_0$). The K value was also divided by the estimated well efficiency, which was assumed at 90% (0.9) for a screened well and 25% (0.25) for an open bottom completion.

These aquifer statistics have associated uncertainty, but provide a useful data set for preliminary analysis of groundwater source potential at selected sites within the Qt1/Qal aquifer. Should a groundwater source become a preferred alternative for the City, a phased investigation will be required to verify site conditions prior to the design and construction of new facilities. Such investigations are included in cost estimates provided later in this report.

---

[1] For a pumping rate, Q (gallons per minute, gpm), and associated drawdown, s (feet, ft), the transmissivity in gallons per day per foot is calculated as $T = 1500 * Q/s$, for unconfined aquifer conditions.

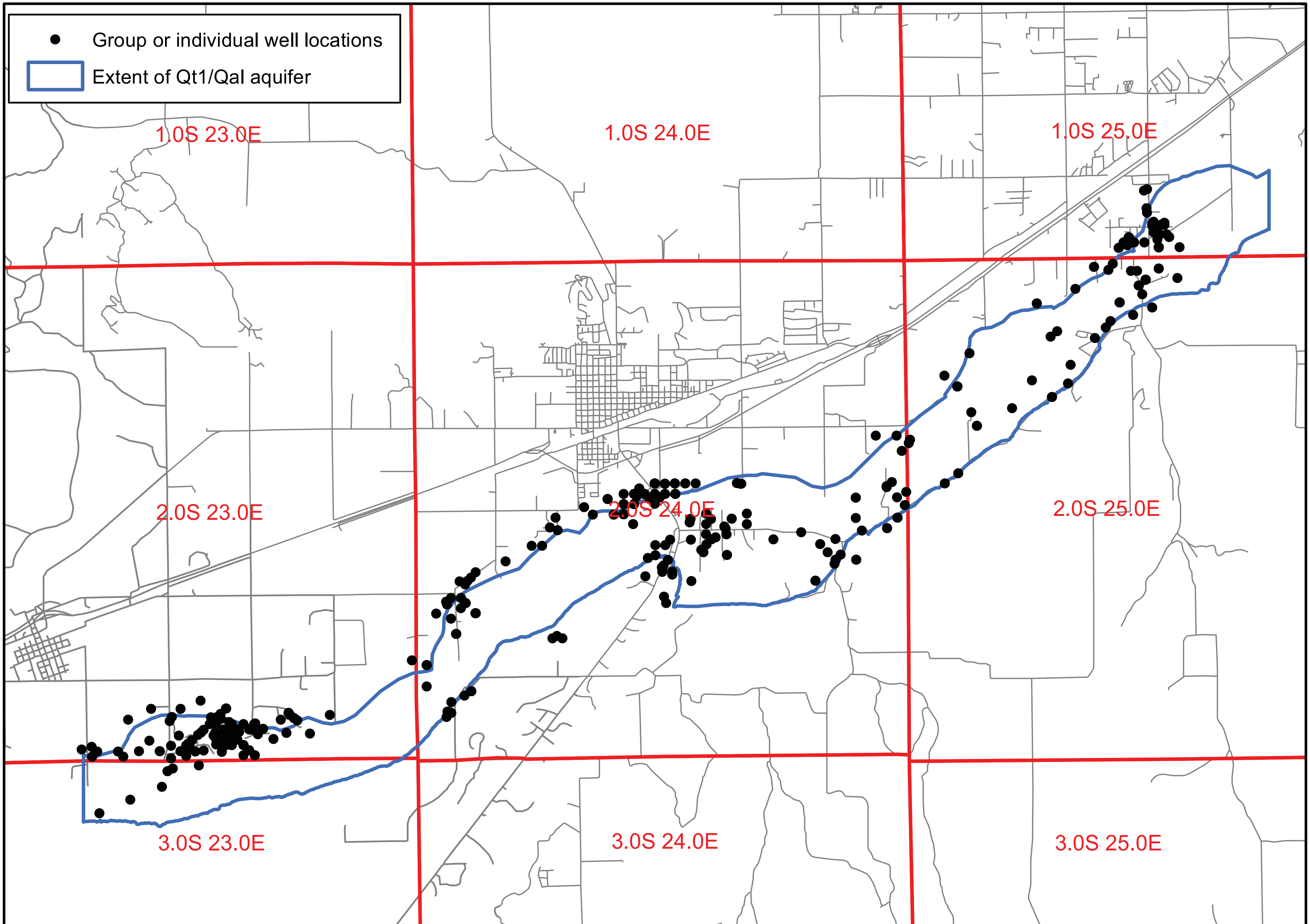
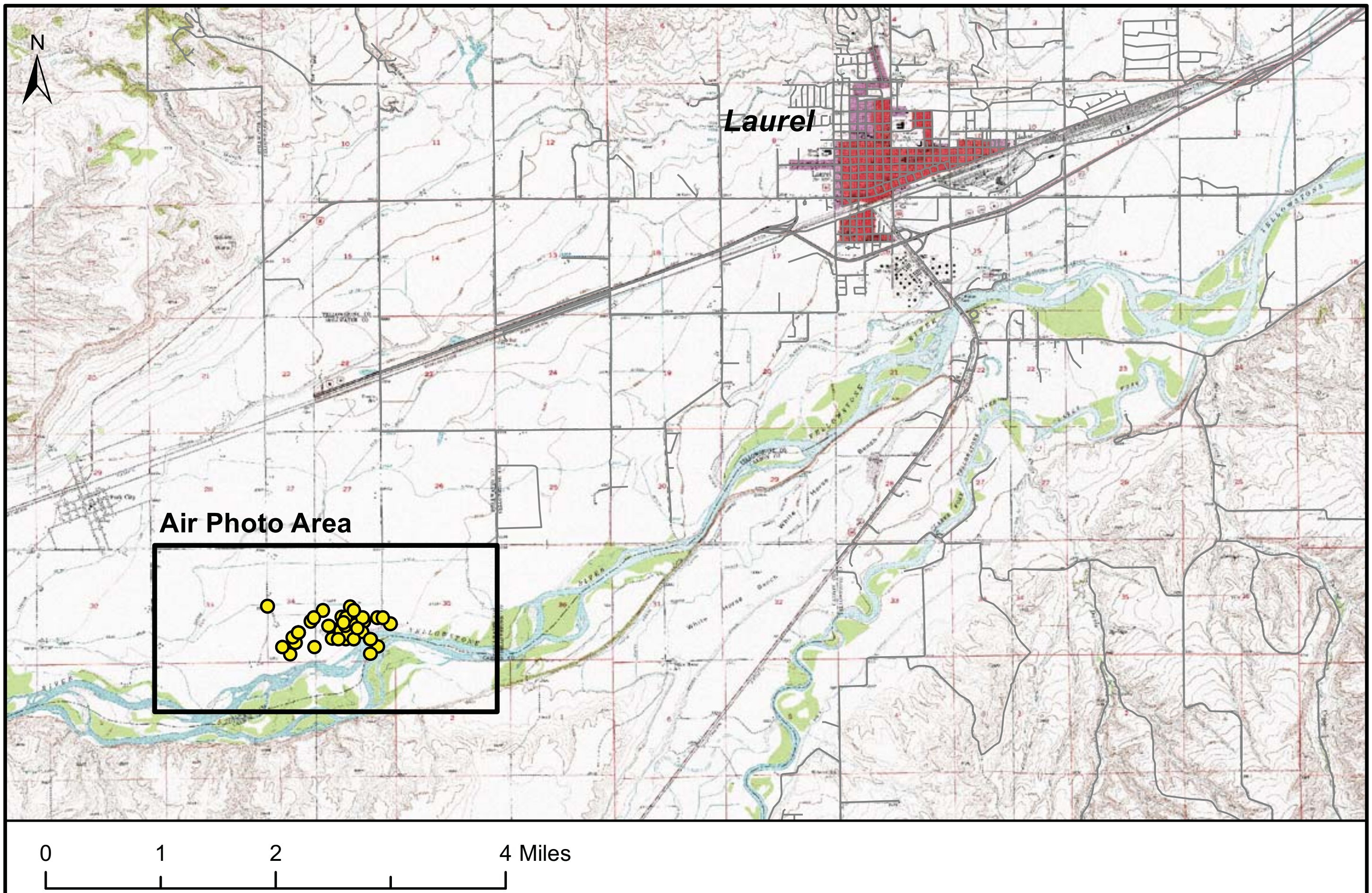


Figure 2-6
Well Log Locations

Western Groundwater Services



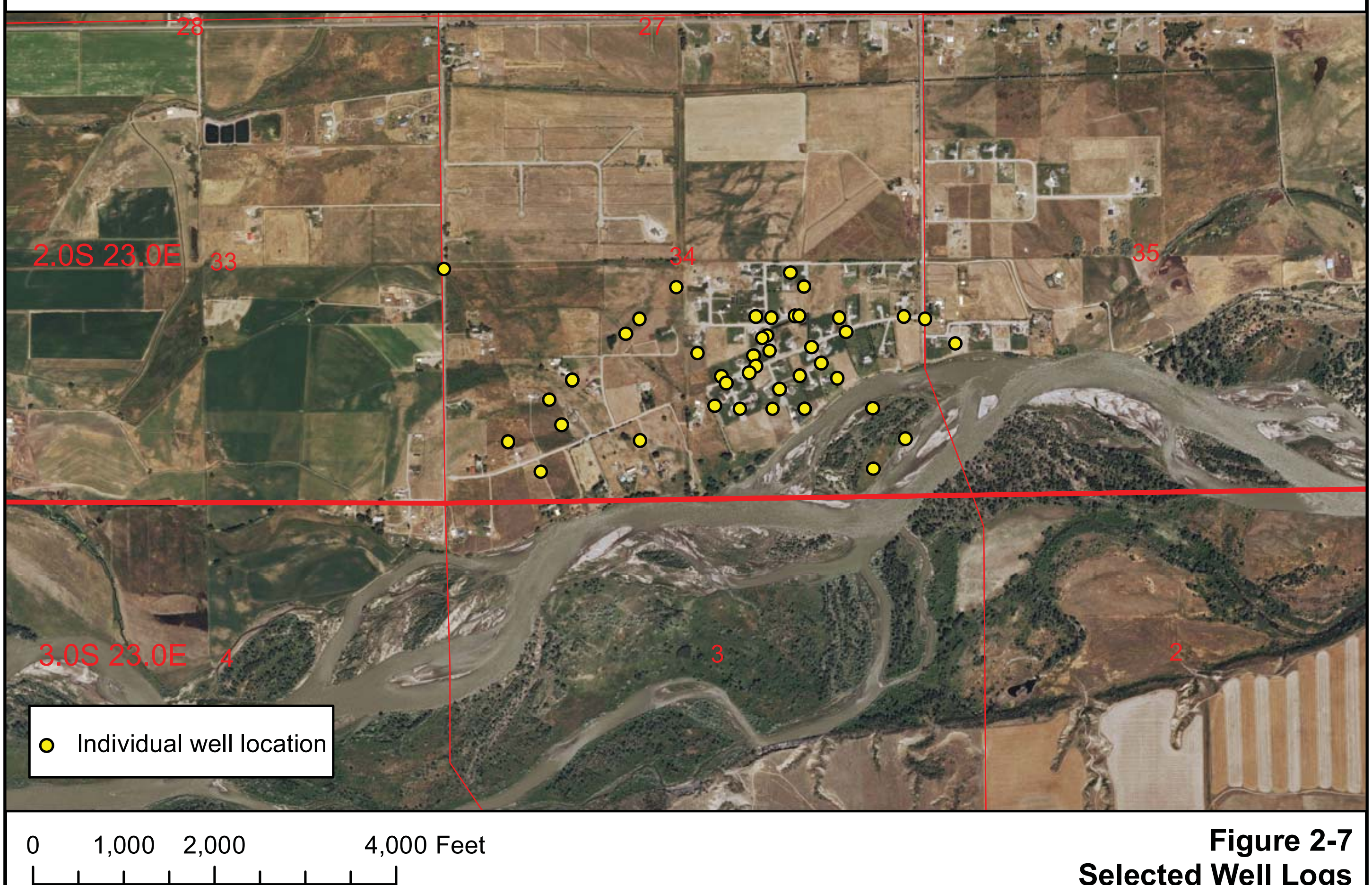


Figure 2-7
Selected Well Logs

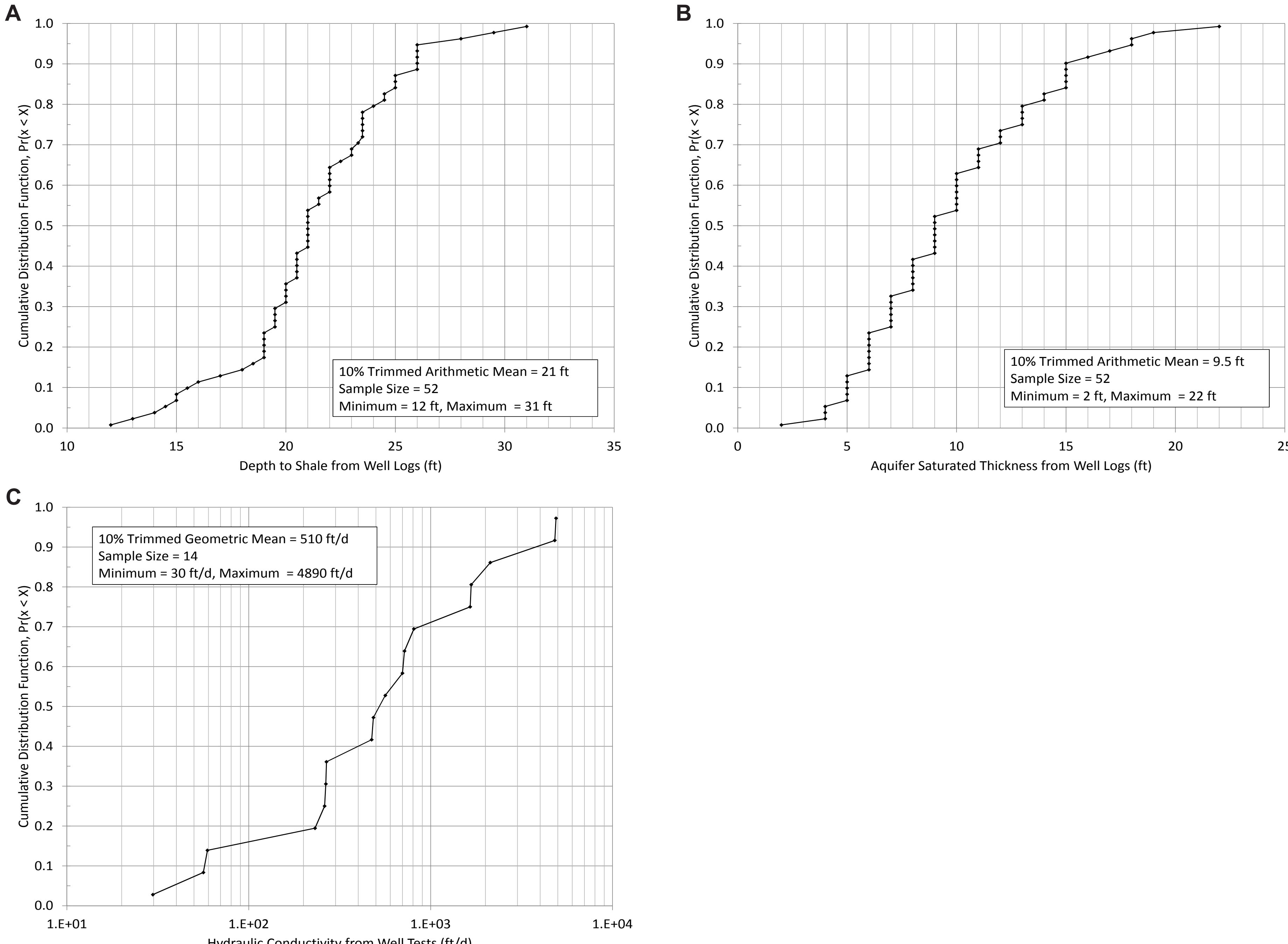


Figure 2-8
Selected Well Logs Statistics

3 YELLOWSTONE RIVER

The reduced source capacity of the existing intake is a direct result of Yellowstone River channel migration. Unfortunately, a new groundwater source is not immune to channel migration impacts, as channel offset is a critical factor in source capacity. At greater offset distances from the channel, groundwater sources produce at lower capacity. If for example a new groundwater source was located on the channel margin, a substantial decline in capacity would be realized if the channel migrated away to create a greater offset. The same situation can arise if a channel bar were to accrete onto the bank at the site of a groundwater source. Given the potential for these conditions, the capacity of a groundwater source cannot be guaranteed into the future to any degree greater than a direct surface water intake.

3.1 Air Photo Analysis

Air photos from 1951, 1976 and 2011 were reviewed to assess channel migration and to possibly identify reaches where the channel margin has been stable. This analysis found that channel migration is dramatic over the full course of the river. While there are some reaches that appear more stable than others, there is no reach over which the channel can be considered fixed.

Figures 3-1A and 3-1B show the 2011 air photo onto which the main channel centerline from 1951 and 1976 has been added. There is some subjectivity in tracing the main channel, as there are cases where large side channels are present and conveying significant flow. There are substantial deviations in the channel location over this time span, and therefore, it should be expected that such deviations will occur into the future.

Potential groundwater source locations are identified on the 2011 air photo. These locations were selected based on channel morphology and the occurrence of well logs that may indicate favorable alluvial- and saturated-thickness. These locations have been numbered from 1 to 6 on Figures 3-1A and 3-1B. Of the six sites, only site 1 is located on public land. The length of these sites was considered in modeling of groundwater source capacity presented in the next section of the report.

3.2 Channel Cross Sections

As part of floodway analysis being completed by Great West Engineering and the Army Corp of Engineers, channel cross section data have been surveyed. Eight sections spanning the project area were reviewed[2] to consider the relation of the channel bottom to the shale, and therefore the thickness of alluvial material below the channel.

The sections are plotted on Figures 3-3A through 3-3D. Actual thickness of alluvium is not known below the channel at the location of these sections, but a reference has been provided based on the average alluvium thickness of 21 feet. Using this reference, alluvial thickness below the channel may range from 0- to 8-feet.

This information and the alluvial thickness data from well logs indicates the channel has a thin or absent alluvial deposit below it. The general trend of the river is also to continue down-cutting into the alluvium and underlying bedrock. Given these circumstances construction of expensive groundwater infrastructure below the channel would be highly risky and prone to failure in the future due to natural erosional processes. Further assessment of developing groundwater from alluvium below the channel is provided in the next section.

[2] These data were provided by Great West Engineering, Inc.

2011 NAIP air photo from NRIS website

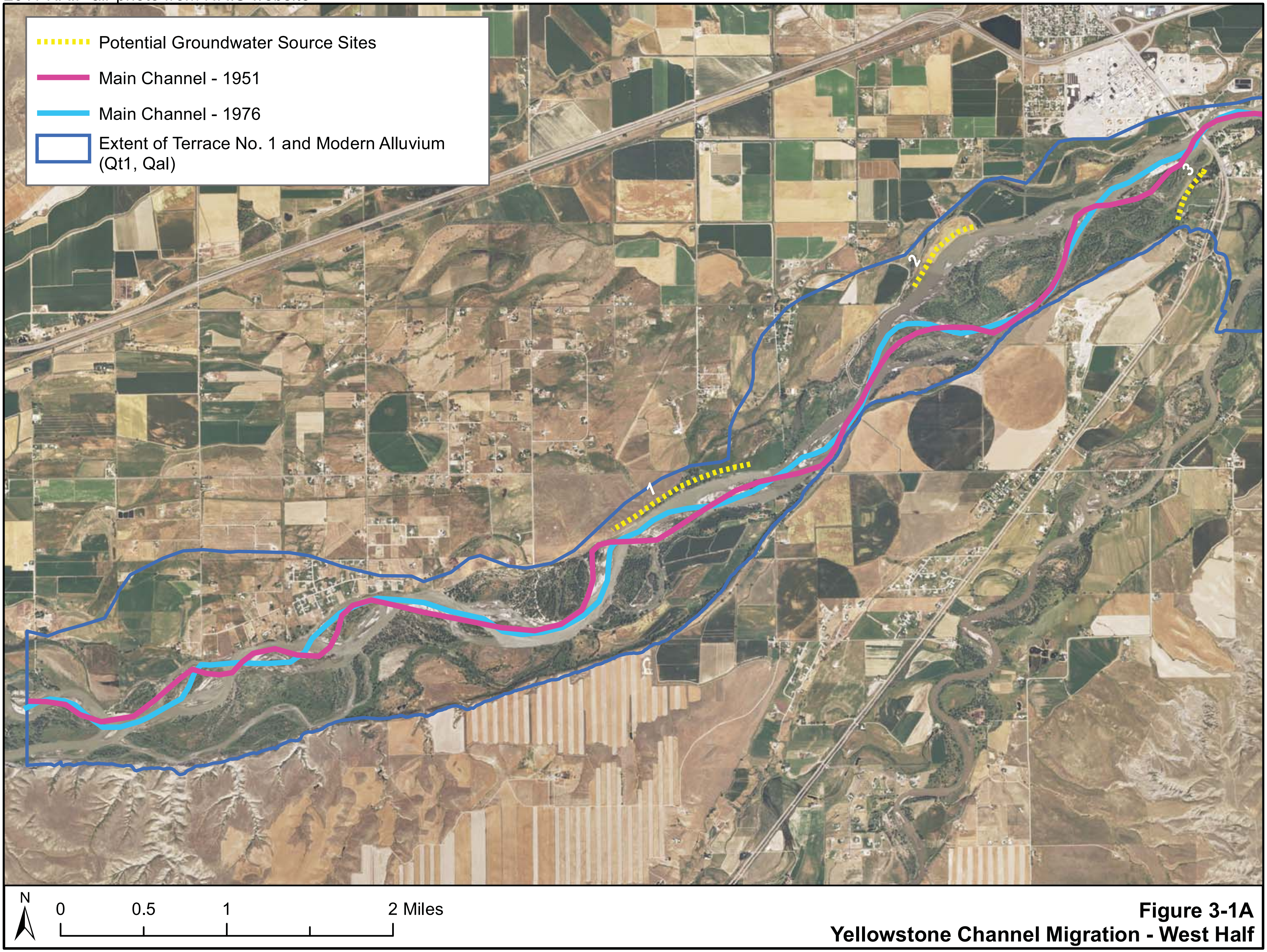


Figure 3-1A
Yellowstone Channel Migration - West Half

2011 NAIP air photo from NRIS website

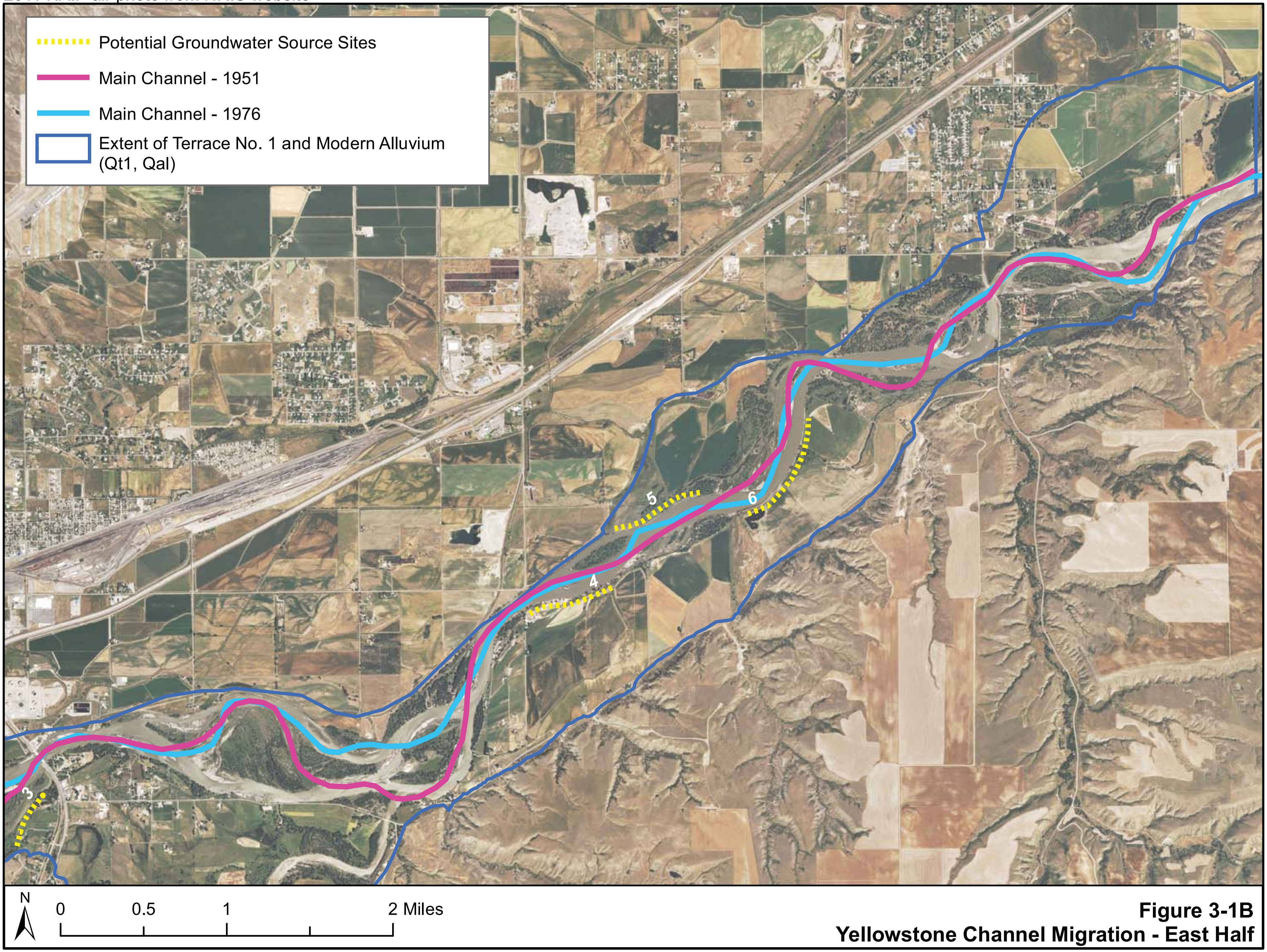


Figure 3-1B
Yellowstone Channel Migration - East Half

Western Groundwater Services

2011 NAIP air photo from NRIS website

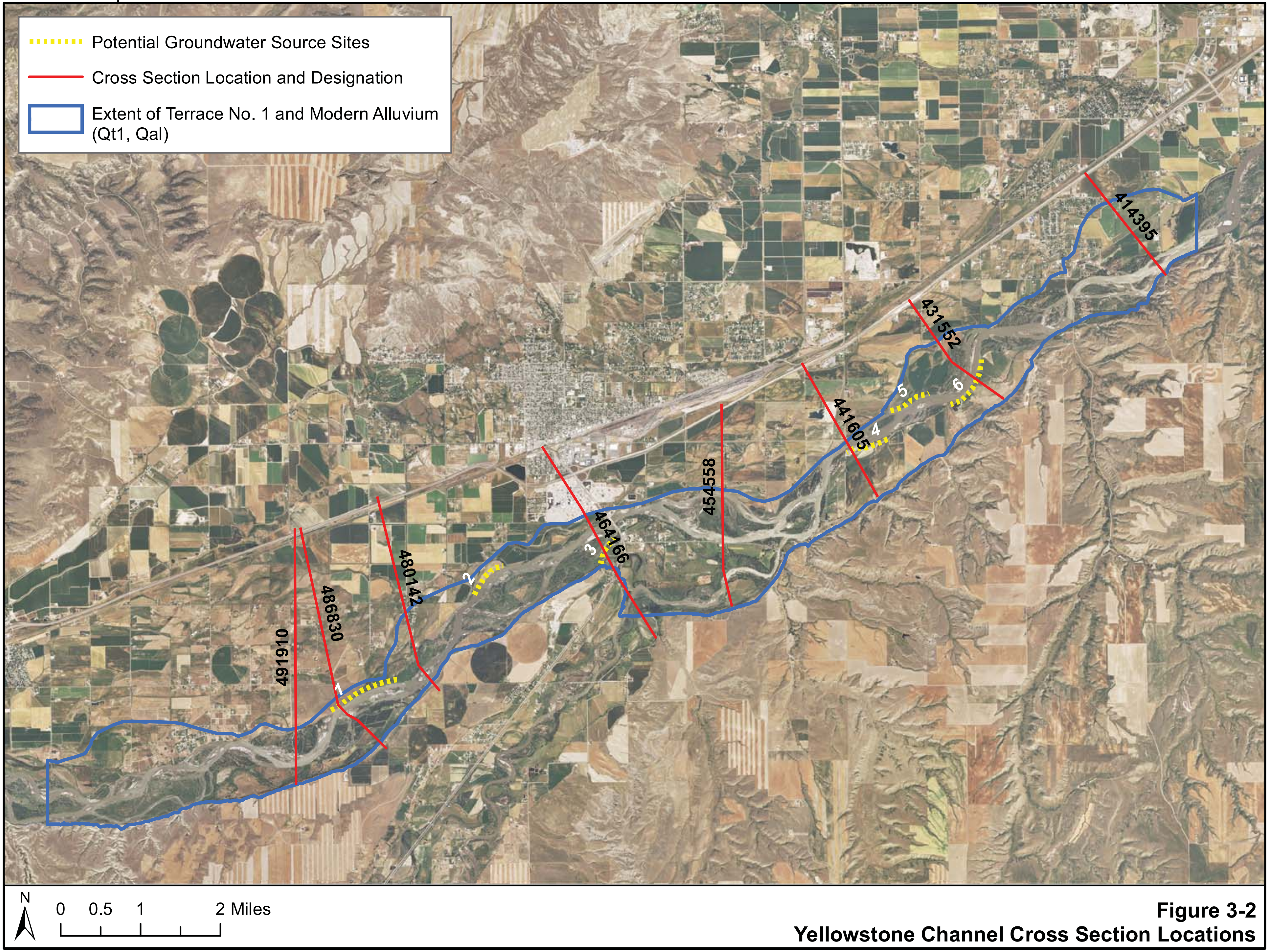


Figure 3-2
Yellowstone Channel Cross Section Locations

Western Groundwater Services

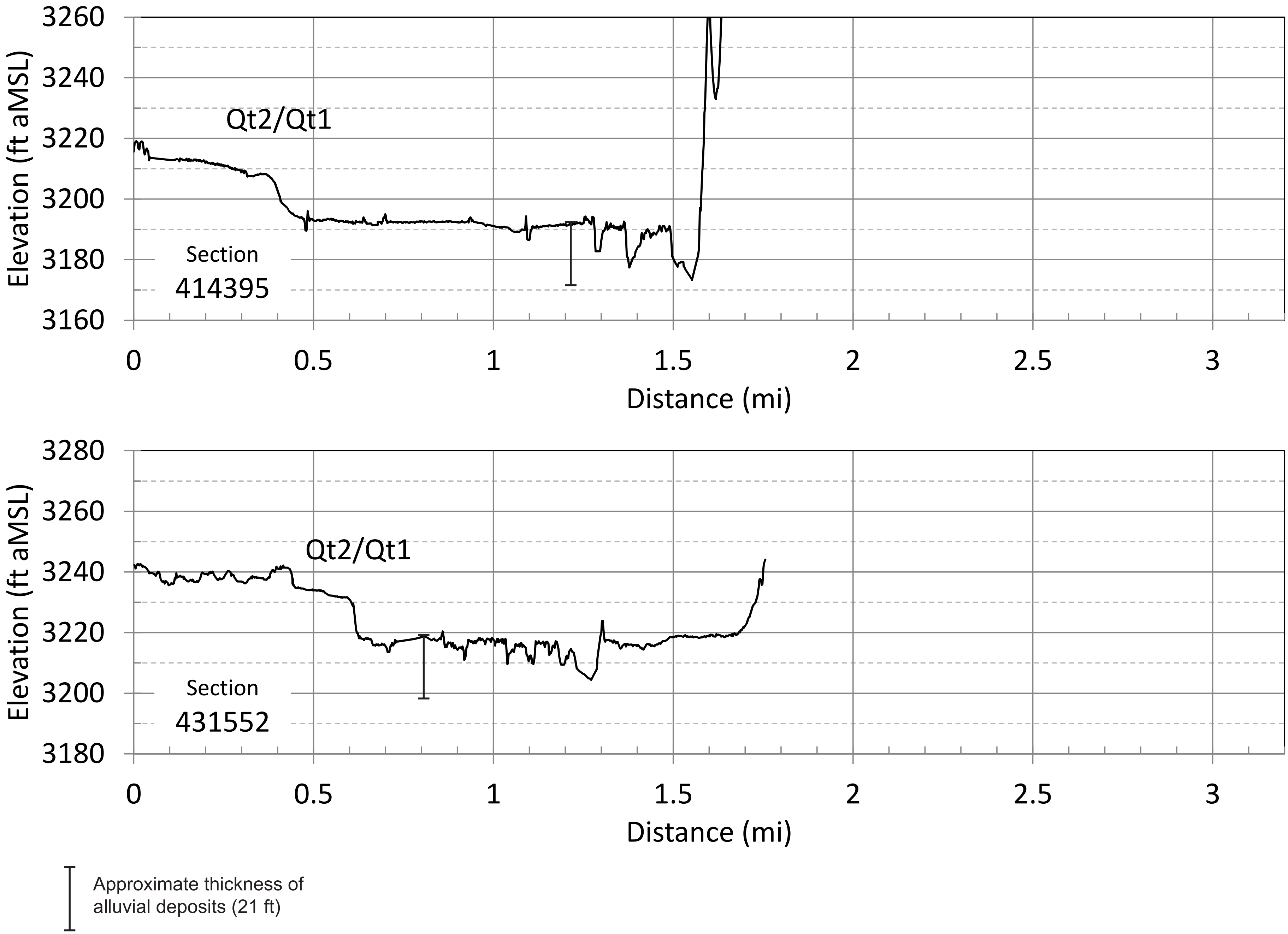


Figure 3-3A
Channel Cross Sections 414395 and 431552

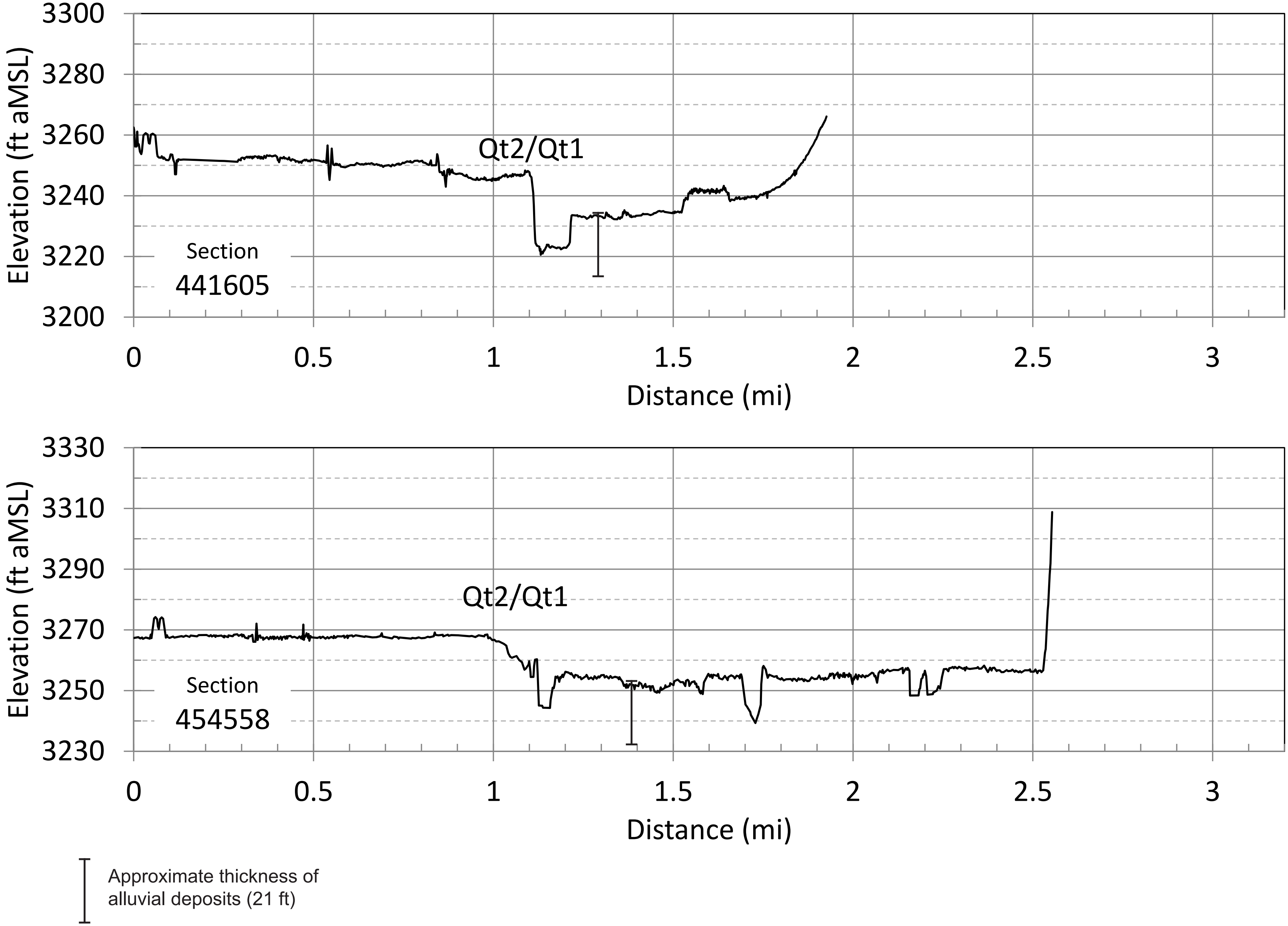


Figure 3-3B
Channel Cross Sections 441605 and 454558

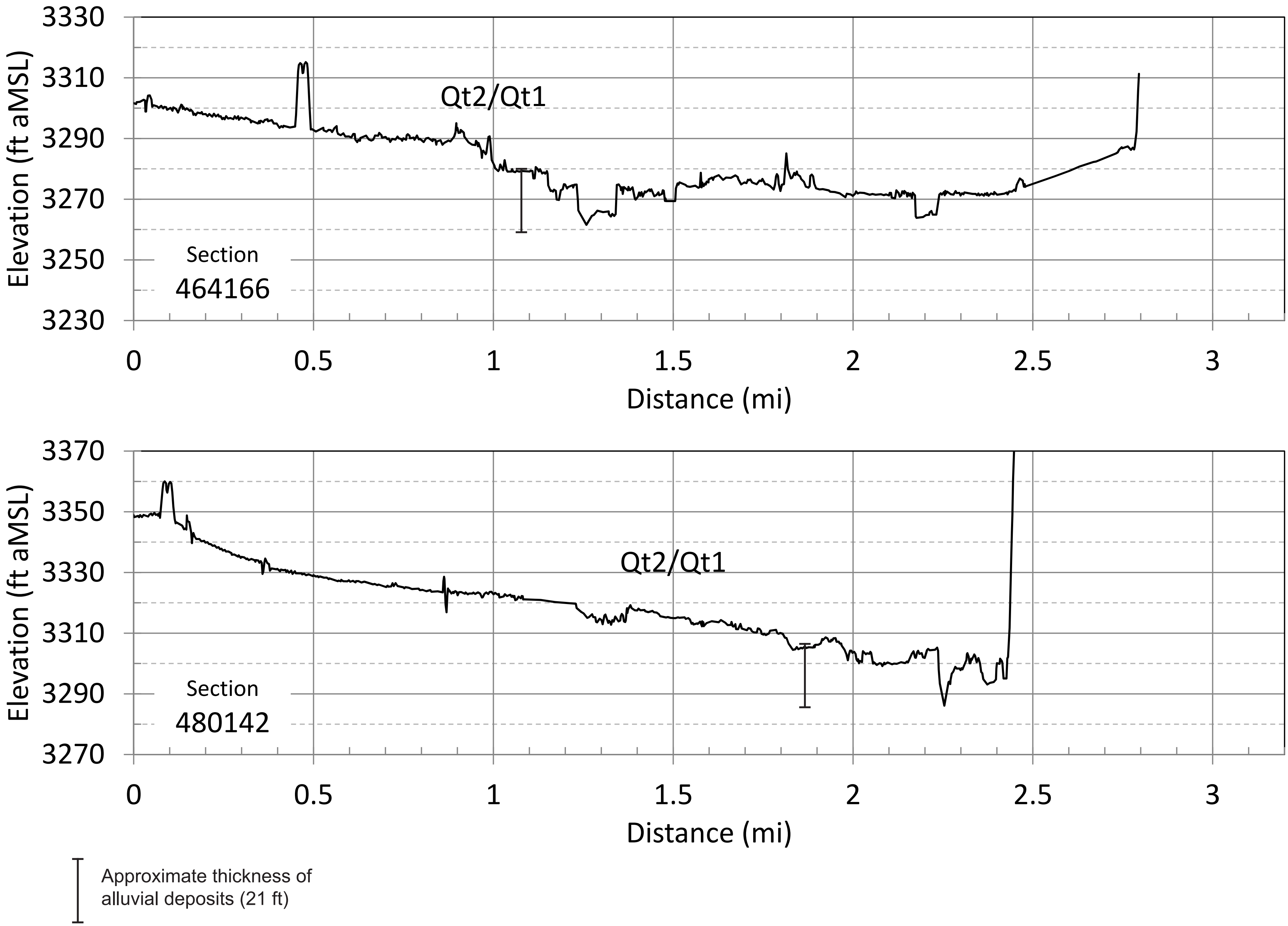


Figure 3-3C
Channel Cross Sections 464166 and 480142

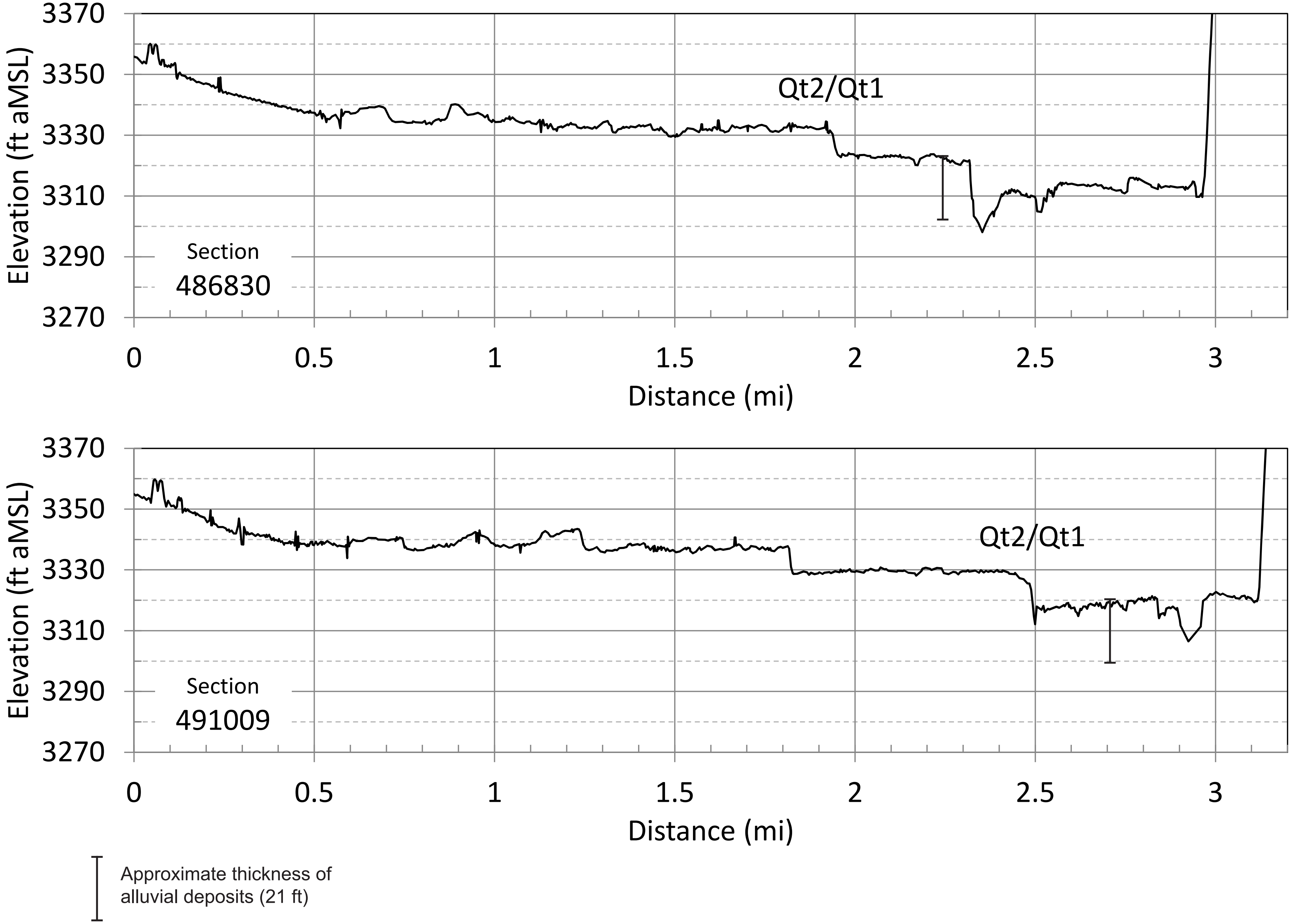


Figure 3-3D
Channel Cross Sections 486830 and 491009

4 MODELING

Analytical analysis of water production potential for groundwater sources was completed using computer modeling. Three types of source intakes were considered including: 1) an infiltration gallery constructed by setting drain pipe in an open trench; 2) an infiltration gallery constructed by horizontal directional drilling; and 3) a radial collector well. Modeling work showed that a trenched infiltration gallery was the most productive intake and the only intake that could be reasoned to produce up to 20 MGD. It was also found to be the least cost source intake construction, as described in the next section.

Vertical wells were not considered an option due to the limited saturated thickness of the aquifer. Vertical wells installed into the Qt1/Qal aquifer at best may produce 300 gallons per minute (gpm), requiring 47 individual wells to achieve the 20 MGD design requirement. Considering well spacing requirements of one well per 500 ft, the wellfield would span a length of about 4.4 miles.

4.1 Model Setup

Modeling work was completed using the U.S. Geological Survey program referred to as MODFLOW-USG[3] and the pre- and post-processing program Ground Water Vistas.[4] The model was configured as a generic representation of the Qt1/Qal aquifer and Yellowstone River. It was not calibrated to the conditions of a specific site.

The general setup of the model is shown on Figures 4-1 and 4-2. The critical factors included in the model are summarized as follows.

- Hydraulic conductivity in the horizontal direction was specified as 508 ft/d (155 m/d). Vertical hydraulic conductivity was set at 20% of the horizontal value, 102 ft/d (31 m/d);

- Saturated thickness was specified as 9.5 ft (2.9 m) above the base of the model, and the aquifer was represented as unconfined;

- The Yellowstone River was input as a constant hydraulic head boundary equal to the saturated thickness (9.5 ft); and

- Source intakes were represented as a series of drains (drain boundary) with a specified hydraulic head of 3.6 ft (1.1 m) and a conductance based on the type of intake.[5]

[3] Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D., 2013, MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

[4] Version 6, Environmental Simulations, Inc., Reinholds, PA.

[5] The drain boundary allows the user to specify the drawdown and then lets the model calculate the produced flow, which is the desired result.

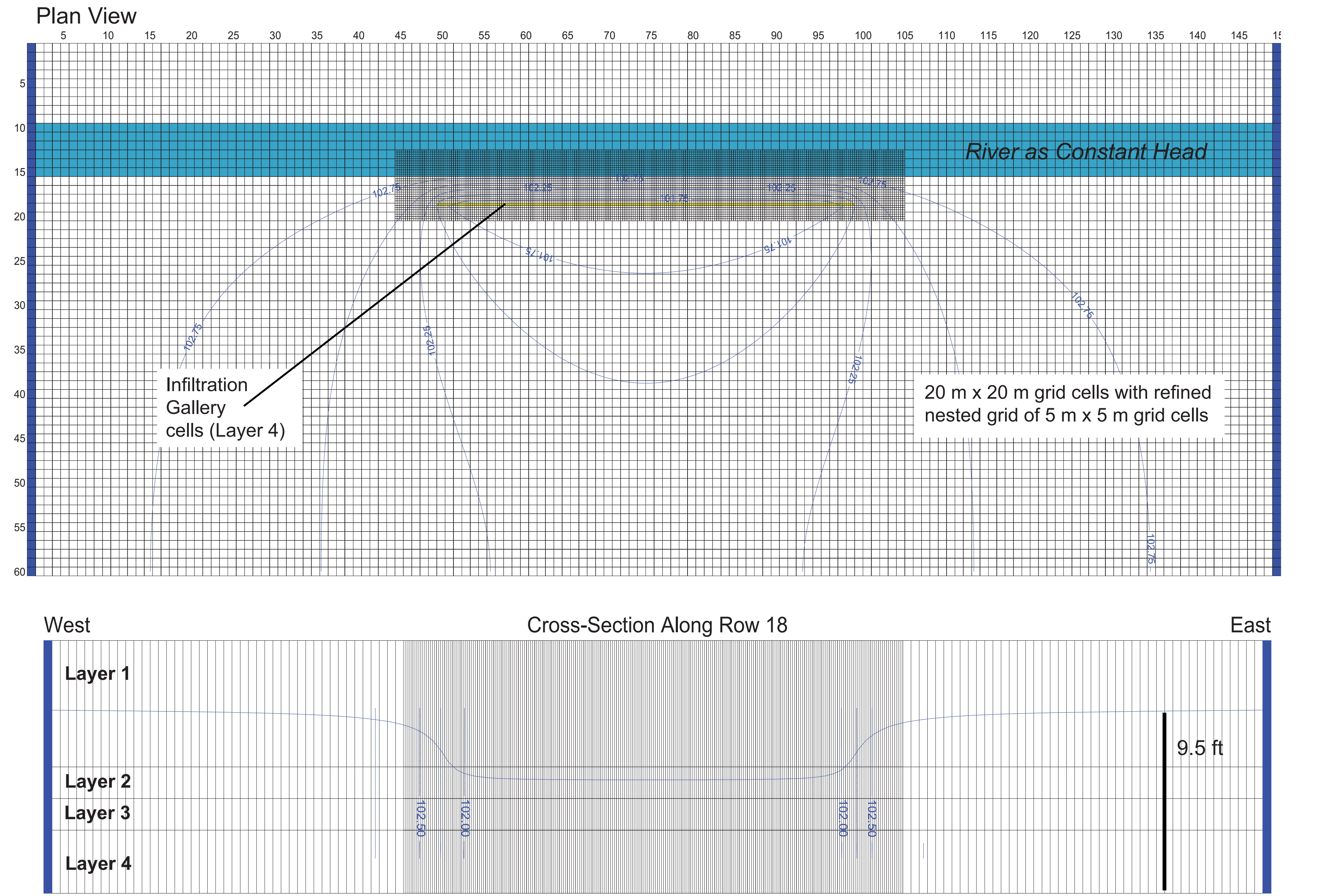


Figure 4-1
Infiltration Gallery Model

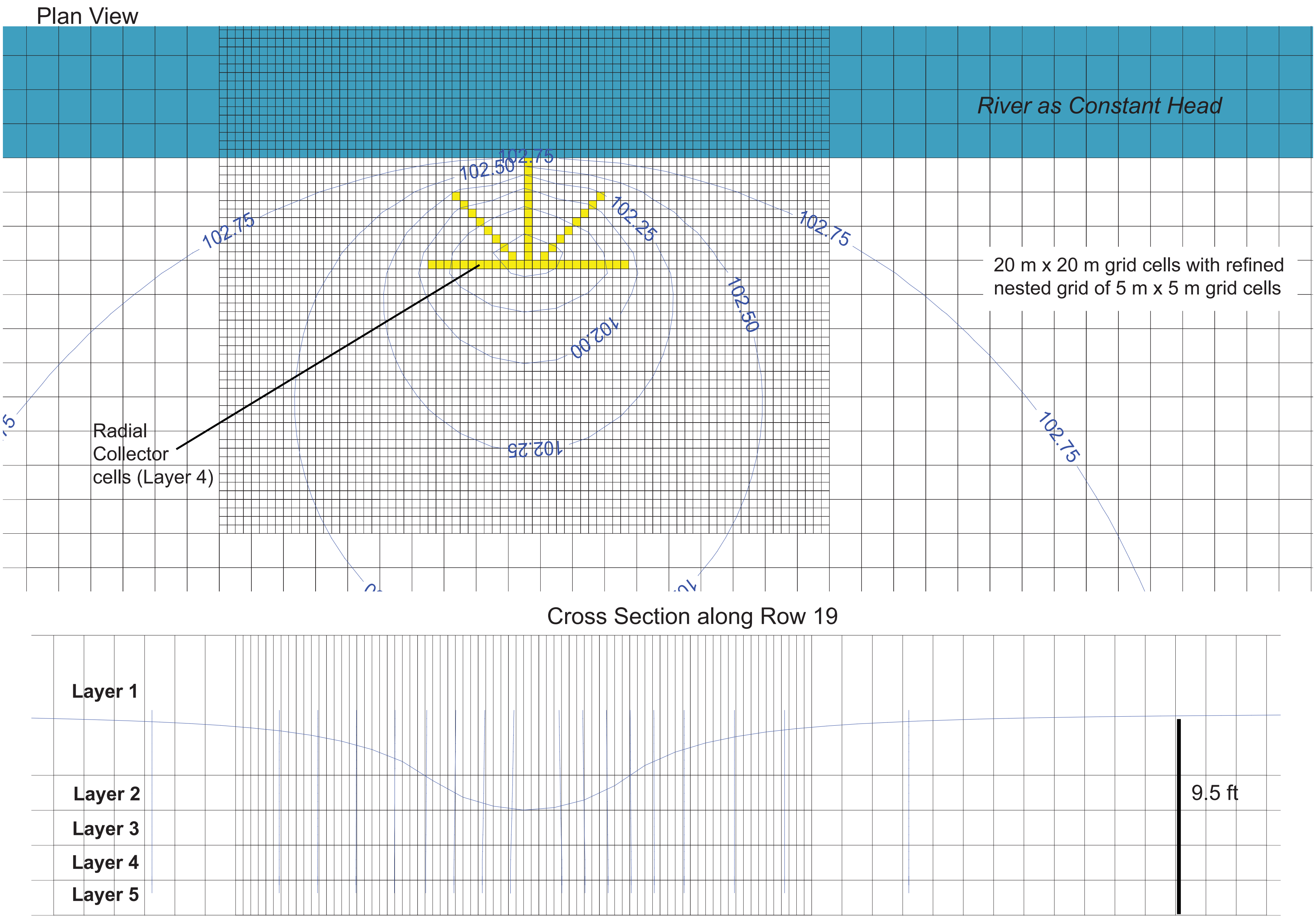


Figure 4-2
Radial Collector Well Model

Model dimension along the row direction (y-axis) and the width of the river boundary was based on informally determined average dimensions of the Qt1/Qal aquifer and main channel. The length dimension of the model (x-axis) was chosen to offset the up- and down-stream boundaries such that they would not impact modeling results. The model included four or five flat layers and a nested grid. Model layers were 0.5- or 1-meter in thickness. The outer grid had dimensions of 20-by 20-meters, whereas the nest had dimensions of 5- by 5-meters. Modeling was completed in steady state, which was considered appropriate given the proximity of the sources to the Yellowstone River.

Designated drain cells used to represent the source intake were oriented as shown on Figures 4-1 and 4-2. The infiltration gallery, as either trench or horizontally drilled and emplaced screen, was represented as consecutive drain cells totaling 3,280 ft (1000 m) and positioned in model layer #4 parallel to the channel.

The infiltration gallery source was also modeled configured with drain pipe set below, or orthogonal, to the channel margin (not shown). Drain pipe was represented in a trench excavated into the shale bedrock, immediately below the channel. A new layer of the model was created with all cells designated as no-flow except for the drain cells.

The radial collector well was represented using a fan pattern of consecutive drain cells. Five screens, each 200 ft (61 m) in length, were included. These drain cells also were placed in layer 4, however, a fifth layer was added to the model to better represent the radial collector well construction. Radial collector well screens were partially underlying the channel for several of the offset distances simulated.

A critical input parameter of the model was the drain conductance, which varied by type of source. The value of this parameter is subjective, and is reasoned based on the source construction. In the case of an infiltration gallery built into an open trench, a high conductance value of 3000 m^2/d was specified. This large value was justified for a 36-inch diameter pipe set into a 6- by 8-foot trench filled with highly permeable filter pack (assumed isotropic hydraulic conductivity of 984 ft/d (300 m/d)). In the case of horizontal drilling and the radial collector well, the drain conductance was specified as 179- and 175-m^2/d, respectively, as both sources use smaller pipe sizes and are set directly into native material. Horizontal drilling was planned with a 20-inch diameter screen; the radial collector well was planned with a 12-inch diameter screen. The effective hydraulic conductivity of the native media was specified as 230 ft/d (70 m/d).[6] A disturbed zone, or skin factor, was not considered for any of the source types.

4.2 Model Results

Model results were generated for the conditions described above, and were then adjusted by scaling to the general lengths of the groundwater site locations shown on Figures 3-1A and 3-1B. The simulation results are presented in Tables 4-1 through 4-3. Offset distances were based on the number of model cells between the source (drain boundary) and the river channel (constant hydraulic head). Because the model used metric units, these offsets were: 8.2-, 24.6-, 57.4-, 106.6-, and 205.1-feet. At least a 50- to 60-ft offset would be required for constructability. These results are highlighted with bold type.

Only the infiltration gallery constructed by the trench method was modeled to achieve a capacity close to 20 MGD, and only at Site #1, requiring a 5,000 ft length for the drain pipe parallel to the channel. Radial collector well spacing, as determined from modeling, was 750 feet. A total of five wells can possibly be accommodated at Site #1, with fewer well sites available at the other locations. Figure 4-3A compares the source intake capacity normalized to length of screen. The primary factor differentiating the curves from one another is the drain conductance value (see above). Note that for the 50 ft offset distance, the

[6] For anisotropic conditions, the effective hydraulic conductivity of the drain is given by $(Kx * Kz)^{1/2}$.

infiltration gallery is modeled to produce at 3 gpm/ft, whereas the other two source types produce at just under 2 gpm/ft.

As shown on Figure 4-3A, source capacity is highly sensitive to offset distance from the channel. Either locating the source farther from the channel or creation of greater offset due to natural processes (channel migration, bar accretion) can result in substantially reduced source capacity.

TABLE 4-1
INFILTRATION GALLERY (TRENCH METHOD) ESTIMATED CAPACITY

Site No.	Length (ft)	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5000	45.5	31.8	**19.5**	12.6	7.6
2	2800	25.5	17.8	**10.9**	7.0	4.3
3	1950	17.7	12.4	**7.6**	4.9	3.0
4	2870	26.1	18.2	**11.2**	7.2	4.4
5	3070	27.9	19.5	**12.0**	7.7	4.7
6	3950	35.9	25.1	**15.4**	9.9	6.0

TABLE 4-2
INFILTRATION GALLERY (HORIZONTAL DRILLING) ESTIMATED CAPACITY

Site No.	Length (ft)	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5000	17.1	14.7	**11.4**	8.6	5.9
2	2800	9.6	8.2	**6.4**	4.8	3.3
3	1950	6.7	5.7	**4.4**	3.4	2.3
4	2870	9.8	8.5	**6.5**	4.9	3.4
5	3070	10.5	9.0	**7.0**	5.3	3.6
6	3950	13.5	11.6	**9.0**	6.8	4.7

TABLE 4-3
RADIAL COLLECTOR WELLS ESTIMATED CAPACITY

Site No.	No. Wells	Capacity (MGD) by Offset Distance (ft)				
		8.2	24.6	57.4	106.6	205.1
1	5	15.8	14.6	**12.4**	9.6	5.6
2	3	9.5	8.8	**7.4**	5.7	3.4
3	2	6.3	5.8	**5.0**	3.8	2.2
4	3	9.5	8.8	**7.4**	5.7	3.4
5	3	9.5	8.8	**7.4**	5.7	3.4
6	4	12.6	11.7	**9.9**	7.7	4.5

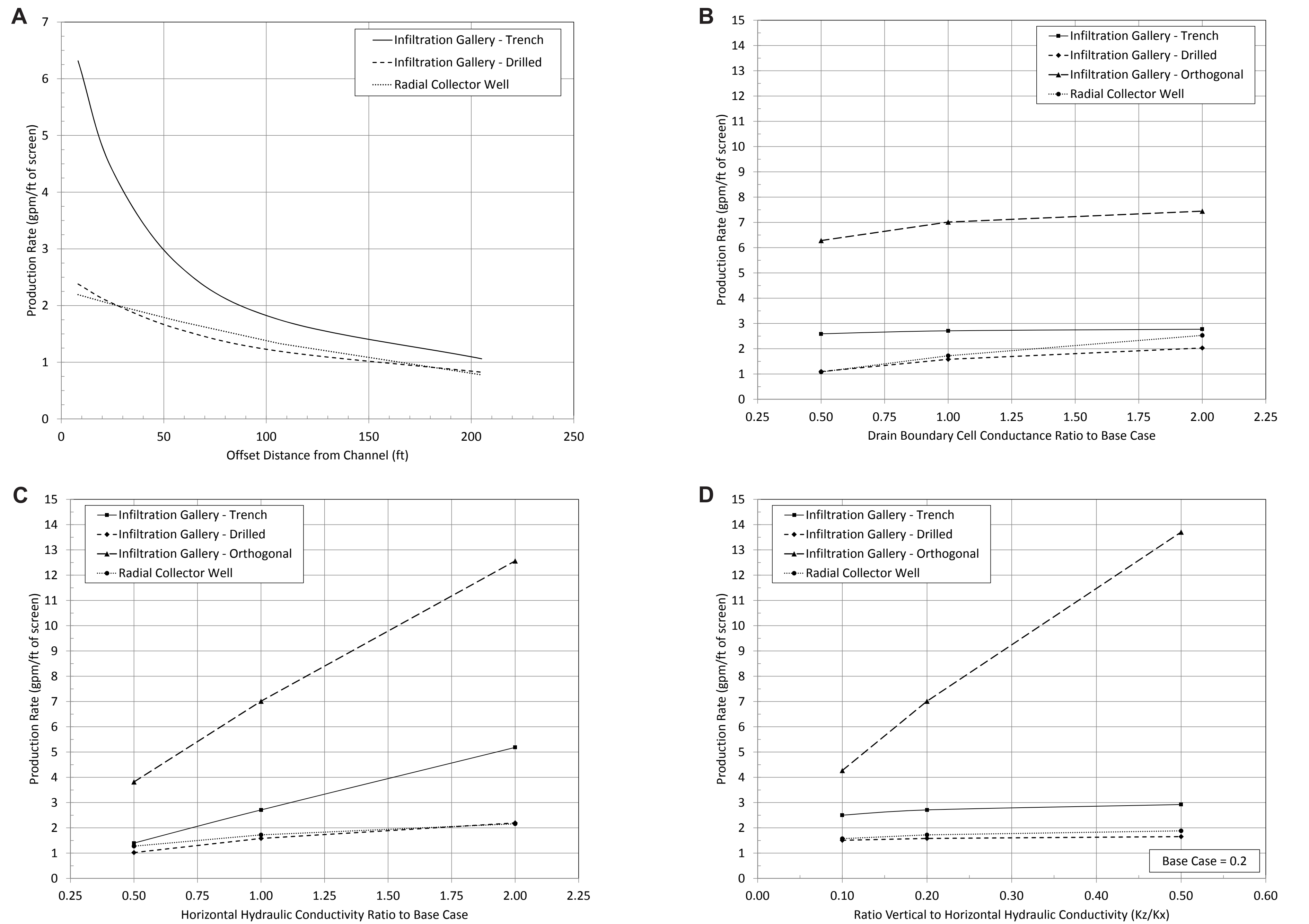


Figure 4-3
Modeling Sensitivity Analysis

4.2.1 Orthogonal Oriented Drain

Drain pipe set into shale below the channel was simulated to produce 4.0 MGD, assuming a 16 ft trench width and 400 ft trench length. This source type was setup with a drain conductance of 3000 m^2/d, the same as for the infiltration gallery installed by trenching parallel to the channel. The model included native materials above the trench, which were a limiting factor in the simulated capacity. This cover material may be reasonable given that any trench constructed below the river channel would be subject to natural erosional and depositional processes over time.

A total of five drains spanning the full width of the Yellowstone River would be required to achieve the 20 MGD design requirement. It is unclear as to how these drains could be installed given the environmentally sensitive conditions and the large flows realized in the channel. This configuration was not considered further due to technical infeasibility.

4.2.2 Modeling Sensitivity Analysis

Sensitivity analysis of the modeling results was completed for offset distance from the channel as discussed above (Figure 4-3A). Sensitivity analysis was also completed for drain cell conductance (CD), horizontal hydraulic conductivity (Kx), and the anisotropy ratio of vertical to horizontal hydraulic conductivity (Kz/Kx). Values for CD and Kx were reduced by a factor of 2, and also increased by a factor of 2. The anisotropy ratio was set to a value of 0.1 and then 0.5, whereas the base case used an anisotropy ratio of 0.2. The results of these model runs presented with respect to source production rate per foot of screen are shown on Figures 4-3B through 4-3D.

Sensitivity to the drain conductance is higher for the lower producing sources, which also were setup to have a lower conductance (Figure 4-3B). In these cases, conductance is more limiting of the source production, and so a larger range in production rate is realized. Greater sensitivity is observed for the higher production sources with respect to horizontal hydraulic conductivity (Figure 4-3C), as Kx is flow limiting to these sources. Only the orthogonal infiltration gallery is highly sensitive to the Kz/Kx ratio, as this source configuration relies on primarily vertical flow from the channel to the drain pipe.

5 COST ESTIMATION

Construction cost estimation was completed for the infiltration gallery source intake by both trench and horizontal drilling methods. Radial collector wells were not considered because it was found this source intake could not reasonably meet the flow requirements. Although this same finding applies to the horizontal drilling method, it was unknown as to how the trench and trenchless costs would compare. Trenchless technologies are favorable for low impact construction and are a relatively new technology (Willoughby 2005). Tables 5-1 and 5-2 provide cost estimate summaries. Detailed cost data sheets are provided in Appendix A.

Cost data were obtained from three sources. Most of the unit rate based costs were obtained from the RS Means CostWorks 2014 database[7] for heavy construction. Unit rates of this database were applied to material quantities based on conceptual design of the constructed facilities. Engineer estimation was made for pre-design studies and selected components of the constructed facilities. These estimates are engineer opinion based on experience with bids for similar work. The third source of cost data was contractor and vendor quotations. There were a few select items quoted, such as sheet pile installation/removal, drain pipe, and horizontal drilling.

TABLE 5-1
INFILTRATION GALLERY (TRENCH METHOD) COST ESTIMATE

Activity	Cost Estimate
Site Access Agreement/Easements	$ 30,000
Environmental/Archeological	$ 15,000
Monitoring Wells and Geophysical Survey	$ 104,140
Production Test Wells	$ 355,878
Subtotal	$ 505,018
Facility Construction (5000 ft, 19.5 MGD)	$ 14,058,881
Project Total	$ 14,563,898
Unit Rate ($/MGD)	$ 728,195

[7] RS Means CostWorks 2014, Heavy Construction, Norwell, MA.

TABLE 5-2
INFILTRATION GALLERY (HORIZONTAL DRILLING) COST ESTIMATE

Activity	Cost Estimate
Site Access Agreement/Easements	$ 30,000
Environmental/Archeological	$ 15,000
Monitoring Wells and Geophysical Survey	$ 104,140
Production Test Wells	$ 355,878
Subtotal	$ 505,018
Construction (5000 ft, 11 MGD)	$ 15,156,896
Project Total	$ 15,661,913
Unit Rate ($/MGD)	$ 1,423,810

5.1 Site Access Agreement/Easements

This fee item shown in Tables 5-1 and 5-2 pertains to negotiations and legal work required to obtain access to project sites by leasing. There would ongoing payments most likely associated with any type of lease agreement. This cost can vary considerably depending on whether private or public access is required.

5.2 Environmental/Archeological

This fee item shown in Tables 5-1 and 5-2 pertains to preparation of environmental and archeological reports for construction at a selected site that uses State and Federal funds. The fee is considered typical for the hiring of a consultant specialist to complete these services.

5.3 Monitoring Wells and Geophysical Survey

Cost details of this pre-design study are provided in Table A-1. This study installs 10 monitoring wells along the infiltration gallery alignment, completes 40 gradation analyses, and completes a geophysical survey. Aquifer hydraulic data would be obtained by completing slug testing in each monitoring well. The geophysical survey cost estimate is based on resistivity profiling, although an alternative similar method could be chosen. Resistivity profiling provides a continuous delineation of the alluvial thickness and variations in alluvium resistivity, which is correlated to lithology. Profiles were included in directions parallel- and orthogonal-to the infiltration gallery alignment.

This pre-design study also includes calibration of the groundwater model and simulation of source capacity with prediction uncertainty. This work is planned to re-evaluate the source construction alternatives and revise the cost estimate. Based on completion of this work, a decision would be made to proceed with development of the selected site, or choose an alternative approach to intake construction.

5.4 Production Test Wells

Cost details of this pre-design study are provided in Table A-2. This study installs three vertical production test wells and completes step rate and 72-hour constant rate pumping tests in each. Hydraulic testing data will be used to characterize aquifer properties, including transmissivity and storativity. One extended pumping test is also included to assess potential for river sediment and algae plugging, and the potential for associated reduced capacity. This extended pumping test includes 60-days of continuous pump runtime using auxiliary power. General water quality sampling and analysis is included.

Data from this testing will be used to further calibrate the groundwater model and assess source capacity, including prediction uncertainty. The entire data set will be reviewed and a decision would be made to proceed with source development, or choose an alternative approach.

5.5 Infiltration Gallery by Trench Method

Cost details for the construction of the infiltration gallery by open trench construction methods are detailed in Table A-3. Total cost of this project could have associated variability of ±$2,000,000. This project includes the construction of two infiltration galleries, each with 2,500 ft of drain pipe and currently estimated to produce 10 MGD. The trench design used for cost estimation is shown on Figure 5-1. The construction project includes the following work items:

- Scraper excavation to a depth of approximately 10 feet to establish a work bench for deeper excavation using a track hoe. Scraper excavation would be entirely in unsaturated alluvium material;

- Track hoe excavation with material hauling for the lower trench section. This excavation extends to a depth of 21 feet and manipulates a trench box for drain pipe installation. Materials are hauled out of the trench and temporarily stockpiled on-site;

- Excavation dewatering costs include installation of a cofferdam wall to a depth of 25 ft below ground, and pumping from in the trench using two dewatering pumps. It was assumed that construction would be staged in sections and that dewatering would apply to a section of about 500 feet at any time. A total of 150 days of dewatering was estimated;

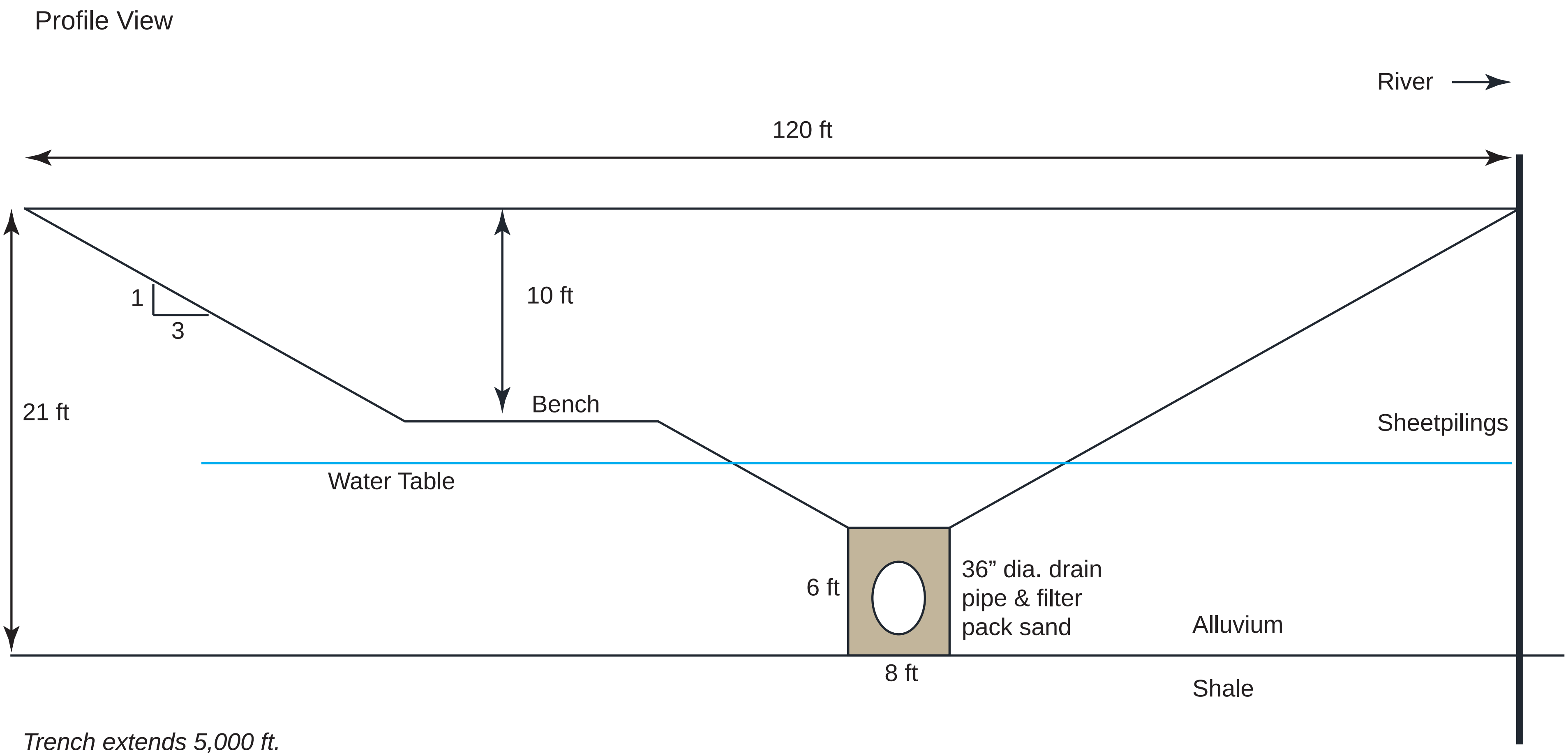
- Installation of 36-inch diameter 80 psi slotted PVC drain pipe rated at 8 gpm/ft of transmittance with a 0.1 ft/s entrance velocity. Drain pipe would be fully bedded in uniform sand obtained from a local gravel pit, assumed to be within a 30-mile distance of the site. There is an estimated four to six month lead time required to obtain the drain pipe;

- Installation of manholes at every 500 ft section, resulting in five manholes per 2500 ft infiltration gallery. The pre-cast manholes are 6-feet in diameter and 24 feet in height, and fitted with a concrete lid;

- Construction of a pumping station for each infiltration gallery that includes a 9-ft diameter pre-cast wet well installed to 35 feet below ground and fitted with a concrete lid that also acts as a pump supporting floor. Two vertical lineshaft turbine pumps with variable frequency drives were included, each at 50 hp and producing at 3,500 gpm, for a total output of 7,000 gpm, or 10 MGD. Each pump station and wet well would be enclosed in a typical commercial building. It was assumed that three phase power would be constructed over a 4-mile distance to reach the site;

- Water transmission piping would be installed from one infiltration gallery to the other, over an estimated distance of 2,800 feet. Pipeline material would be 24-inch diameter PVC. Ductile iron fittings are included. It is assumed the pipeline would be installed into the trench during backfilling, and therefore does not include excavation of a completely new trench. The pipe would be bedded in uniform sand, as for the drain pipe; and

- Contingency and engineering fees were estimated at 15% and 25% of construction, respectively, which are typical feasibility level estimates used for general civil construction projects.



Trench extends 5,000 ft.
Project includes two infliltration galleries of 2,500 ft, each with pump station.

Figure 5-1
Infiltration Gallery by Trenching

Maintenance requirements for this facility would include periodic cleaning of the drain pipe screen and filter pack. The screen and the filter pack can be partially clogged by microbiological growth resulting in lost capacity. Typical cleaning procedures under these conditions apply an organic acid that permeates the entire filter pack followed by treatment with a strong disinfectant. The procedure requires large volumes of solution and associated contact time, taking the source out of service for a period of two to four weeks. Redundancy of the sources is included in part to accommodate this work. Frequency of cleaning would be expected to be on the order of once per 10 to 20 years of operation and has associated costs of about $200,000 to $400,000. Given the construction of the infiltration gallery as a groundwater source with a burial depth of approximately 18 feet, it is not normal practice to construct an engineered backflushing system.

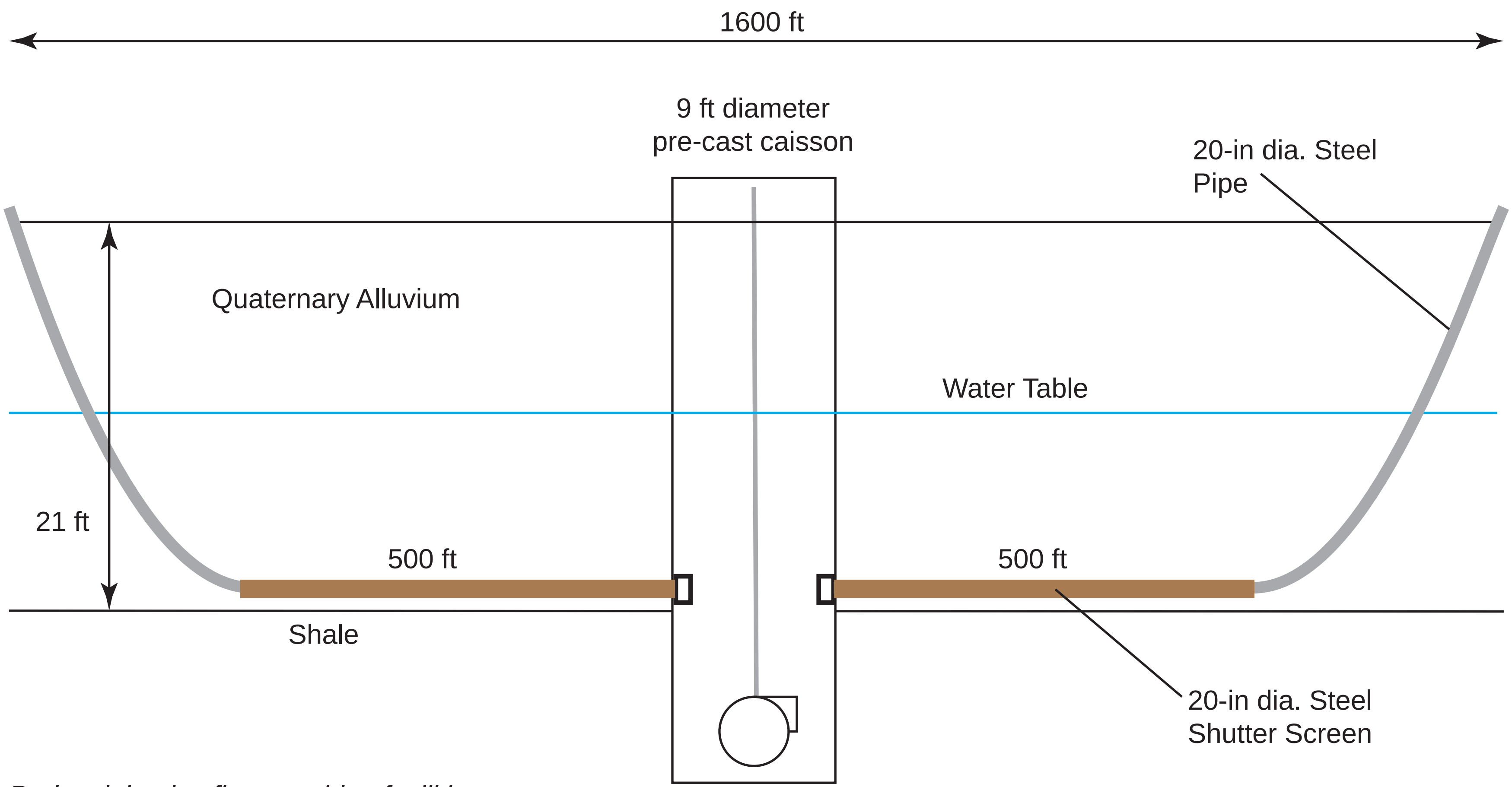
Plugging of the source intake by particulate in the river is unlikely to impact either the screen or filter pack, due to the offset from the channel, the low hydraulic gradient to the source, and the natural filtration that would occur by native media. However, plugging of the interface between the river and the aquifer, as a natural recurring process could occur, and as described above, would be evaluated as part of the pre-design work.

5.6 Infiltration Gallery by Horizontal Drilling

Cost details for the construction of the infiltration gallery by horizontal directional drilling (HDD) are provided in Table A-4. Total cost of this project could have associated variability of ±$2,000,000. This project includes the construction of five infiltration galleries, each including 1,000 ft of screen. Total production of the five units is estimated at approximately 11 MGD, falling well short of the 20 MGD design requirement. Although the infiltration gallery constructions use the same length of drain pipe, the HDD method is installing 20-inch drain pipe into native material, which has lower capacity. Figure 5-2 illustrates the concept design for one facility.

It is unclear that HDD contractors in the U.S. have the capability or interest at present to complete the installation as planned. The cost data and design were developed with informal consultation of an HDD contractor. Contractors in three states were contacted (California, Texas, and Washington), and it appears that none have installed 20-inch diameter well screen as would be required for the project. The HDD industry at present appears to be largely involved with the installation of pipelines and small diameter environmental remediation wells.

The HDD approach to construction is highly desirable because it avoids the enormous quantity of earth work required by the trench method. But it may not be ideal for water supply production, as the method is essentially a mud-rotary drilling method. Mud products are used to stabilize the borehole, which in some conditions could be difficult to remove and therefore would impair water production. Compaction of the native formation also can occur as part of the screen installation process, which again could impact water production potential. There are also a myriad of problems that can occur during installation, as for any drilling operation, that can further impact the project outcome. With further technology development and contractor experience, HDD has great potential in the water well industry, and would be expected to become highly competitive to other methods.



Project inlcudes five matching facilities.

Figure 5-2
Infiltration Gallery by Horizontal Directional Drilling

The infiltration gallery construction project using HDD technology was planned to include the following work items:

- A 9-ft diameter pre-cast caisson would be installed to a depth of 30 feet, set about 10-feet into shale, and plugged at the bottom. This installation would be made by a radial collector well contractor or equivalent. The lower 15-ft of the caisson would be temporarily filled with light cement (e.g., 12 lbs/gal). Subsequent to setting of the screen the light cement would be cleaned out and the screen penetrations would be finished with aprons and gate valves;

- HDD installation of 20-inch diameter steel pipe and louvered screen would be included. HDD would drill a borehole through the caisson and then pull the screen and pipe back through. There is 580 ft of 20-inch diameter pipe between the screen section and the entry and exit points (290 feet per side). It may be possible to eliminate the pipe on the exit side. Eighty hours of well development was included;

- Each caisson would be equipped with a 1,600 gpm pump and variable frequency drive. It was assumed that controls would be housed within a single building for all five units and that three phase power would be constructed for four miles to reach the site;

- 4,250 ft of new pipeline construction is included ranging from 12- to 24-inch diameter PVC with ductile iron fittings to deliver water to the site boundary from the facilities. The pipeline manifolds together the five facilities; and

- Contingency and engineering fees were estimated at 15% and 25% of construction, respectively, which are typical feasibility level estimates used for general civil construction projects.

Maintenance cleaning of the screens as described for the trench construction, also applies to the horizontally drilled facilities. These facilities can be cleaned with mechanical methods as well as chemical methods, which will improve the outcome. Mechanical cleaning is accomplished by running drill tools into the screens from the entry and exit points. Chemical cleaning would be similar to that described above, however, a smaller volume of solution would be used due to the absence of a filter pack. The cleaning frequency and cost range would be similar.

6 REFERENCES

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APPENDIX A

COST ESTIMATION DETAILS

TABLE A-1
MONITORING WELLS AND GEOPHYSICAL SURVEY

Surveying	5,000			
Pre-design	3,000			
Design	1,500			
Bidding	1,000			
Bid Award / Contract	500			
Data Analysis & Reporting	20,000			
Subtotal	31,000			
Construction				
Monitoring Wells (10)	21,600			
Gradation Analyses	6,000			
Resistivity Profiling (12 @ 1100')	30,000			
Subtotal	57,600			
Construction Inspection/Geologist	6,000			
Construction Phase Total	63,600			
Construction Phase Contingency	9,540			
Construction Total	73,140			
Construction + Non-Construction	104,140			
Monitoring Well Contractor				
Activity	Qty	Units	Rate	Total
Mobe/Demobe	1	LS	2,000	2,000
Support Truck	8	DAY	75	600
8" HSA Drilling w/SPT	250	LF	20	5,000
Well Installation	250	LF	25	6,250
Monuments	10	EA	100	1,000
Well Development	20	HR	150	3,000
Abandonment	250	LF	15	3,750
TOTAL				21,600

TABLE A-2
PRODUCTION TEST WELLS

Surveying	5,000					
Pre-design	5,000					
Design	5,000					
Bidding	2,500					
Bid Award / Contract	1,500					
Data Analysis & Reporting	30,000					
Subtotal	49,000					
Construction						
Production Wells (3)	71,250					
Pumping Tests (3)	75,600					
Extended Pumping Test (1)	40,000					
Water Level Monitoring Instruments	20,000					
Analytical Laboratory	4,000					
Subtotal	210,850					
Construction Inspection/Geologist	24,000					
Pumping Tests/Hydrogeologist	32,000					
Construction Phase Total	266,850					
Construction Phase Contingency	40,028					
Construction Total	306,878					
Construction + Non-Construction	355,878					
Production Well - Driller						
Activity	Qty	Units	Rate	Total		
Mobe/Demobe	1	LS	5,000	5,000		
16" Drilling w/Temporary Casing	8	LF	250	2,000		
Surface Seal	1	EA	1,000	1,000		
12" Drilling w/Casing	22	LF	225	4,950		
12" TS Screen Assembly Installed	24	LF	250	6,000		
Development	12	HR	400	4,800		
			TOTAL	23,750	3	71250
Temporary Pumping System	1	EA	10,000	10,000		
Pumping Test Hourly	76	HR	200	15,200		
			TOTAL	25,200	3	75600
Extended Pumping Tests						
Temporary Pumping System	1	EA	10,000	10,000		
Pumping Test Daily	60	DY	500	30,000		
			TOTAL	40,000	1	40000

TABLE A-3
INFILTRATION GALLERY BY TRENCH METHOD

INFILTRATION GALLERY, 5000 LF			
Activity	Quantity	Units	TOTAL
Mobe, bonding, per diem, admin.	1	LS	$ 1,116,250
Clearing	18	AC	$ 5,425
Topsoil stripping/stockpiling	26,000	CYD	$ 24,180
Excavation, scraper	163,000	CYD	$ 350,450
Excavation, trackhoe	30,000	CYD	$ 123,600
Excavation, hauling	30,000	CYD	$ 107,400
Filter pack hauling	9,000	CYD	$ 100,350
Filter pack purchase and loading	9,000	CYD	$ 364,500
Filter pack emplacement	9,000	CYD	$ 27,990
Backfill, native	250,000	CYD	$ 517,500
Backfill, compaction	250,000	CYD	$ 70,000
Rough grading, sitewide	1	LS	$ 72,000
Topsoil placement	26,000	CYD	$ 152,100
Seeding	700	MSF	$ 22,400
Manholes, 6' ID x 8' depth	10	EA	$ 51,000
Manholes, additional depth below 8'	160	LF	$ 98,400
Manholes, covers	10	EA	$ 9,250
Drain pipe, 36" HDPE or PVC	5,000	LF	$ 947,500
Dewatering system, one pump	150	DAY	$ 140,250
Dewatering system, additional pump	150	DAY	$ 18,900
Cofferdam wall, 25' depth, steel sheetpiles	5,200	LF	$ 3,900,000
		TOTAL	$ 8,219,445
PUMPING STATION			
Wet well excavation	1	LS	$ 20,000
Wet well w/plug, 9' dia. x 35'	1	EA	$ 88,460
Line shaft pump w/VFD, 3500 gpm	2	EA	$ 150,000
Power Service (1/2)	2	MI	$ 70,000
Electrical w/controls	1	EA	$ 100,000
Mechanical	1	EA	$ 100,000
Building	625	SF	$ 93,750
	TOTAL PER UNIT		$ 602,210
	TOTAL TWO UNITS		$ 1,204,420
PIPELINE			
Excavation	2,100	CYD	$ 8,421
Bedding purchase and loading	1,750	CYD	$ 70,875
Bedding hauling	1,750	CYD	$ 19,513
Bedding emplacement	1,750	CYD	$ 5,443
PVC Pipe, 24" dia.	2,800	LF	$ 180,600
Ductile Iron Fittings, 24" dia.	6	EA	$ 71,375
			$ 356,226
Contractor Total			$ 9,780,091
Contingency		15%	$ 1,467,014
Contractor Total with Contingency			$ 11,247,105
Engineering, Admin.		25%	$ 2,811,776
20 MGD FACILITY TOTAL			$ 14,058,881
UNIT RATE ($/MGD)			$ 702,944

TABLE A-4

INFILTRATION GALLERY BY HORIZONTAL DRILLING

1000 LF HORIZONTAL SCREEN				
Activity	Quantity	Units	TOTAL	
Mobe, bonding, per diem, admin.	1	LS	$	282,000
Drilling and setting of screen	1580	LF	$	632,000
Drilling fluid additives	1	LS	$	50,000
20" steel pipe, tip + tail	580	LF	$	58,750
20" steel shutter screen	1000	LF	$	183,750
Development	80	HRS	$	40,000
		TOTAL	$	1,246,500
9' OD x 30 FT CAISSON				
Caisson Installed	1	EA	$	423,140
Light cement, installed	1	EA	$	15,000
Cement clean out	1	EA	$	25,000
Screen penetrations & valves	2	EA	$	60,000
		TOTAL	$	523,140
PUMPING STATION				
Line shaft pump w/VFD, 1600 gpm	1	EA	$	75,000
Power Service (1/5th)	0.8	MI	$	28,000
Electrical w/controls	1	EA	$	60,000
Mechanical	1	EA	$	60,000
Building (1/5th)	125	SF	$	18,750
		TOTAL	$	241,750
TOTAL PER UNIT			$	2,011,390
TOTAL FIVE UNITS			$	10,056,950
PIPELINE				
Clearing	3	AC	$	930
Topsoil stockpiling	1500	CYD	$	1,395
Excavation	6300	CYD	$	25,263
Bedding purchase and loading	3500	CYD	$	141,750
Bedding hauling	3500	CYD	$	39,025
Bedding emplacement	3500	CYD	$	10,885
Backfill	2700	CYD	$	5,589
Compaction	2700	CYD	$	3,240
Rough grading	1	LS	$	4,950
Topsoil grading	1500	CYD	$	8,775
Seeding	13.3	MSF	$	426
12" PVC Pipe	1250	LF	$	29,375
16" PVC Pipe	1000	LF	$	30,000
20" PVC Pipe	1000	LF	$	47,000
24" PVC Pipe	1000	LF	$	64,500
Ductile Iron Fittings	16	EA	$	73,875
		TOTAL	$	486,978
Contractor Total			$	10,543,928
Contingency		15%	$	1,581,589
Contractor Total with Contingency			$	12,125,517
Engineering, Admin.		25%	$	3,031,379
11 MGD FACILITY TOTAL			$	15,156,896
UNIT RATE ($/MGD)			$	1,377,900

APPENDIX G – HKM ENGINEERING. SEPTEMBER 2002. DESIGN REPORT, NEW RAW WATER INTAKE & PUMP STATION

DESIGN REPORT

City of Laurel, Montana

New Raw Water Intake & Pump Station

SEPTEMBER 2002

HKM ENGINEERING

DESIGN REPORT

CITY OF LAUREL, MONTANA

NEW RAW WATER
INTAKE & PUMP STATION

Prepared By:

HKM ENGINEERING

HKM Engineering Inc.
PO Box 31318
222 North 32nd Street, Suite 700
Billings, MT 19101

September 2002

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1.0 INTRODUCTION

1.1 BACKGROUND

The Yellowstone River is the source of supply for the City of Laurel's water needs. The raw water intake and pump station are located south of town on the north bank of the river. The intake provides raw water for the City's water treatment plant as well as for the primary industrial user in the area, the Cenex refinery. Figure 1-1 is a project location map.

The City has encountered water supply problems, particularly in the last several years, associated with sedimentation, channel migration, and low flows in the Yellowstone River. In recent years, the river has required annual maintenance, consisting of the construction of dikes in the channel, to sustain an adequate flow at the existing tower intake structure. These actions have required emergency USACE Section 404 Permits to complete.

A feasibility study was recently completed to investigate alternatives to correct this costly and environmentally damaging, albeit necessary, practice (HKM, 2002). The selected alternative, concurred upon by the City and all interested agencies, is to construct a second intake structure located in the main channel of the Yellowstone River near the south bank.

A secondary supply problem for the City of Laurel is the age, configuration, and reliability of the raw water pumps and building. The existing pump station is one of the original components of the City's water system. Among other problems, the structure is near the end of its useful life and the pumps do not provide a dependable supply of water to the treatment plant and refinery at low river levels due to their elevations and layout. The existing pumps have each been rebuilt over time and are also near the end of their useful lives.

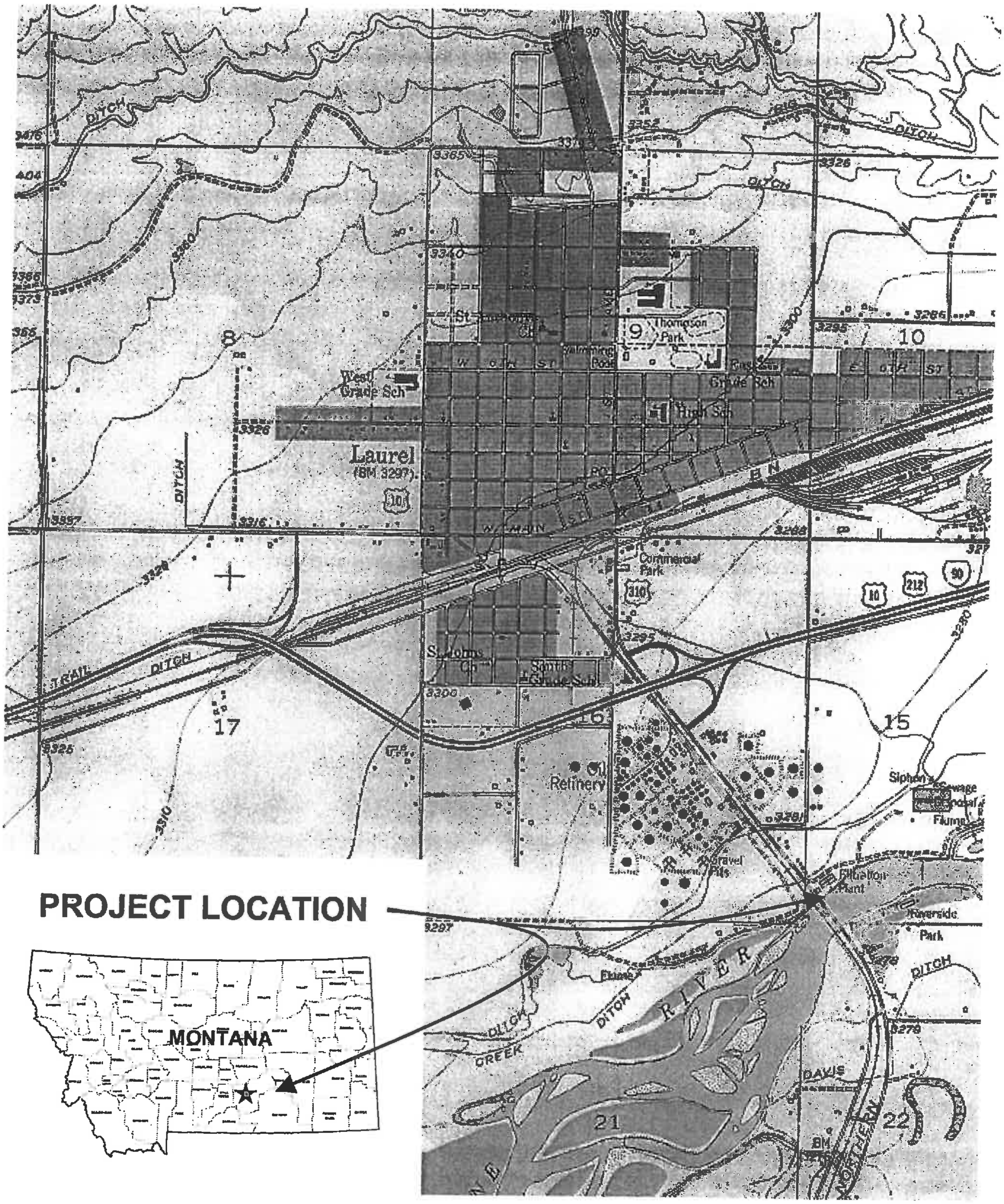
This project will correct the deficiencies of the existing intake and raw water pump station. A new intake will be constructed to provide a second source of supply. A new pump station will also be provided to replace the outdated and unreliable pumps and building. Funding for this project will come from an USACE grant and City funds.

1.2 EXISTING SYSTEM

Construction drawings, treatment plant records, site inspections, survey data, and City personnel knowledge have been used to define and analyze the existing intake and raw water pumping system. Complete and accurate as-built drawings are not available for either the intake or the pump station.

1.2.1 River Intake

The existing river intake is a concrete tower structure located near the left (north) bank of the Yellowstone River, just downstream of a pier supporting the Highway 212/310 bridge. The tower consists of a single flow-through chamber on the southeast side with two sluice gate inlets



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

PROJECT LOCATION MAP

FIGURE 1-1

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to feed dual chambers inside the structure. The gates are equipped with bar screens for debris removal. Two buried 20-inch pipelines were recently installed to convey water from each of the intake chambers to the pump station on the adjacent bank. The new intake lines were necessary due to a large ice flow that tore out the previous shallow-buried lines.

The Yellowstone River is constantly changing in its morphology, but according to river surveys, aerial photos, and City personnel the main channel has been near the right (south) bank for several decades. The channel bottom elevation in the main channel just downstream of the bridge is approximately 3254-55 ft (NAVD88). The existing intake structure is located in a secondary channel with an approximate channel bottom elevation of 3258 ft. According to City personnel, limited water is available from the existing intake when the river stage is lower than approximately 3262 ft.

1.2.2 Raw Water Pump Station

The existing raw water pumping station consists of five pumps. Three of these pumps supply the City's water treatment plant and the remaining two supply the raw water needs of the refinery. A summary of the existing pump sizes, types, and other data is provided in the adjacent table. The accuracy of the pump performance data is unknown, as the several of the pumps have been rebuilt and piping modifications have been made, which has likely resulted in slight changes in their operating characteristics. The refinery pumps typically operate at higher heads and lower flows than the values shown.

The two supply systems are completely independent of one another (aside from the shared intake). The existing pumps draw water directly from individual suction pipelines off of common manifolds. The pumps are located in an underground dry well and driven by motors located on the ground floor. All of the pumps are controlled by manual operation.

TABLE 1-1
EXISTING RAW WATER PUMPS SUMMARY

Pump ID	*Motor HP*	*Rated Discharge (gpm)*	*Approx. TDH (ft)*	*Pump Type **	*Original Install Year*
City #1	25	2,000	30	C	1974
City #2	20	2,000	25	C	1964
City #3	15	1,400	27	C	1960
Subtotal	60	5,400	—	—	—
Refinery #1	75	2,000	100	VT	1970
Refinery #2	50	1,400	100	VT	?
Subtotal	125	3,400	—	—	—
Total	**185**	**8,800**	—	—	—

* C = Centrifugal (vertical shaft driven); VT = Vertical Turbine (lineshaft)

1.2.3 Water Treatment Plant System

1.2.3.1 Process Overview. Raw water supplied to the City's treatment plant is pumped from the intake to a Parshall flume located in the main filter building, which discharges into the sedimentation basins after treatment chemicals are added. The settling basins feed by gravity directly to the treatment plant's two filters. Flow through each filter is regulated by an inline meter and electric flow control valve. The filter effluent discharges into a small (30,000 gal) 'deep well' that contains a tailwater control weir for the filters and provides very temporary storage.

Variable-speed transfer pumps are used to convey the finished water from the deep well to the clearwell (1.0-MG capacity) at the same rate as the filter operation. High service pumps then deliver water to the distribution system. A simplified schematic of the existing treatment plant system's major hydraulic components is shown in Figure 1-2.

1.2.3.2 Intake Pump / Treatment Plant Operation. Virtually all aspects of the treatment plant, with the exception of the raw water intake pumps, are operated automatically by an integrated control system. One or more raw water pumps are manually turned on to provide a discharge approximately equal to the desired filter rate. If the filter rate and raw water delivery rate do not match, the water levels in the sedimentation basins and the filters fluctuate. Only one filter is used for flowrates up to about 2,000 gpm (loading rate = 2.6 gpm/ft^2) before switching to both filters.

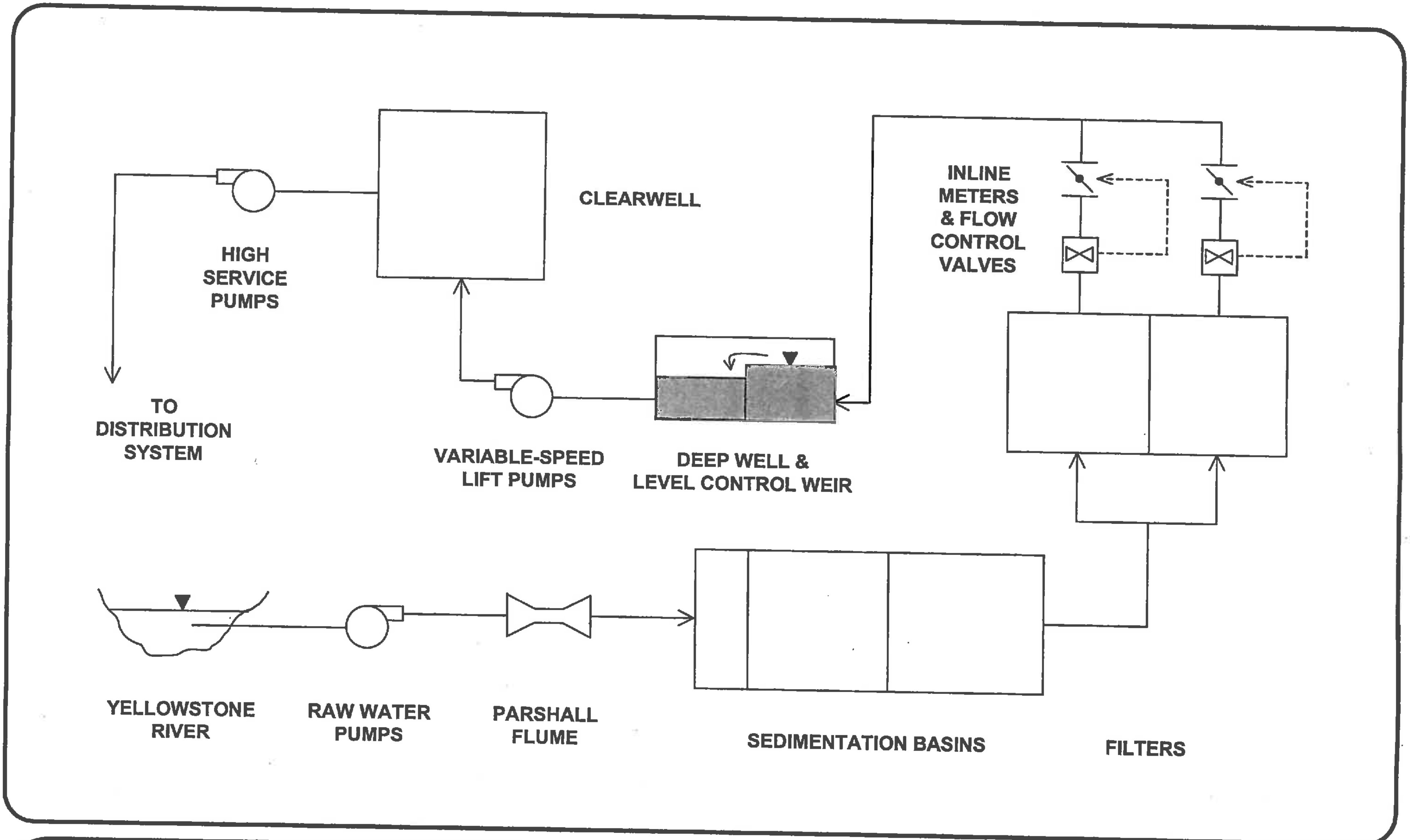
Only one raw water pump is operated for much of the year. During peak demand periods in the summer months, the operation of two or three pumps is sometimes required. The filters and raw water pumps are operated continuously (24 hours/day).

1.2.4 Refinery System

1.2.4.1 Process Overview. The refinery's raw water is pumped from the intake approximately ½-mile to its point of use. A propeller flow meter and pressure gauge are located on the intake pump discharge manifold. At the refinery, the water passes through an in-line screen and a flow control valve (FCV) before discharging into a small, constant-level, temporary storage basin. Overflow from the storage basin feeds a small wet well, which serves as the suction source for the refinery's process pumps. A level indicator in the wet well automatically controls the operation of the FCV and thus the water supplied from the intake. A simplified schematic of the existing treatment plant system's major hydraulic components is shown in Figure 1-3.

1.2.4.2 Intake Pump Operation. The refinery's raw water process pumps operate continuously to feed a variety of system components. Due to a lack of significant storage capacity at the refinery, the refinery's intake pumps must operate continuously as well. Therefore, at least one (and typically only one) of the two intake pumps is operating at all times. The FCV at the refinery regulates the intake pump discharge rate to match the process pump(s) discharge rate, which varies widely and is often much lower than either of the intake pump's rated capacity. Therefore, the intake pumps often operate outside of their recommended ranges, which has resulted in more frequent maintenance than normal.

The refinery has the capability to use treated water from City's distribution system as an alternative to the raw water supply pumps. This option is sometimes necessary, such as when the river level is low and the intake pumps loose their suction, but is not desirable. The refinery must purchase the treated water and then re-treat it (to remove the chlorine) before use.



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

SIMPLIFIED WATER TREATMENT PLANT SCHEMATIC

FIGURE 1-2

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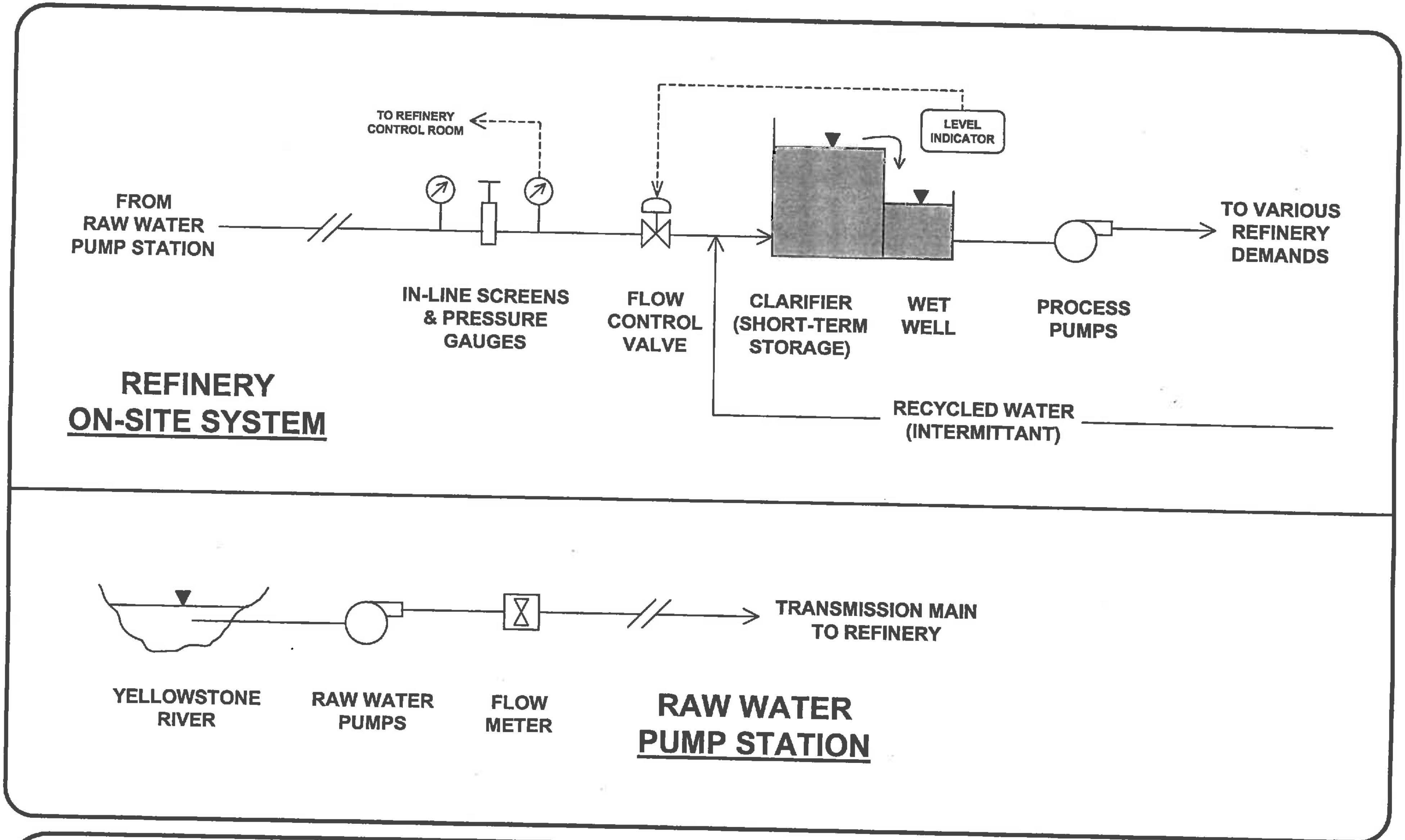

CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

SIMPLIFIED REFINERY RAW WATER SYSTEM SCHEMATIC

FIGURE 1-3

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1.3 WATER DEMANDS

This section summarizes the current water usage of the treatment plant and refinery, as well as establishes the raw water demands that will [illegible] design of the intake and pump station project.

1.3.1 Current Usage

The treatment plant maintains records of flow meter readings and pump operation hours. Monthly summary records for the previous five years of operation have been analyzed to determine current raw water supply quantities from the intake pump station.

1.3.1.1 Water Treatment Plant. The flow meter records indicate an average day raw water pumping rate to the treatment plant of 1.62 MGD (1,120 gpm). According to treatment plant personnel, the peak day water production has been in excess of 5 MGD (approx. 3,500 gpm) briefly during the summer and the minimum day supply is as low as 0.9 MGD (600 gpm). The typical filter rate in the winter is one filter at 1,000 gpm, while in the summer both filters sometimes operate at close to 2,000 gpm each.

1.3.1.2 Refinery. According to the flow meter records obtained from the treatment plant, the average daily raw water usage of the refinery is 1.09 MGD (760 gpm). Refinery personnel have indicated that the maximum daily water usage to date has been 1.7 MGD (1,180 gpm), but the peak capacity of their raw water process pumps, which is the maximum potential demand, is 1.9 MGD (1,320 gpm). Flows from the raw water intake pumps were recently observed as low as 460 gpm but can be even lower.

1.3.2 Design Capacities

The design demands presented in this section will be the basis for sizing the intake structure, pumps, and all other project appurtenances.

1.3.2.1 Treatment Plant. The adjacent table summarizes the design flows that will be used for the treatment plant's raw water pumps. The pumps installed during this project will have a 'firm' capacity (with the largest pump out of service) greater than the current peak day demand, while having the flexibility to efficiently deliver flows down to the typical low flow shown. The pump station will be designed to accommodate additional future pumps to achieve a total treatment plant supply equal to the future design demand given in the table, which has been taken from a previous planning report prepared for the City of Laurel (Morrison-Maierle, 1997).

TABLE 1-2
DESIGN CAPACITY - WTP INTAKE PUMPS

Description	*Design Flowrate*	
	(gpm)	*(MGD)*
Minimum Day Flow	600	0.9
Typical Low Flow	1,000	1.4
Project 'Firm' Capacity	4,000	5.8
Future 'Expandable' Capacity	10,400	15.0

1.3.2.2 Refinery. The adjacent table summarizes the design flows that will be used for the refinery's raw water pumps. Similar to the treatment plant's pumps, the refinery pumps installed during this project will have a 'firm' capacity greater than the current peak day flow. The pump station will be designed to accommodate additional future pumps to achieve a total capacity for the refinery equal to the future peak demand shown in the table. Refinery personnel have indicated a future need of only 2.0 MGD, which is based on their current (relatively short-term) operation plan. The value of 5.0 MGD being assumed for design has been taken from the previously mentioned planning report (M-M, 1997).

TABLE 1-3
DESIGN CAPACITY - REFINERY INTAKE PUMPS

Description	*Flowrate*	
	(gpm)	*(MGD)*
Current Average Day Demand	760	1.1
Project 'Firm' Capacity	1,500	2.2
Future 'Expandable' Capacity	3,500	5.0

1.3.2.3 River Intake. The intake will be designed with a capacity equal to the sum of the estimated future peak flowrates for the treatment plant and the refinery, as shown in the adjacent table. This will prevent the need to undertake construction activities in the river in the near future in order to upgrade the intake capacity.

TABLE 1-4
DESIGN CAPACITY - INTAKE

Description	*Capacity*	
	(gpm)	*(MGD)*
Treatment Plant	10,400	15.0
Refinery	3,500	5.0
River Intake	13,900	20.0

2.0 RIVER INTAKE

2.1 PREVIOUS STUDIES

As mentioned in the introduction, a recent report fully investigated several intake design options (HKM, 2002). This report combined the investigations of multiple previous reports and made a determination to construct a second intake structure located in the main channel of the Yellowstone River just downstream of the Highway 212/310 bridge near the south bank. This decision was made based on the probable effectiveness, cost, and longevity of each alternative considered. Figure 2-1 shows the proposed location of the new intake.

Other alternatives considered included:

- bendway weirs or spur dikes to direct flow to the existing intake
- a new intake upstream or downstream of the selected site
- various rehabilitation options for the existing intake, including installation of submersible pumps or a new wet well
- abandoning the existing intake for an earth holding pond
- groundwater wells

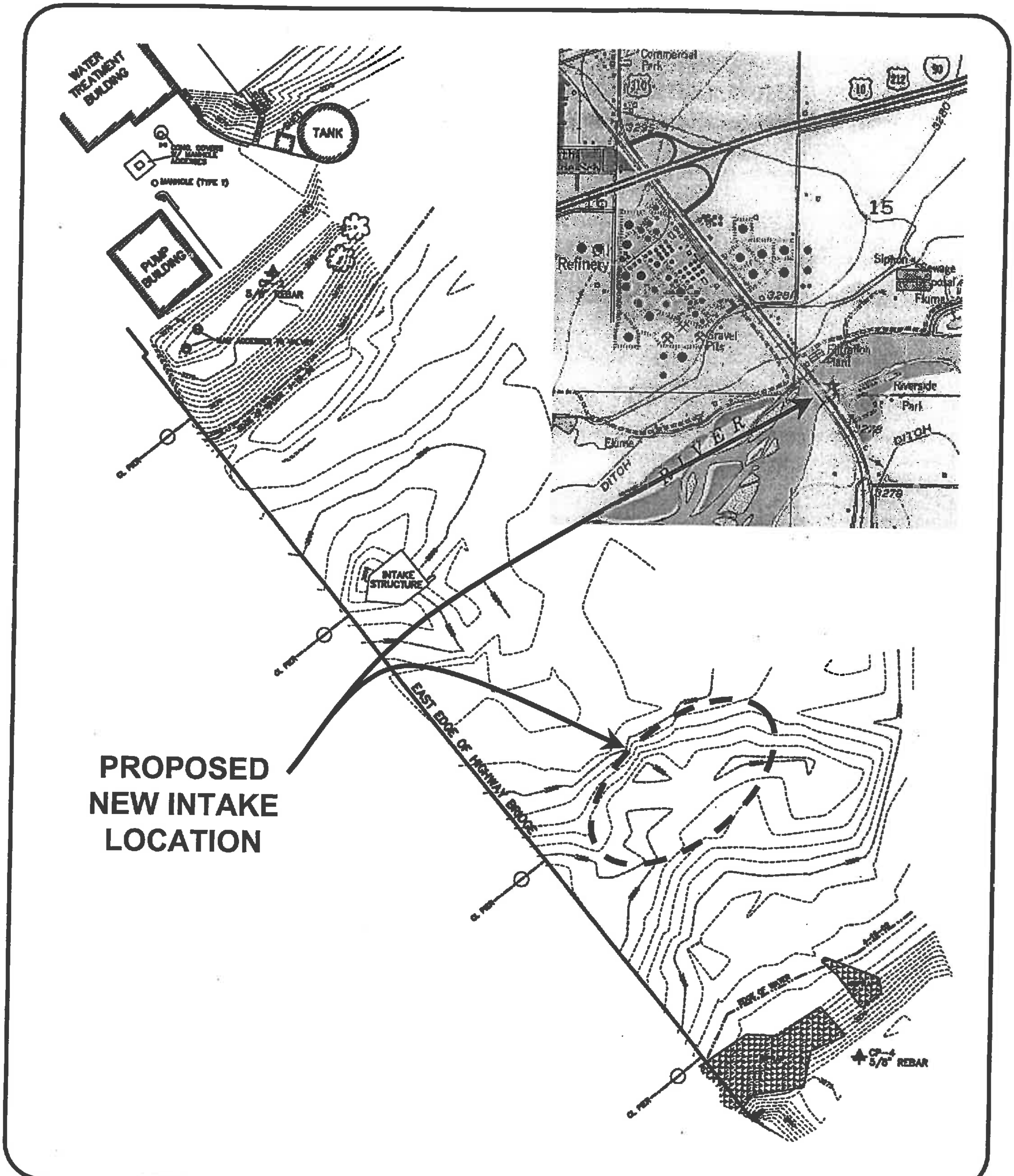
Due to the thoroughness of this previous document, all of these alternatives are not discussed in detail here. The intake types considered during this preliminary design phase for the previously selected site are discussed below.

All interested agencies have concurred with the selected design concept, including the US Corps of Engineers, Montana Department of Environmental Quality, Montana Department of Natural Resources & Conservation, Montana Fish Wildlife & Parks, US Fish & Wildlife Service, Yellowstone County Emergency Services (floodplain administrator) and the Montana State Historical Society. The USACE has issued a Finding Of No Significant Impact (FONSI) following their review of the Environmental Assessment (EA) associated with the intake construction. Several of these agencies will require review of the final design and will have to issue permits for construction.

2.2 INTAKE TYPE

The three intake types considered for the selected location are a tower intake, infiltration gallery, and submerged passive screens. The tower alternative has been immediately rejected due to the problems encountered by the City with their existing intake. These difficulties include hydraulic problems and the accumulation of bed material. In addition, the existing tower's large profile has, at one time, caused it to become dislodged from its location by ice flows. As further support for this decision, the City of Billings no longer uses their tower intake as a primary source of water, indicating that this type of intake is not ideal for the Yellowstone River at this location.

An infiltration gallery was eliminated from consideration during the feasibility study, but has been reconsidered here as part of the preliminary design phase at the request of the City.



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

PROPOSED RAW WATER INTAKE LOCATION

FIGURE 2-1

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Some of the primary considerations relevant to the selection of an intake type are large ice and debris flows, frazil ice, low water levels, moss and high sediment loads, riverbed geomorphology, and subsurface geology. Other analysis criteria include backwash capability and effectiveness, extent of disruption during construction, accessibility, long-term reliability, and past performance of similar systems on the Yellowstone River.

2.2.1 Infiltration Gallery

An infiltration gallery would consist of a series of screened collection pipes buried underneath the riverbed. The intake lines are bedded in a gravel and sand pack to allow infiltration into the system and would typically also allow a high-pressure backwash of the lines. In a standard design, the collection pipes would normally be placed a minimum of five feet below the river bottom. Preliminary calculations indicate the need for approximately 1,000 feet of collection lines (covering up to 10,000 square feet of area) in order to achieve the design capacity. Eight transmission lines would be required from the infiltration gallery to the pump station. Figure 2-2 shows a possible layout for an infiltration gallery.

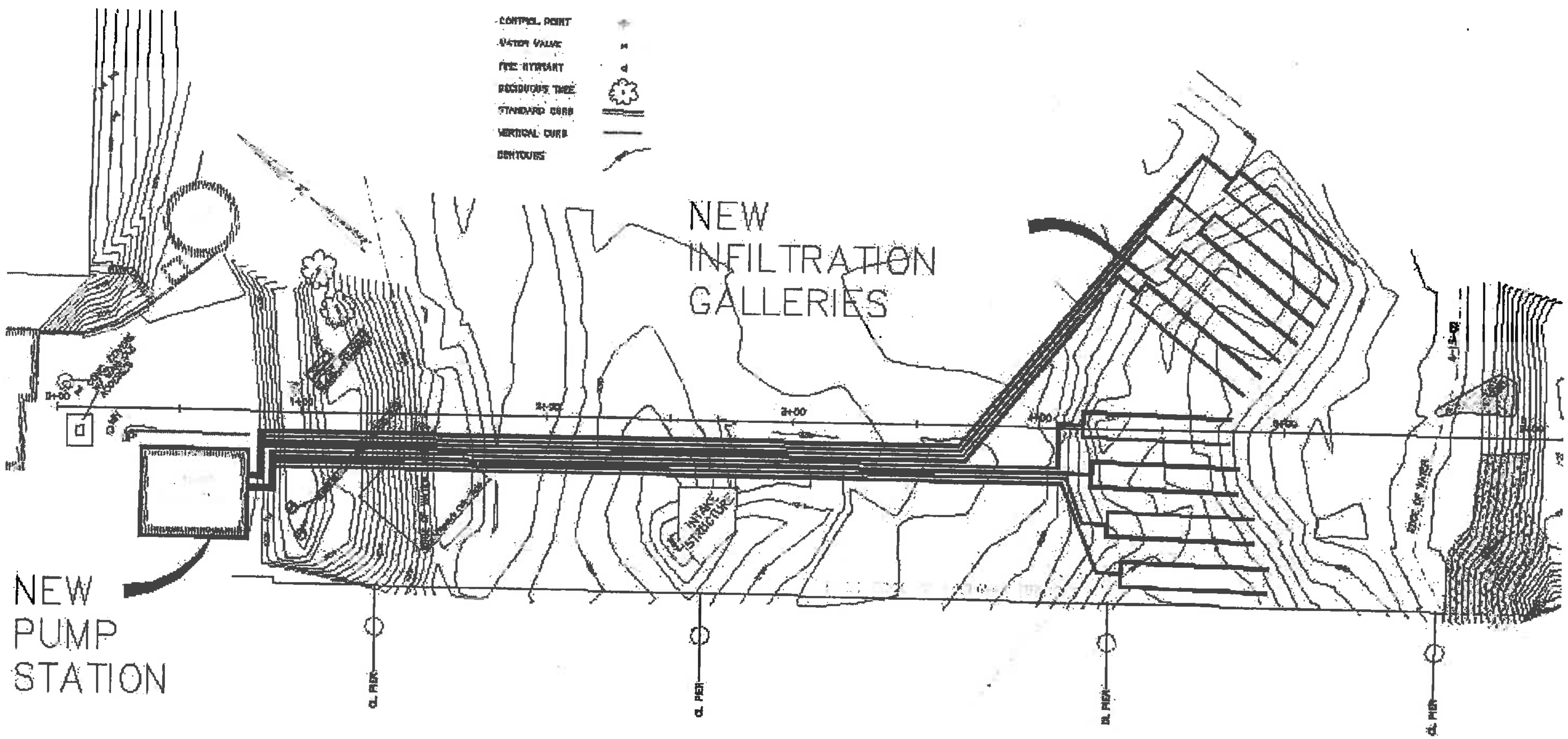
The primary advantages of an infiltration gallery would be its lack of obstruction in the river channel and constant submergence. Large debris and ice in the river would not be as much of a concern with this type of system. Also, during low flow periods and as the main channel shifts within the river's banks, the infiltration gallery would still be able to draw water. However, an infiltration gallery would also have some significant risks and disadvantages, including:

- Local geology indicates that the collection lines would be located in bedrock material, which would limit production to only vertical inflow from above rather than from the entire circumference of the screened pipes. This single direction flow would necessitate the long and expansive system described above.

- High sediment loads in the river and its unstable bed will gradually plug the packing material surrounding the collection screens, eventually causing the system to fail and become unusable. Even well designed backwash systems often cannot maintain a clean system. The siltation problem would be exacerbated by the one-directional flow discussed above.

- Several nearby communities have considered infiltration galleries in the Yellowstone River in the past but have also decided against them due to technical unfeasibility, including Billings Heights, Lockwood, Blue Creek, and the Montana Power Company (Forsyth area). More than one infiltration gallery at Hysham has been unsuccessful.

- As mentioned above, a high-pressure and high-volume backwash system would be required to clean the intake screens and sand pack. Either ground storage with backwash pumps or an elevated tank delivering untreated water would need to be provided, adding significant cost and maintenance. Oftentimes the velocities needed to effectively remove silt and other material from the system will displace or destroy the integrity of the packing material.



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

INFILTRATION GALLERY LAYOUT

FIGURE 2-2

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- The unevenness of the river bed and the changing river bottom would make this system difficult to construct and would vary the flow rates into the infiltration gallery. As sediments are deposited over the pipe, flow will decrease. Conversely, as overlying bed material is scoured away, flow will increase.

2.2.2 Passive Screens

This alternative would consist of large-diameter submerged screens located in the river current. Preliminary calculations indicate that four 24-inch tee screens with 1/8" openings would provide the required capacity. The screens would be mounted on and protected by a reinforced concrete structure. Two transmission lines from the intake to the pump station would be provided. Figure 2-3 shows a possible layout for a passive screen intake system.

The advantages of this type of a system over an infiltration gallery would be its above-ground accessibility and its greater reliability in terms of avoiding permanent disability. The communities of Glendive and Lockwood have had recent success with a passive screen intake system of similar design on the Yellowstone River.

Possible concerns with this type of intake structure include protection from ice and debris, maintaining submergence, plugging with moss or frazil ice, and preventing sand, gravel and cobble deposits from building up around the screens. However, each of these concerns can be effectively addressed and reasonably mitigated with a properly designed structure and backwash system.

2.2.3 Recommended Type

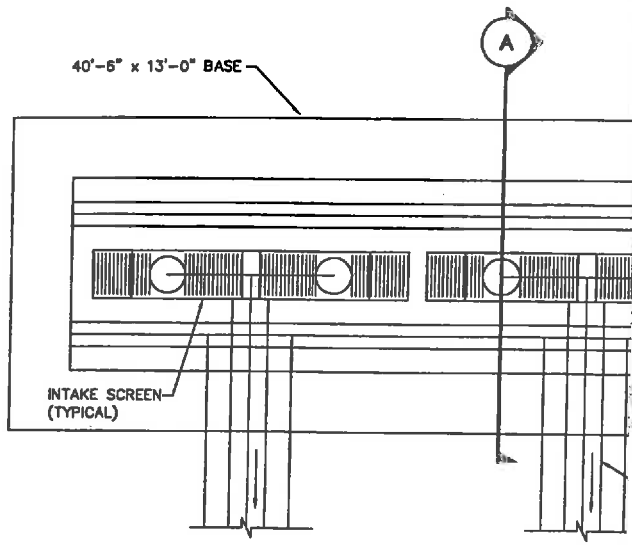
Neither of the intake options discussed above, an infiltration gallery and a passive screen system, would be fail-safe or without risks. Each system has obvious advantages and disadvantages as discussed above. Considering that long-term reliability is the most important factor for the City, the recommended intake type is a passive screen system. This selected option is also expected to be less expensive, in terms of materials, installation, operation and maintenance, than the infiltration gallery.

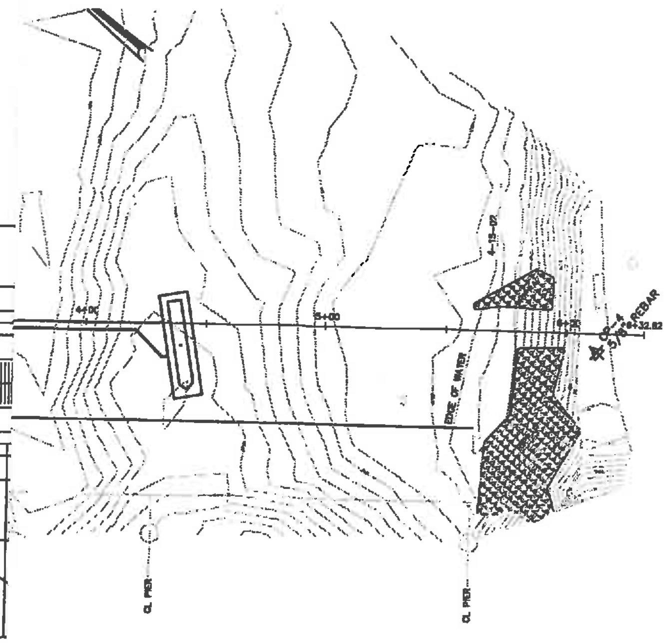
2.3 DESIGN FEATURES

This section describes the proposed design features of the recommended passive screen intake system. These design elements address the potential problems that could occur during operation of the intake, primarily with regard to the unpredictable nature and harsh environment of the Yellowstone River.

2.3.1 Physical Protection

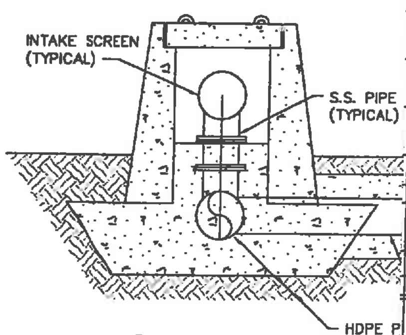
One potential problem with an above-ground intake design is the hazard associated with damage from large debris, floating ice, or anchor ice. The new intake will be designed as a massive reinforced concrete structure, with the majority of the structure's weight in the foundation below

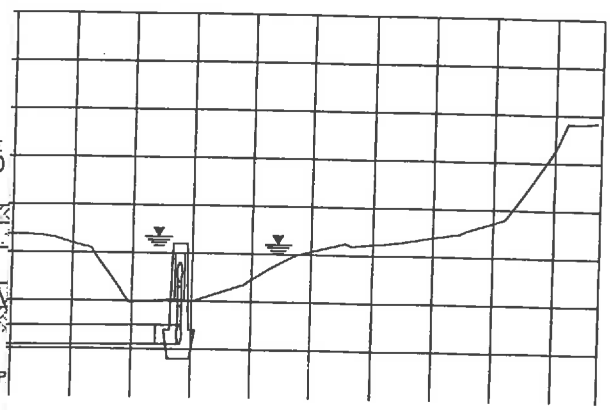




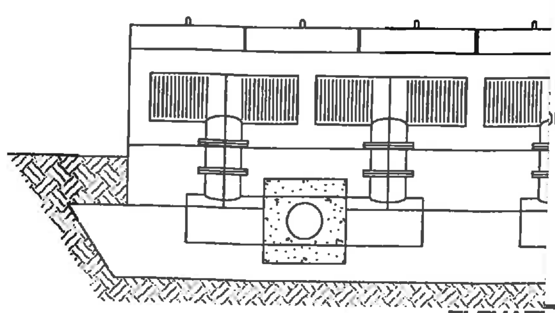
PLAN VIEW
RIVER INTAKE PIPING

SCALE 1/4" = 1'-0"

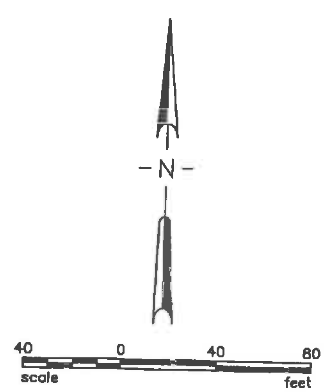




A SECTION
PIPING
SCALE : 1/4" = 1'-0"



1" = 40'
UR INTERVAL = 1'



ELEVATI
RIVER INTA
SCALE 1/

ATION

AYOUT

FIGURE 2-3

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Q:\06\M069145\dwg\LARL_IDTK.dwg 09/26/2002 04:11:20 PM MDT the river's bed. The structure will be designed to be narrow and low-profile in order to avoid as much impact as possible. It will be located just downstream of a bridge pier (although not directly in line with it due to hydraulic considerations), which will provide some added protection. In addition, the front of the intake will have a "cow catcher" wedge design to deflect debris and ice to the sides and above the structure. The screens will be protected on the top and sides by solid reinforced concrete walls and removable lid. The intake pipelines will be buried several feet deep in most places and be provided with a concrete encasement.

2.3.2 Maintaining Flow

Several potential conditions could exist which would restrict water flow through the screens, including low water levels and plugging with moss or frazil ice.

According to the information obtained thus far, maintaining sufficient submergence of the screens is possible during even the lowest river flows. Three recent river surveys in April (during low flow), June (just following high runoff), and August (also during low flow) indicate a relatively consistent river bottom elevation of 3254-55 at the proposed intake site. The estimated low water level reported by MDT for their recently completed bridge project is 3260.7. During a low water period in January of this year, which by most accounts was much lower than normal low water, the river level was surveyed at 3261.68 at the intake. Therefore, a minimum of 5.5 – 6.0 feet of water depth will be available for the intake at all times, which is adequate for screen submergence at all flow levels.

As for clogging of the screens, with moss and frazil ice being of highest concern, an air backwash system will be provided to keep the screen openings clear. Air lines connected to a compressor and large receiver in the pump station will transmit a burst of air to each screen and remove any accumulated blockages. Because the air lines are submerged, the air burst is preceded by a water flush as the air lines are evacuated, which provides a supplemental cleaning mechanism.

Another design consideration is that frazil ice is attracted to metallic surfaces. Alternative screen materials and/or coatings will be investigated during final design. In addition, piping will be installed from the pump station to the intake to allow for future hot water flushing if the air backwash system is not adequate for eliminating frazil ice accumulation.

2.3.3 Sediment Control

One of the problems with the existing intake is sediment buildup around the openings. In order to mitigate this problem at the new intake, the structure will be designed with ports in the front, at deck level, to produce a sluicing effect through the screen enclosure and out the open back. In addition, the structure deck will have blow-off lines connected to the air backwash system to provide further cleaning of the screen enclosure at regular intervals. Deposition of sand and gravel should be minimal in the main river channel anyway, especially just downstream of the bridge pier.

2.3.4 Redundancy

The final recommended design feature that will increase the reliability of the intake system is to connect the existing intake to the new pump station. This will provide a redundancy for when maintenance has to be performed or if the channel shifts in the future. Valves will be provided for each intake line so that each source can be isolated if necessary.

3.0 RAW WATER PUMP STATION

3.1 GENERAL

The second component of this project is a new raw water pump station. The function of the pump station is to deliver the design demands from the new and existing intakes to the treatment plant and refinery. This chapter discusses the hydraulics associated with the delivery system, applicable design criteria, and various design options considered.

3.1.1 System Hydraulics

The two systems that the pump station serves (the treatment plant and the refinery) are currently completely independent of one another. Each system has dedicated pumps and separate delivery pipelines. Each system also has unique hydraulic requirements, particularly with regard to head. The treatment plant raw water pumps require very little head due to the close proximity and small elevation difference of the point of delivery. The refinery pumps require significantly more head due to the longer pumping distance and elevation gain. Figure 3-1 shows the approximate 'system curves', or discharge-head relationships, for the two different facilities.

Due to the large differences in the system curves and the distinct operational considerations for each system, integrating the two systems using shared pumps is not feasible. Therefore, the new pump station will be designed as two independent systems with separate pumps, discharge piping, control systems, etc. in a shared building, similar to the existing arrangement.

3.1.2 Design Criteria

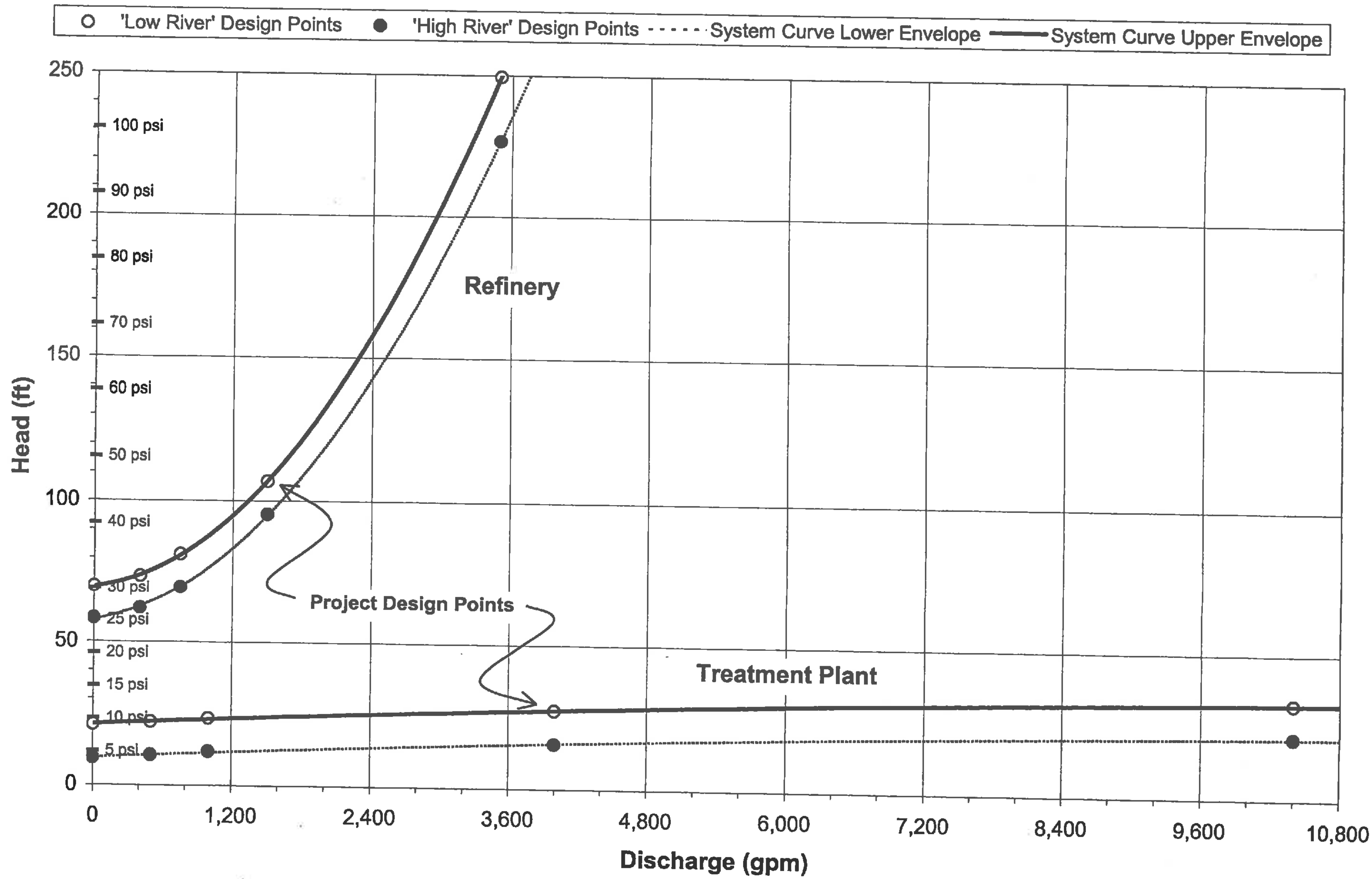
The primary design criteria for the new pump station is the Montana DEQ regulations presented in *Circular DEQ 1 – Standards for Water Works*, 1999 edition.

3.1.3 Summary of Pump Station Design Options

Several major design alternatives are available for the new raw water pump station, including those listed below. These and other design options will be presented in subsequent sections of this chapter, along with their advantages, disadvantages, City personnel preferences, and other considerations.

- Location
- Building layout and pump type
- Number of pumps, their discharge capacity, and drive type (constant v. variable speed)
- System controls

Figure 3-1
Raw Water System Curves



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3.2 PUMP STATION LOCATION

The available area for the new raw water pump station location is somewhat limited. The logical placement, and the assumed construction site for this report, is in the vicinity of the existing pump station as shown in Figure 3-2. This location allows for convenient connections to both the existing intake pipelines and both of the pump discharge pipelines. The existing pump station could either be demolished or remain in place, as discussed below.

3.2.1 Maintain Existing Building

Other than to house the raw water pumps, the existing pump station is currently used for garage space, miscellaneous storage, and as a work area. In order to maintain these auxiliary functions, the new pump station would have to be located adjacent to the existing pump station (between the pump station and the standpipe reservoir). However, several potential conflicts exist within this location, including:

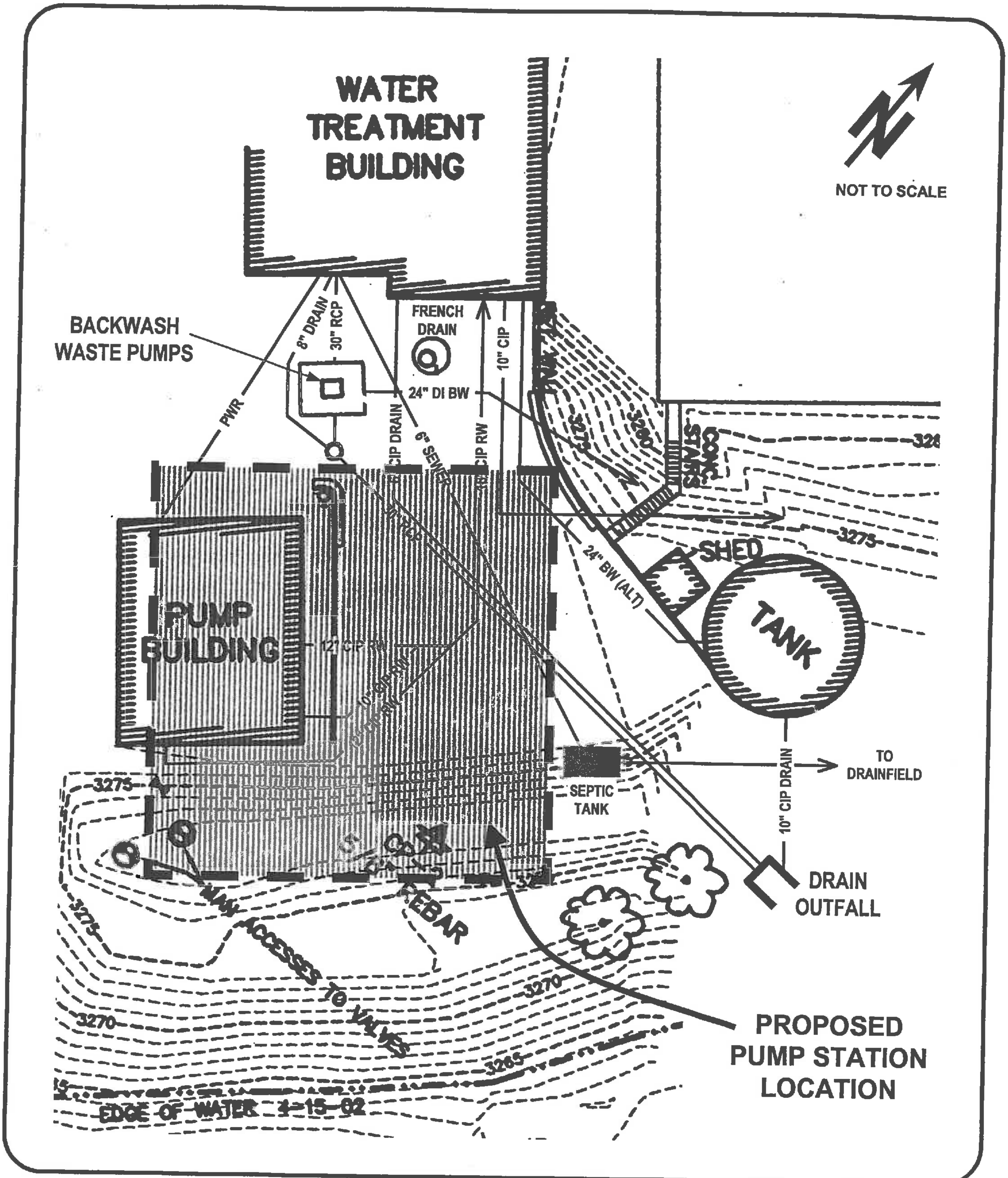
- Existing 10", 12" & 18" CIP raw water pump discharge lines
- Buried 30" RCP (filter backwash waste bypass drain) and 6" CIP (building drain) outfall lines directly underneath the proposed site
- Treatment plant sewer line (6" PVC) and septic tank positioned at the northeast end of the constructed levee along the river bank
- Construction difficulties associated with excavation near the existing foundation
- Access to the service road heading northeast beyond the standpipe reservoir
- Elimination of most parking at the treatment plant

The certainty or extent of each of these potential conflicts will depend somewhat on the pump station layout selected among the alternatives presented later in this report. The raw water lines will be abandoned or removed following construction of the new pump station, so the only potential conflict in this instance is maintaining service during construction, which could be accomplished with temporary pipelines. The other existing buried pipelines and septic tank will be avoided if possible, but could be relocated if necessary. Excavation for the new building would require near-vertical sides and expensive shoring and bracing. Vehicle access beyond the standpipe can be achieved from the opposite side of the settling ponds.

In addition to these potential conflicts, the existing building is the oldest structure at the treatment plant and, according to City personnel, experts have recently questioned its structural integrity. Several structural members are visibly deteriorating. In order to remain functional, the building would require significant strengthening and considerable maintenance in the future.

3.2.2 Demolish Existing Building

Another option for the new pump station placement is to demolish the existing building and utilize that space as well as the adjacent area considered above, if necessary. With this additional area, the new pump station could be expanded to include space for the auxiliary functions eliminated by demolition of the existing building. Many or all of the conflicts listed above could



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

PROPOSED RAW WATER PUMP STATION LOCATION

FIGURE 3-2

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be avoided. The pump station could also be moved slightly further east than the existing building, which is very nearly encroaching on the state highway right-of-way. In order to keep continuous service to the treatment plant and refinery, temporary raw water pumps and piping would need to be provided during construction if the pump station is eliminated.

3.2.3 Recommended Alternative

Due to the age, condition, and limited future functionality of the existing pump station, the recommended alternative is to demolish the building and utilize this vacated area and the adjacent space for construction of the new pump station. This will allow for a pump station design that is not constrained by area and which has plenty of floor space for maintenance access and other purposes.

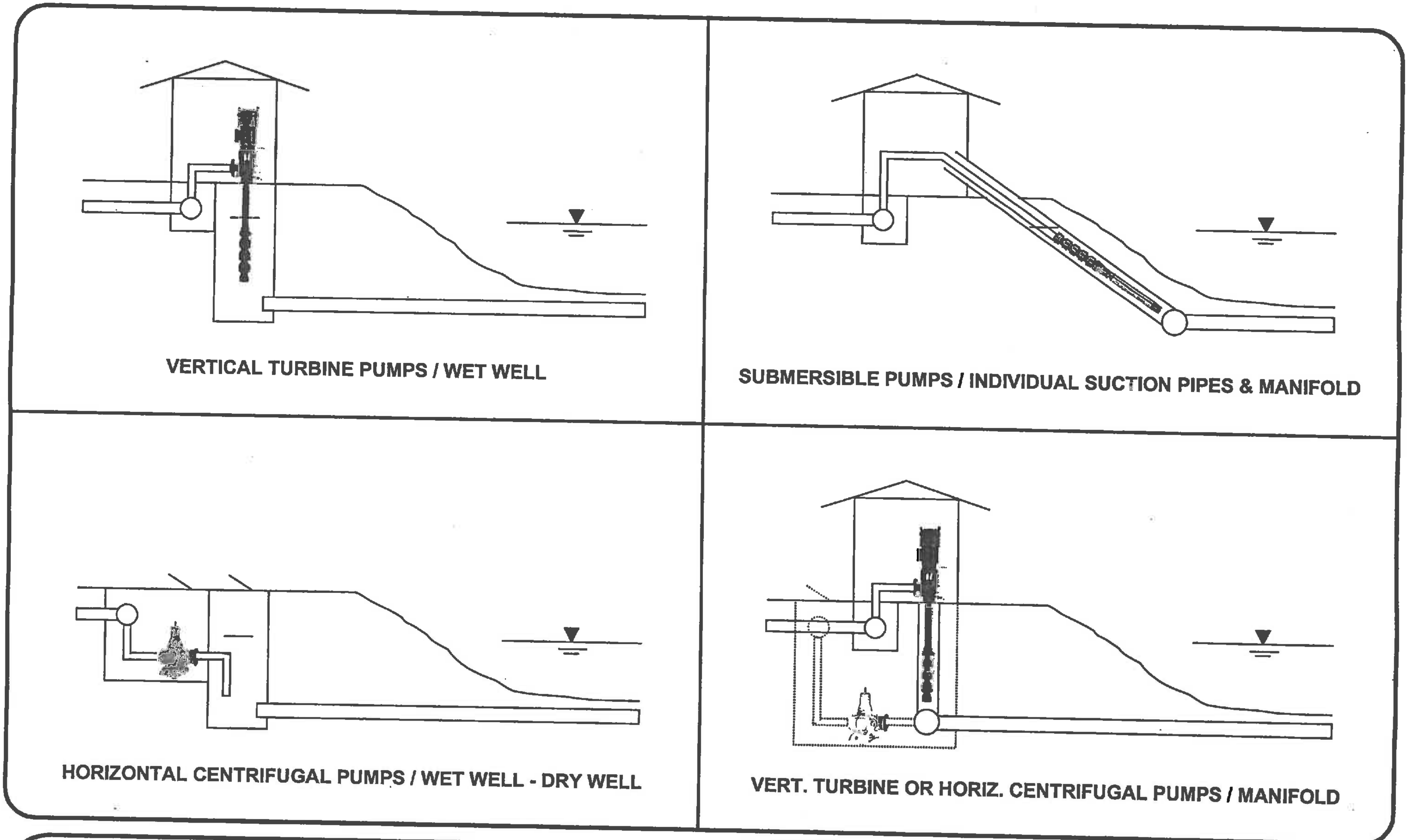
3.3 BUILDING LAYOUT & PUMP TYPE ALTERNATIVES

This section describes four alternative pump types and pump station configurations. In each case, the pump impellers will be set lower than the existing pumps and low river stage to avoid the suction problems that are currently encountered. The advantages and disadvantages of each option are given below before a recommendation is offered.

3.3.1 Alternative Descriptions

The various alternatives for pump type and building layouts are described briefly below. In addition, Figure 3-3 depicts the design concepts for each alternative.

> 3.3.1.1 Vertical Turbine Pumps / Wet Well. This alternative consists of vertical turbine pumps positioned above a common wet well. The wet well is fed directly from the intake structure and has a free surface approximately equal to the river stage. The pump motors are located above ground with a vertical lineshaft that drives the pumps. The pump bowls and impellers extend down into the wet well below the estimated low river stage.
>
> 3.3.1.2 Submersible Turbine Pumps / Individual Suction Pipes & Manifold. This alternative consists of submersible turbine pumps drawing water from individual suction pipes on a common manifold. The suction pipes and pumps are located on an incline down the bank of the river to reduce excavation costs. The submersible pumps, including motor, are positioned at the base of the inclined casing pipes below the estimated low river stage. The manifold is located at the river's edge and fed directly from the intake structure. A pump station building is still required to house the valving and other appurtenances on the pump discharge lines.
>
> 3.3.1.3 Horizontal Centrifugal Pumps / Wet Well - Dry Well Configuration. This option consists of an underground wet well and an adjacent dry well to house the centrifugal pumps. The horizontal pumps draw from the wet well much like the vertical turbine pumps described in the first alternative above. The entire pump station could be completely buried if desired.



CITY OF LAUREL
WATER SUPPLY INTAKE & RAW WATER PUMP STATION

ALTERNATIVE BUILDING LAYOUT / PUMP TYPE DESIGN CONCEPTS

FIGURE 3-3

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3.3.1.4 Vertical Turbine or Horizontal Centrifugal Pumps / Manifold. This alternative has elements of each of the other alternatives above. The pumps (either horizontal or vertical) would draw water from a common manifold that extends directly to the intake structure. No wet well would be provided, but (unlike the submersible pump option above) both the manifold and pumps would be housed in the pump station for convenient maintenance access.

3.3.2 Alternatives Comparison

Table 3-1 lists the some of the primary advantages and disadvantages of the various pump station layouts discussed above. The major considerations and selection criteria include available space (site constraints, excavation required, etc.), pump preference, access for inspection and

TABLE 3-1
PUMP STATION TYPES - ADVANTAGES & DISADVANTAGES

Pump Type / Building Layout	*Advantages*	*Disadvantages*
Vertical Turbine / Wet Well	* nothing enclosed, buried, or "hidden" with wet well design * ideal for large variations in water level & moderately deep installation * flexible in meeting head requirements by adding stages * suction always flooded / no priming * pump motors above flooding level * relatively small floor area / structure * wide selection of pumps available	* inspection / repair requires motor disconnect and pulling pump - tall structure or roof hatches required * sediment buildup in wet well requires air lift grit pump * long shaft requires more bearings and potential vibration problems * need air-vac valve (or priming equip.) if air collects in pump column
Submersible Turbine / Individual Suction Pipes	* least excavation required * small (but long) pumphouse footprint * most practical and economical for deep installations & handles variations in water level * no long-shaft problems as with VT * quiet operation * water cooling is effective	* pumps inaccessible for routine insp. * when maintenance is required, entire unit must be pulled, requiring tall structure and difficult extraction * more sediment is pumped with absence of wet well, seal problems may develop * long electrical cables * proprietary parts
Horizontal Centrifugal / Wet Well & Dry Well	* easy accessibility for pump inspection / maintenance, no motor disconnect required * wide selection of pumps available * if pumps below water level – no priming and air problems, but… * if pumps above water level – limits excavation, but…	* large area / excavation required * personnel access more difficult * sediment buildup in wet well requires air lift grit pump * ...motors subject to flooding (as shown in Figure 3-3) * …priming equip. is req., increasing complexity and reducing reliability
Vert. Turbine or Horiz. Centrifugal / Common Manifold	* similar to existing system (familiarity) * see other alternatives above, as applicable	* more sediment is pumped with absence of wet well * see other alternatives above, as applicable

maintenance, sediment management, and flood potential. There is assumed to be little difference in the cost of each alternative, although the submersible pump alternative would likely be the least expensive due to the limited excavation and pump station size. The alternatives utilizing horizontal pumps would likely be the most expensive due to the large pump station footprint and excavation quantities involved. Detailed estimates of each building layout alternative have not been completed.

3.3.3 Recommended Alternative

The recommended pump station layout is a vertical turbine pump configuration drawing from a common manifold. The manifold is housed in a dry well for maintenance access. This alternative is most similar to the existing pump station layout and is the preferred alternative of City personnel.

3.4 ALTERNATIVES FOR PUMP DRIVE TYPES, NUMBER & SIZES

This section describes four possible alternatives for each pump group, each with different numbers/sizes of pumps and pump drive types (constant-speed or variable-speed). The advantages, disadvantages, and operational considerations for each system are given before a recommendation is offered.

3.4.1 Alternative Descriptions

3.4.1.1 Constant-Speed Drives / Equal Size Pumps. This alternative consists of multiple equivalent pumps that operate at a constant discharge rate that is dependent on the system pressure. The possible raw water delivery rates from one or multiple pumps are incremental in roughly equal steps (i.e. with three pumps operating, the discharge is roughly equal to three times the output of one pump), and there would be large gaps in the flow spectrum.

3.4.1.2 Constant-Speed Drives / Unequal Size Pumps. This option is similar to the alternative above with the exception of the pump sizes. In this scenario, the discharge rates and motor sizes vary from pump to pump. The desired withdrawal rates are accomplished using specific combinations of pumps (e.g. two different sized pumps allow for three different discharge rates when used alone or in combination, three pumps allow for seven discharge rates, etc.). The range of possible delivery rates would have fewer gaps that with equal size pumps.

3.4.1.3 Variable-Speed Drives / Equal Size Pumps. This alternative consists of multiple equivalent pumps that are each able to operate at multiple discharge rates by varying the motor speed. Typically, a variable-speed pump can operate efficiently at discharge rates as low as 30 – 50% of its rated capacity (best efficiency capacity at highest speed). The entire flow spectrum is available with this option, from approximately half of the rated capacity of one pump to the sum of the rated capacities of all the pumps.

3.4.1.4 Mix of Variable- & Constant-Speed Drives. This option is essentially a combination of the alternatives above. The operational flexibility of variable-speed drives is available on some pumps, and the remaining pumps are less expensive constant-speed. Two variable-speed pumps (includes backup) can often fill in the gaps of the incremental discharge rates available from multiple constant-speed pumps. A variable-speed pump can also be used to deliver minimum flowrates without having to provide very small constant-speed pump that is not often needed (such as for the treatment plant).

3.4.2 Alternatives Comparison

The comparison table below shows the relative rank of the alternatives listed above with regard to several important criteria. The following definitions explain the various criteria:

- *Discharge Variability* – the ability of the pump group to cover the full range of desirable discharges
- *Operational Flexibility* – the interchangeability of pumps for lead-lag operation, backup purposes, etc.
- *Operational Complexity* – the involvedness and difficulty of proper pump operation to achieve the desired discharge (note: the introduction of automatic pump controls greatly reduces the complexity of variable speed pumps, thus reducing the significance of this criteria)

TABLE 3-2 - PUMP DRIVE TYPES & REALTIVE SIZES ALTERNATIVES COMPARISON

Drive Types / Relative Sizes	Rank (1 = Best , 4 = Worst)				
	Discharge Variability	Operational Flexibility	Operational Complexity	Capital Cost	Maintenance
Constant-Speed / Equal Sizes	4	1	1	2	1
Constant-Speed / Unequal Sizes	3	4	2	1	2
Variable-Speed / Equal Sizes	1	1	3	4	3
Mix of C/S & V/S	1	3	4	3	3

- *Capital Cost* – the initial construction cost, which reflects the relative number of pumps required and the drive types (note: variable-speed drives are typically the costliest components in a pump and motor installation)
- *Maintenance* – this criteria takes into consideration the cost, frequency, complexity, etc. of pump/motor/drive maintenance

3.4.3 Operational Considerations

There are important operational considerations for each of the two systems to be served by the pump station. These factors, as described below, are critical to the proper functionality of the systems and serve as guidance for weighting the importance of the different criteria considered above.

3.4.3.1 Treatment Plant. The new raw water pumps for the water treatment plant must somewhat match the filter rate in order to avoid large fluctuations in the water level of the sedimentation basins and filters. The filter rate is controlled by modulating valves that can discharge over a wide and continuous range of flows to match the system demand. Therefore, a new pump group that can operate at any discharge rate within the design flow range is desirable, however total flexibility is not critical. The capability to pump raw water at close to the filter rate will increase both the plant efficiency and treatment effectiveness. If only constant-speed pumps with discrete discharge intervals are provided, avoiding fluctuating filter levels would require either the pumps being frequently cycled on and off to match the filter rate or the filter rate would need to be adjusted to match the raw water pump operation.

3.4.3.2 Refinery. As with the treatment plant system, the refinery also requires a continuous supply of raw water at a variable rate. However, the required flowrate at any time is much less well defined, less predictable, and inconsistent. A further complication at the refinery is the lack of storage to buffer differences in supply and demand. Therefore, a new pump group that can operate at any discharge rate within the design flow range is imperative. In other words, variable-speed pumps are essential for effective and efficient operation of the refinery raw water delivery system.

3.4.4 Recommended Alternatives

In light of the operational considerations discussed above, the 'discharge variability' of the new pump station is the most important criteria in terms of selecting pump drive types, numbers and sizes, especially for the refinery pumps. The other criteria become somewhat secondary, but due consideration has been given to cost and maintenance requirements in making the following recommendations.

TABLE 3-3
RECOMMENDED PUMP INSTALLATIONS

Pump #	*Laurel WTP* Rated Discharge (gpm)	*Laurel WTP* Drive Type	*Cenex Refinery* Rated Discharge (gpm)	*Cenex Refinery* Drive Type
1	1,000	V/S	750	V/S
2	1,000	V/S	750	V/S
3	2,000	C/S	750	V/S
4	2,000	C/S	Future	?
5	Future	?		
6	Future	?		
Total No.	4 now, up to 2 future		3 now, up to 1 future	
Total Cap.	6,000	---	2,250	---
'Firm' Cap.	4,000	---	1,500	---

A combination of constant-speed and variable-speed drives is recommended for the treatment plant and all variable-speed pumps should be used at the refinery. The suggested numbers and approximate sizes of pumps for each system are shown in Table 3-3.

The four recommended project pumps for the treatment plant system can discharge at any flowrate from approximately 500 gpm to 2,000 gpm, and most flowrates above 2,000 gpm to a maximum of approximately 6,000 gpm. The plumbing for future installation of two more pumps will be provided for the treatment plant system. In addition, the treatment plant pumps installed for this project can be replaced with higher capacity pumps in the future, if necessary.

Likewise, the three recommended project pumps for the refinery system can discharge at any flowrate from approximately 375 gpm to 2,250 gpm. Using typical pump sequencing logic, a constant-speed pump, if provided, would not operate except when all three pumps were needed, therefore, has been disregarded. The plumbing for future installation of one more pumps will be provided for the refinery system. In addition, the refinery pumps installed for this project can be replaced with higher capacity pumps in the future, if necessary.

3.5 SYSTEM CONTROLS

Each group of raw water pumps will require a new control system for operation. The existing control systems are discussed below, followed by a presentation of several new control options for each system.

3.5.1 Existing Controls

The treatment plant has an existing SCADA system that currently allows automatic control of all major process features except the raw water pumps. The existing treatment plant intake pumps have to be manually turned on and off from inside the pump station.

The refinery intake pumps also require manual starting and stopping. However, the treatment plant personnel who must operate the pumps do not have direct knowledge of the amount of water that the refinery needs. Instead, they rely on telephone communication of how many pumps are required, which is an inconvenience for both parties and results in operational inefficiencies and pump maintenance problems. Examples of the types of problems that currently exist with this system, due to lack of communication or other issues, include:

- The refinery pumps often operate with little or no demand, resulting in wasted power and damage to the pumps.
- If the refinery needs more water than is being supplied by the raw water pumps, sometimes they switch to treated water even though the intake pump capacity could meet their demand.
- When treatment plant personnel are off duty, there is no convenient way to change the pump operations to match the refinery demands.

3.5.2 Treatment Plant System Alternatives

The following control options are available for the treatment plant intake pumps. The City has indicated a desire to integrate the raw water pumps into their existing SCADA system to achieve automatic operation. To be comprehensive, manual controls are also discussed below.

3.5.2.1 Manual Controls Only. This option is similar to the existing system, however the recommended V/S drives would require an added level of manual operation. The intake pumps speeds could be adjusted by hand until the existing intake flume indicates a flowrate equal to the filter rate, which would require trial and error fine-tuning. Considering the automatic control system that operates the remainder of the treatment plant, installing manually operated intake pumps would be neither efficient nor sensible. However, if manual controls are considered, constant speed pumps may be more practical.

3.5.2.2 Automatic Level Control. The intake pumps could be operated to maintain a constant level in the sedimentation basins and filters. Level sensors in the filters would control the intake pump(s) speed. If the filter rate were changed, the effect would be seen in the filter water level, signaling the pumps to speed up or slow down as appropriate.

3.5.2.3 Automatic Flowrate Control. Under this alternative, a signal from the existing flume would be used to adjust the V/S intake pumps. The treatment plant operators could select the desirable flowrate and the pumps would automatically adjust to discharge that amount. If the pumps were set to match the filter rate, the water level in the sedimentation basins and filters would remain constant in this case also.

3.5.2.4 Recommended Alternative. Automatic flowrate control is recommended for controlling the new treatment plant intake pumps. This option is similar to how the existing V/S clearwell transfer pumps are operated. Following the implementation of this project, the operators will be able to set the flow from the intake equal to the filter rate and the transfer pump rate under most conditions. Keep in mind that the series of intake pumps selected by the City for the treatment plant (Table 3-3) has certain discharges that are not possible due to the large C/S and small V/S pumps selected.

3.5.3 Refinery System Alternatives

Several control alternatives are also available for the refinery system. After speaking with refinery personnel, a couple alternatives were determined to be unfeasible and thus eliminated. These rejected alternatives included: (1) pumping to another storage location (possibly the existing storage tank) and using level controls to operate the intake pumps, and (2) matching the intake pump discharge rate with the total refinery demand using a aggregate flowmeter signal.

Among other concerns, the existing storage tank and refinery raw water system could not be easily converted for the first option. As for the second option, the refinery has multiple raw water demands (many of which are not currently metered) and also recycles some raw water back to the clarifier. Adding the new meters, totalizing logic, and a telemetry signal is too complex, easily susceptible to malfunction due to the number of components, and costly to the refinery.

The most practical alternative control concepts for the refinery intake pumps are described below. Again, automatic controls are preferred, but manual controls are discussed for completeness.

3.5.3.1 Manual Controls Only. This option is similar to the existing system, however, a recycle valve on the pump manifold is recommended to waste excess water back to the pump suction manifold during demands below the minimum operating range of the pumps. Turning the pumps on and off and adjusting the V/S drives (if provided) would continue to be a manual operation that would require verbal coordination between the refinery and the treatment plant operators. This alternative would not correct the control deficiencies that currently exist with the refinery intake pumps.

3.5.3.2 Automatic Control With Constant Discharge Pressure. In this alternative, the V/S drives on the pumps would maintain a constant discharge pressure equal to the maximum head required at the design peak discharge. The existing FCV at the refinery would be wide open at the peak demand and partially closed at lower flowrates to burn the excess head. During operation, a decrease in refinery demand raises the wet well level and signals the FCV to throttle back, which in turn will raise the discharge pressure of the intake pumps and signal the V/S drives to decrease in speed, lowering the pressure to the preset value and lowering the pump output. The FCV position and the intake pumps speed will reach equilibrium to supply the proper amount of water. A recycle valve would also be provided for this alternative to accommodate when there is very low or no refinery demand and the V/S drives cannot be turned down any lower.

3.5.3.3 Automatic Level Control Using Refinery Clarifier or Wet Well. Instead of the current configuration where the wet well level controls the FCV, new level controls would operate the intake pumps through a telemetry system and the FCV would be removed. In theory, the small volume of the current wet well is not a concern because the intake pumps will match the suction rate from the refinery's wet well. However, with a greater wet well volume, the V/S pump operation would be much easier to control. Also, when storage is limited, a minimum allowance of two feet of available water level fluctuation is typically provided for V/S pump control purposes. Ideally, the adjacent clarifier could be converted to a fluctuating pump suction well under this alternative.

3.5.3.4 Recommended Alternative. The second alternative, which maintains a constant discharge pressure for the refinery intake pumps, is the recommended control option. The primary advantage to this alternative is the lack of need for a telemetry system or other communication between the refinery and the treatment plant. The refinery can continue to operate its on-site raw water system similarly and the new intake pumps, in combination with the refinery's FCV, will deliver the required demand. As discussed above, during very low demand periods the recycle valve will open and discharge to the pump suction manifold. Also, some excess head will typically be pumped and burned by the refinery's FCV under this scenario (except at peak flows), but the pump speed will match the refinery's demand, which will result in some power savings.

4.0 SUMMARY OF RECOMMENDED ALTERNATIVES

4.1 OVERVIEW OF RECOMMENDATIONS

This section summarizes the recommendations made previously in this report regarding the new raw water intake and pump station. It is followed by a description of the system layout, a discussion of other project features, and a preliminary cost estimate.

4.1.1 River Intake

A passive screen intake structure located in the main channel of the Yellowstone River near the south bank and downstream of the Highway 212/310 bridge is planned for this project. The intake will include submerged slotted screens enclosed in a protective concrete structure. A backwash system will be provided to flush away any accumulated debris or ice. The existing intake tower will remain available for use.

4.1.2 Pump Station

A new raw water pump station will be constructed to replace the deteriorating existing building and pumps. The treatment plant and refinery systems will share a suction manifold, but the two systems will continue to operate independently of one another with separate pumps. Vertical turbine pumps are the preferred pump type for both systems, due their hydraulic characteristics, familiarity to the operators, limited space requirements, above-ground motor mounting, and other factors.

A total of seven pumps will be installed for this project, including four to serve the treatment plant and three for the refinery's needs. The pump station will be design with space for three additional pumps for flexibility in future expansion. The treatment plant will have a combination of constant-speed and variable-speed pump motors in order to maximize the range of deliverable flowrates while minimizing cost. These pumps will be controlled through the existing SCADA system using flowrate control tied to the inlet flume. The refinery system will include all variable-speed pumps and recirculation valve to achieve a constant discharge pressure at any flowrate.

4.2 OTHER PUMP STATION FEATURES

This section briefly discusses some of the more important supplemental design features of the pump station.

4.2.1 Maintenance Access

An under-hung crane and hoist will be provided on the main floor of the pump station to extract the vertical turbine pumps for maintenance or replacement. This option has been selected in lieu of providing roof hatches (which would also require a mobile exterior crane for removal) due to the number of pumps. An overhead garage door will allow vehicle access to the pump station. Stairs will be provided for frequently accessed building levels and floor hatches will allow access to all levels.

4.2.2 Treated Water Supply

A treated water line passes through the existing pump station building and continues south across the highway bridge. This line will be relocated outside of the new pump station, but a new service tap will be provided for the building. A hose bib will be provided on each level of the pump station for cleaning and other miscellaneous needs. An interior water line will also be provided for the pumps' lubrication system. In addition, the existing heat tracing system for the bridge crossing will be relocated to the new building.

4.2.3 Other Building Uses

The pump station has been designed to include an additional room for the future installation of an emergency diesel generator. Wall knockouts and floor penetrations will be provided for the future electrical and mechanical equipment. This room can be used temporarily for storage or other uses until the generator is installed. A garage and storage area is also located in the main pump room.

4.2.4 Architectural Considerations

The building material used for construction of the pump station will be designed as low maintenance, durable, and inexpensive. City personnel are not overly concerned about appearance and amenities. However, the building will need to be insulated from freezing. Considering all of these issues, a masonry block building with a plain-block facing and insulated core is proposed. A standing seam metal roof will be used.

4.3 SYSTEM LAYOUT

The completed Construction Drawings show the locations of the major project components. The new refinery meter has been placed in a vault that is separate from the pump station in order to achieve the straight piping configuration required for accuracy of the proposed electromagnetic meter. The pump station will consist of three levels, with the following features on each level:

1. Lower Level – contains the intake isolation valves, pump suction manifold, and individual pump suction lines;

2. Piping Gallery – contains the individual pump discharge lines and valves, the discharge manifold for each system, the refinery recirculation valve, and the floor stand operators for the intake line valves;

3. Main Floor – contains the pump motors, intake screen air backwash system, pump seal water system, garage, future generator room, and the electrical and control equipment.

4.4 OVERALL COST ESTIMATE

Table 4-1 is a preliminary cost estimate for the project. A contingency of 10% has been used to account for unforeseen conditions and possible changes in project scope. An itemized estimate is included in Table 4-2 on the following page.

TABLE 4-1
PRELIMINARY CONSTRUCTION COST ESTIMATE

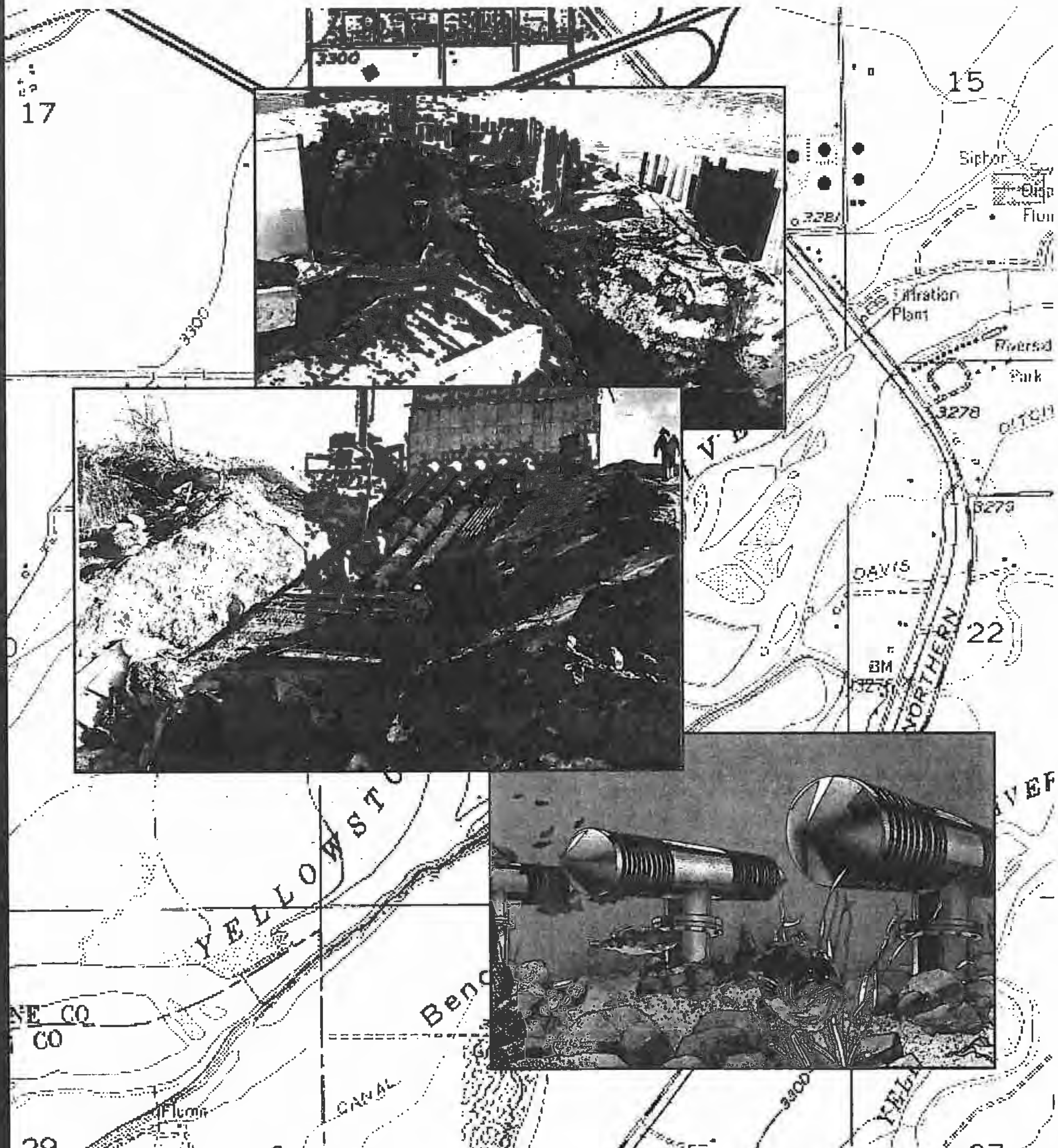
Description		*Cost*
Intake		$371,750
Pump Station		$890,350
Site Work		$59,875
Temporary Water System		$127,000
Unlisted Items	5%	$72,449
	Field Work Subtotal	**$1,521,424**
Mobilization	5%	$76,071
Taxes, Bonds, Insurance, Etc.	4%	$60,857
Contingencies	10%	$152,142
	Construction Total	**$1,810,494**

TABLE 4-1
ITEMIZED COST ESTIMATE

	Description	Quantity	Unit	Unit Cost	Total Cost
Intake	Shoring, Excavation & Dewatering	375	LF	$400	$150,000
	Concrete Intake Structure	100	CY	$600	$60,000
	Intake Foundation Piles	6	EA	$2,500	$15,000
	Stainless Steel Spools	4	EA	$1,000	$4,000
	24" Tee Screen	4	EA	$7,000	$28,000
	Dual 24" HDPE Pipe (Concrete Encased)	375	LF	$220	$82,500
	Dual 20" HDPE Pipe (Concrete Encased)	75	LF	$230	$17,250
	2 - 3" HDPE Air / Water Lines	3,000	LF	$5	$15,000
				Intake Subtotal	**$371,750**
Pump Station	Demolish Exist. Building & Piping / Salvage Equip.	1	LS	$20,000	$20,000
	Building Excavation (incl. Backfill & Compaction)	2,000	CY	$8	$16,000
	Shoring & Dewatering	1	LS	$160,000	$160,000
	Interior Piping (8-36" Steel, Supports, etc.)	1	LS	$38,000	$38,000
	WTP 2,000 gpm Vertical Turbine Pumps (20 HP)	2	EA	$15,000	$30,000
	WTP 1,000 gpm Vertical Turbine Pumps (10 HP)	2	EA	$14,000	$28,000
	Refinery 750 gpm Vertical Turbine Pumps (30 HP)	3	EA	$13,000	$39,000
	Sump Pump, Valves Fittings, etc.	2	EA	$1,500	$3,000
	Building Drain System	1	LS	$2,000	$2,000
	Air Backwash System	1	LS	$28,000	$28,000
	Potable Water System (Lines, Hose Bibs, etc.)	1	LS	$2,000	$2,000
	24" Knife Gate Valve	2	EA	$4,900	$9,800
	20" Knife Gate Valve	2	EA	$4,000	$8,000
	12" Check Valve	2	EA	$2,000	$4,000
	10" Check Valve	2	EA	$1,200	$2,400
	8" Check Valve	2	EA	$750	$1,500
	12" Gate Valve	2	EA	$1,700	$3,400
	10" Gate Valve	2	EA	$1,350	$2,700
	8" Gate Valve	2	EA	$850	$1,700
	6" Gate Valve	2	EA	$750	$1,500
	2" Air-Vac Valve Assembly	2	EA	$600	$1,200
	1" Air-Vac Valve Assembly	5	EA	$450	$2,250
	6" Pressure Relief (Recycle) Valve	1	EA	$2,200	$2,200
	Gauge / Transmitter Assemblies	11	EA	$200	$2,200
	Structural Concrete	300	CY	$400	$120,000
	Underhung Crane & Hoist System	1	LS	$35,000	$35,000
	Misc. Structural (Stairs, Hatches, Grating, etc.)	1	LS	$9,500	$9,500
	Masonry Block Building / Metal Roof	2,200	SF	$50	$110,000
	Doors, Miscellaneous Hardware	1	LS	$11,000	$11,000
	Electical, Controls & Lighting	1	LS	$175,000	$175,000
	Heating & Ventilation	1	LS	$21,000	$21,000
				Pump Station Subtotal	**$890,350**
Site Work	24" DIP Discharge Pipe	50	LF	$75	$3,750
	18" DIP Discharge Pipe	75	LF	$55	$4,125
	Fittings, Reducers & Connections	1	LS	$9,000	$9,000
	Meter Manhole (8' Depth)	2	EA	$2,200	$4,400
	8" Electromagnetic Meter	1	EA	$3,500	$3,500
	10" Gate Valve	1	EA	$1,350	$1,350
	8" Gate Valve	2	EA	$850	$1,700
	6" Gate Valve (and smaller)	3	EA	$750	$2,250
	Water Line / Heating Cable Relocation	1	LS	$4,500	$4,500
	Sidewalk	525	SF	$8	$4,200
	Curb & Gutter	170	LF	$30	$5,100
	Asphalt Restoration	400	SY	$40	$16,000
				Site Work Subtotal	**$59,875**

APPENDIX H – HKM ENGINEERING. MARCH 2002. FEASIBILITY STUDY FOR MITIGATING LAUREL'S WATER SUPPLY PROBLEM

Feasibility Study for Mitigating Laurel's Water Supply Problem



Prepared for
City of Laurel
115 West First Street
Laurel, MT 59044

HKM ENGINEERING

March 25, 2002

MEMORANDUM

HKM ENGINEERING
222 N. 32nd Street
Suite 700
P.O. Box 31318
Billings, MT 59107.1318
Phone: 406.656.6399
Fax: 406.656.6398
www.hkminc.com

TO: Jim Darling, MT FW&P, Billings
Lou Hanebury, USFWS, Billings
Bob Harrington, MT DNRC, Billings
Jim Kraft, Yellowstone County, Billings
Larry McCann, City of Laurel
Larry Robson, COE, Billings
Jeff Ryan, MT DEQ, Helena
Allan Steinle, COE, Helena
Gary Wiens, MT DEQ, Helena

FROM: Gary E. Elwell, P.E.

DATE: April 29, 2002
H:\06\M069144\feasstdymemo.doc

RE: Feasibility Study for Mitigating Laurel's Water Supply Problem

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Attached is a copy of the final report dated March 25, 2002 and a copy of the signed FONSI.

FINDING OF NO SIGNIFICANT IMPACT FOR THE CITY OF LAUREL'S WATER SUPPLY LAUREL, MONTANA MARCH 2002

The City of Laurel, Montana, has prepared a feasibility study to evaluate the impacts of constructing a new intake downstream of the south pier of the Highway 212/310 bridge over the Yellowstone River at Laurel. The study incorporates an Environmental Assessment (EA), which was reviewed for adequacy by the U.S. Army Corps of Engineers, Omaha District, (Corps) in accordance with the National Environmental Policy Act and implementing regulations. The structure is located immediately south of the town, along the Yellowstone River in Sections 15 and 22, Township 24, Range 24E in Yellowstone County. The Corps adopts the study prepared for the City of Laurel by HKM Engineering, Inc., as it has been reviewed by the Corps and has been determined to be adequate.

The purpose of the proposed project is to mitigate the existing Yellowstone River problems of sedimentation and channel changes immediately adjacent to the water intake facility. The sedimentation and channel changes impact the ability to provide adequate water for the health and safety of the citizens and businesses of Laurel. The design will provide a minimum capacity of 7 million gallons per day (MGD), which is the existing capacity, with the option of expanding capacity to 20 MGD without dewatering the river.

Although at least eight other alternatives were evaluated in this study, as well as the no-action alternative, the preferred alternative was selected because the environmental impacts of construction would be short-term and should result in a solution for the City of Laurel that does not require annual intrusion into the Yellowstone River to create gravel diversions. This alternative attempts to collect the necessary river water as it shifts back and forth across the channel width rather than directing it to one location. The other eight alternatives investigated included different intake types and piping, bendway weirs, spur dikes, submersible trash pumps in existing intake, vortex breaker and three new pumps, discharge into wetwell and pump out of wetwell, and abandon intake and construct inlet/earth holding pond were reviewed to determine their ability to provide an adequate supply of water. The ability to be approved by permitting agencies, the potential impacts on the Yellowstone River, the potential impacts to other property owners, and the best and most cost effective alternative for the City of Laurel were also considered. They all fell short of the preferred proposed alternative. The alternatives considered in detail, but eliminated, were (1) an infiltration gallery and (2) groundwater wells. The infiltration gallery could not be reasonably designed to provide 20 MGD and the relatively shallow deposits and limited saturated thickness in the vicinity of the Laurel Water Treatment Plant do not make ground water a viable source for the high production required for the city. The no-action alternative (which includes no new intake) would not alleviate the city's water supply problems due to sedimentation and channel changes which include mechanically moving sandbar material (constuct berm) in order to maintain adequate water supply to its intake facility. These actions have required emergency Corps Section 404 permits in the past. Under this alternative, the needs of the proposed project would not be fulfilled.

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1.0 SUMMARY

The City of Laurel's water intake structure is located south of town on the north bank of the Yellowstone River. The City provides water for residential and municipal uses, plus the Cenex refinery located just south of Laurel. The City of Laurel has water supply problems due to sedimentation and channel changes in the Yellowstone River immediately adjacent to the water intake facility. For the past several winters, the City has had to mechanically move sandbar material (construct berm) in order to maintain adequate water supply to its intake facility. These actions have required emergency U.S. Army Corps of Engineers Section 404 permits.

The purpose of this study is to review previous studies and reports pertaining to the water supply problems for the City of Laurel and make recommendations that will mitigate the annual water supply problems. Mitigation of the City's water supply problem is necessary to provide adequate water supply for the health and safety of the citizens and businesses of Laurel. The study is being funded by the Federal Emergency Management Agency Project Impact.

Previously identified mitigation alternatives were reviewed to determine the best and most cost effective alternative for recommendation to the City of Laurel. Additional alternatives were also identified and evaluated. Ten alternatives, including a no action alternative, were evaluated. Several others were considered, but rejected.

The proposed action consists of constructing a new intake downstream of the south pier of the Highway 212/310 bridge over the Yellowstone River at Laurel. Several options for intake types and piping are available and will be decided on during final design. The design will provide a minimum capacity of 7 MGD (existing capacity), with the option of expanding capacity to 20 MGD without dewatering the river again in the future. Construction cost estimates range from $550,000 to $780,000 depending on the configuration and capacity.

Environmental impacts of the proposed action are short term, during construction. A temporary dike and/or cofferdam would be required for installation of a new intake and piping. The dike would be removed after construction.

2.0 INTRODUCTION

2.1 DESCRIPTION AND HISTORY OF THE PROJECT

The U.S. Army Corps of Engineers (COE) report the following (2000)[1]:

> "The Yellowstone River is a braided stream with wooded islands. The form of the river varies throughout its length in relation to the river valley. In general, when the river flows along a valley wall, it will continue to follow the wall until the valley changes direction. The main channel tends to migrate to the outside of the bends. Bedrock exists in the channel bottom at several locations, which exerts control on slope and form. The meanders will often flip abruptly from one side of the valley to the other, often after extreme flood events. The river is approximately 500 feet wide where it flows under U.S. Highway 212/310 and the Burlington Northern Railroad bridges. The channel's radius of curvature is approximately 2200 feet upstream from the highway/railroad bridges. After the river bends left, it takes a straight line path under the bridges then turns right after exiting the bridges, as shown on Sheet 1. A more detailed discussion of the Yellowstone River geomorphology was provided by Aquoneering of Laurel, Montana, and is attached as Appendix A.
>
> A site visit took place on February 11, 1999, and the following observations were made.
>
> - On the point bar immediately upstream from the intake (right bank), the sediments appeared to be relatively stable.
> - There appeared to be a thin armoring layer of very large cobbles (6 inches and larger). Therefore, it is unlikely that a large amount of this material will move across the channel and cause problems for the intake.
> - The point bar located along the left bank approximately 1 mile upstream from the intake was covered with a large amount of loose sand and gravel and will likely move downstream with the first

[1] Sheets and appendices referred to within the quotations are not attached.

unconfined high flows. There is a good chance that this material could settle out near the intake.

A hydrographic survey was done in July of 1999.

The City of Laurel's water supply problems are due to sedimentation and channel changes in the Yellowstone River immediately adjacent to the water intake facility. Following the floods of 1996 and 1997, the main channel shifted from the left bank (intake side) to a position near the center of the channel. These channel changes and the subsequent instabilities appear to be the result of an abundance of bed material left behind by the floods. For the past two winters, the City has had to mechanically move sandbar material in order to maintain adequate water supply to its intake facility. This has required emergency Section 404 permits. The City provides water not only for residential and municipal use but also for the CENEX refinery located just south of Laurel. Presently, the City of Laurel removes material from the channel to maintain adequate water supply. However, spring floods redistribute the sandbars, leaving the City with the same problem each winter. The dynamic nature of the sediment deposition patterns makes for an unreliable water supply. Even a loss of 25 percent capacity would be unacceptable for the City".

Correspondence from the U.S. Army Corps of Engineers and the Montana Department of Environmental Quality regarding this project is contained in Appendices P and Q.

The purpose of this study is to review previous studies and reports pertaining to the water supply problems for the City of Laurel and make recommendations that will mitigate the annual water supply problems. The study determined action to be taken to mitigate the existing Yellowstone River problems impacting the ability of the existing intake to provide adequate water supply for the health and safety of the citizens and businesses of Laurel.

The scope of work for this project includes the evaluation of water supply issues and previous studies to mitigate annual water supply problems and provide a sustainable water supply through winter freezing, high runoff, and summer drought conditions. All previously identified mitigation measures and alternatives were reviewed to determine the best and most cost effective alternative for recommendation to the City of Laurel. Additionally, during the course of this review process, additional alternatives were identified and evaluated. This study is an independent evaluation of all existing information/data that provides a sound basis for the City of Laurel to implement a plan to mitigate the affects caused by natural disaster and a future natural disaster.

2.2 AUTHORIZATION

This project is being funded by Federal Emergency Management Agency (FEMA) Project Impact.

2.3 NEPA/MEPA PROCESS

Since this project will use state and federal funds, compliance with the National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA) is required.

2.4 PROJECT AREA

Laurel's water intake structure is located immediately south of the town, along the Yellowstone River, in Sections 15 and 22, T24, R24E, in Yellowstone County, as shown on Figure 2-1.

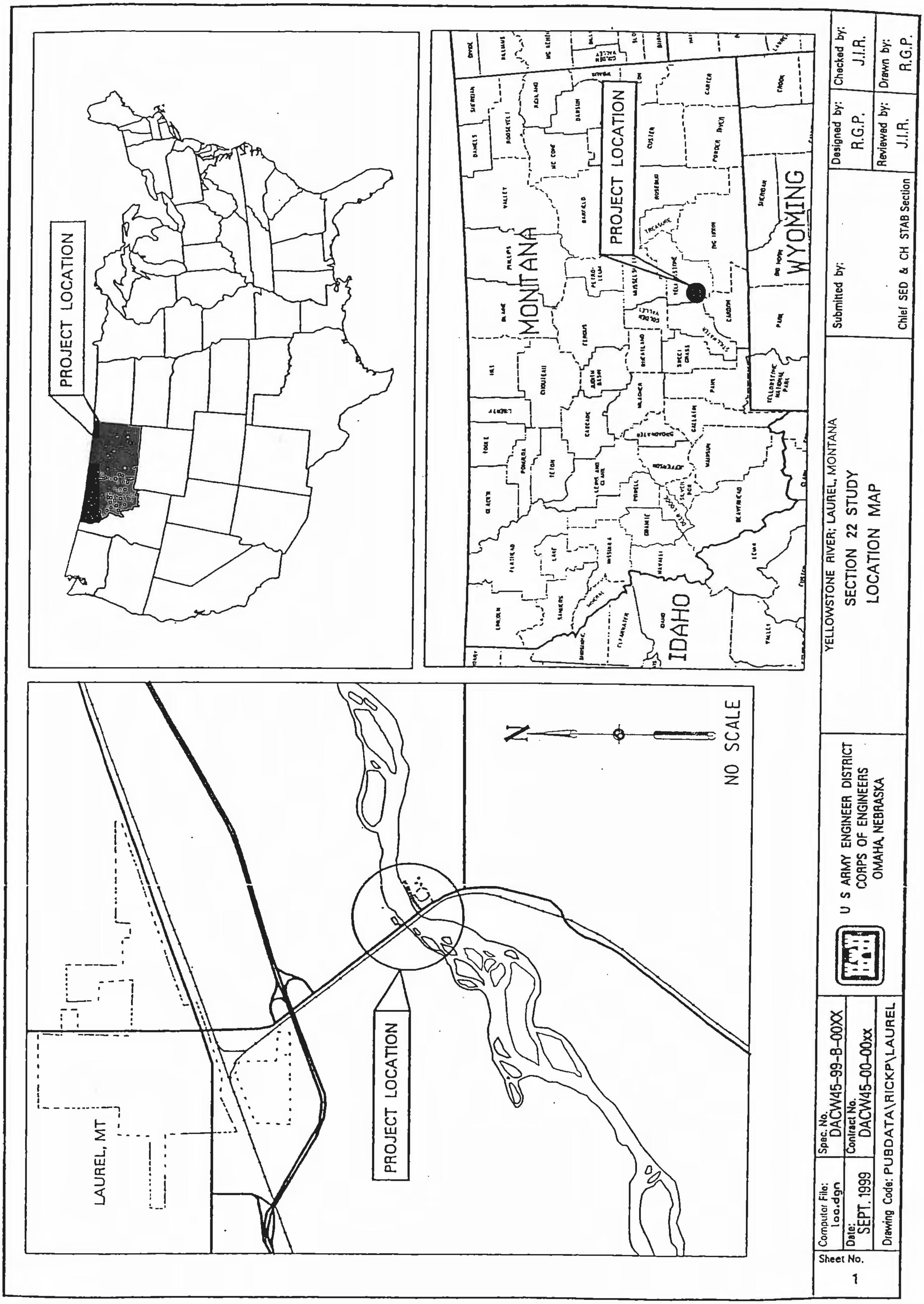

Figure 2-1 Location Map

3.0 PURPOSE AND NEED

3.1 PROPOSED ACTION

3.1.1 Purpose

The purpose for the proposed action is to mitigate the existing Yellowstone River problems impacting the ability of the existing intake to provide adequate water supply for the health and safety of citizens and businesses of Laurel.

3.1.2 Description of Proposed Action

The proposed action consists of constructing a new intake downstream of the south pier of the Highway 212/310 bridge over the Yellowstone River at Laurel. Several options for intake types and piping are available and will be decided on during final design. The design will provide a minimum capacity of 7 MGD (existing capacity), with the option of expanding capacity to 20 MGD without cofferdaming the river again in the future. Construction cost estimates range from $543,750 to $776,600 depending on the configuration and capacity.

3.2 DECISIONS REGARDING PROPOSED ACTION

Issuance of required permits by responsible agencies.

3.3 CONCERNS AND ISSUES

A conference call was held on Friday, January 11, 2002 to discuss the project. Conferee's and their comments are provided in Table 3-1.

3.4 RESPONSIBLE AGENCIES

Agencies having jurisdiction over this project and required permits and licenses are provided in Table 3-1.

3.5 OTHER ENVIRONMENTAL REVIEW DOCUMENTS

There are no other environmental review documents that influence or supplement this document.

TABLE 3-1
AGENCY CONCERNS & ISSUES

Name	Agency	Permits	Comments
Clyde Allen	COE, Omaha		400000 of Section 595/WERDA99 funds are available cost share (75% federal/25% non-federal COE desires best engineer solution/NEPA compliance funds can be used for any aspect of planning, design, construction COE needs a local financing plan Laurel can then get funds immediately funds must go to public entity numerous projects in Nevada, this would be first in, MT must stay within program amount program follows federal fiscal year best to use this year commit $, but maybe not finish this fiscal year
Jim Darling	MT FWP, Billings	Streambed Protection Act (SPA 124)	spur dikes - way to intrusive - need good weirs - long, even weir 40' considered a problem no problem locating intake near the bridge locate intake at the bridge future fish benefits funds -compete with benefits on other projects river pipe crossings OK -MDU and others crossed -short-term
Lou Hanebury	USFWS, Billings		same concerns with MT FWP weirs intrusive 2nd pier intake OK infill gallery preferred a new intake at another location is good need to stay out of river on an annual basis funds for smaller projects -passage, spawning, etc. -Lou will inquire about funding
Tom Hughes	MT DNRC, Helena	Navigable Rivers Land Use License/Easement	spur debris - unpalatable new intake best DNRC is state landowner no funding there are DNRC funding programs

TABLE 3-1 (continued)

AGENCY CONCERNS AND ISSUES

			passive screened intakes OK, need backwash thin alluvial veneer, especially near water plant h35 years river on right channel do not go back to spur dikes
Jim Kraft	DES, Yellowstone County	Floodplain Permit	no increase in flood elevations is desirable FEMA emergency funds were not applied for
Larry McCann	City of Laurel		city attorney has reviewed the funding program mayor ready to go $100,00 ready for design open sedimentation ponds, need to close federal government has $3 billion for water security
Larry Robson	COE, Billings	Section 404	Project Manager for COE 404 Permit public notice comments oppose bendway weirs and favored new intake can possibly go with existing public notice (for new intake)
Jeff Ryan	DEQ, Helena		original comments still apply opposed to bendway weirs locate intake where river is h1 1/2 year since notification of problems with intake cannot leave this matter open want long-term plan want a solution with least environmental problems
Allan Steinle	COE, Helena		would there be enough money for the proposed plan?
Gary Wiens	DEQ, Helena		revolving fund program -city already received funds -$5.25 million -$759,000 loan remaining -fee to use for design/construction -cannot build a dam -city can increase the loan amount -80% federal/20% state -issued thru the state, so can be used for match -it is Laurel's money

everybody opposed to weirs/dikes, OK with alternative intake

4.0 ALTERNATIVES

4.1 SUMMARY OF ALTERNATIVES

Alternatives are summarized in Table 4-1.

TABLE 4-1
SUMMARY OF ALTERNATIVES

Alternative	Description	Source	Date
A-New Intake	New surface water intake d/s of south bridge pier	HKM	Jan-02
		COE Alt#3	Apr-00
B-Bendway Weirs	Four bendway weirs at upstream end of problem area	COE Alt#1	Apr-00
C-Spur Dikes	Two spur dikes at upstream end of problem area	COE Alt#2	Apr-00
D-New Intake	New intake 6500 feet upstream from water treatment plant	COE Alt#3	Apr-00
		M&M Alt#5	Aug-97
E-New Intake	New intake 1800 feet downstream from water treatment plant	COE Alt#3	Apr-00
F-Rehab Existing Intake	Four submersible trash pumps in existing intake	M&M Alt#1	Aug-97
G-Rehab Existing Intake	Vortex breaker and three new pumps	M&M Alt#2	Aug-97
H-Rehab Existing Intake	Discharge into wetwell and pump out of wetwell	M&M Alt#3	Aug-97
I-Earth Holding Pond	Abandon intake and construct inlet/earth holding pond	M&M Alt#4	Aug-97
J-No Action		HKM	Jan-02
Alternatives Considered But Rejected			
Rejected Infiltration Gallery		HKM	Jan-02
Wells		HKM	Jan-02

4.2 STUDIES OF ALTERNATIVES

Alternatives previously identified are contained in the following reports:

- "Evaluation of the Sediment Deposition Problem's Along the Yellowstone River Near Laurel, Montana", U.S. Army Corps of Engineers, Omaha District, April 2000 (Appendix A).
- "Financing Future Water System Taps and Extensions", Morrison-Maierle, Inc., Billings, MT, September 1997 (Appendix B).

In reviewing these reports, several problems were identified in cost estimates. For example, a table indicates a cost item is 20 percent of another cost, when the dollar value stated is actually based on a different percentage. HKM discussed these concerns with the authors and attempted to apply previous information in the most correct way possible.

HKM looked at several additional alternatives during this study.

4.3 BASIS FOR DEVELOPMENT OF ALTERNATIVES

Alternatives have been developed that will mitigate the existing Yellowstone River problems impacting the ability of the existing intake to provide adequate water supply for the health and safety of the citizens and businesses of Laurel. Alternatives include both surface water from the Yellowstone River and groundwater. The purpose of this project is to mitigate water supply problems related to the existing intake. At this time, the existing pumping capacity of 7 MGD is adequate to serve Laurel's water demands. However, the City of Laurel has requested that increasing the capacity of the raw water intake system be examined (M & M, 1997):

City Treated Supply	15 mgd (10,400 gpm)
Cenex Refinery Water Supply	5 mgd (3,500 gpm)
	20 mgd (13,900 gpm)

Some of the alternatives leave pump capacity at 7 MGD and some reflect an increase in pump capacity to 20 MGD. The existing problems could be mitigated now, leaving an increase in pump capacity until a later phase of work.

4.4 SELECTION OF ALTERNATIVES

The criteria used to select the Proposed Action included the ability to provide a adequate supply of water, the ability to be approved by permitting agencies, the potential impacts on the Yellowstone River, the potential impacts to other property owners, and cost.

Cost estimates, whether developed in previous reports, or for this study, are general in nature and not based on detailed engineering designs. Cost estimates have been prepared over the period 1997 - 2002 and due to the general nature of the estimates, no attempt was made to index them to a common date. These costs are primarily useful in selecting a proposed action.

4.5 PROPOSED ACTION - ALTERNATIVE A

4.5.1 Plan Accomplishments

Alternative A will provide a reliable source of 7-20 MGD of water for the City of Laurel.

4.5.2 Detailed Plan

The proposed action consists of constructing a new intake downstream of the south pier of the Highway 212/310 bridge over the Yellowstone River at Laurel. The COE described the plan as follows (2000) (Appendix A):

> "This alternative consists of placing a new reinforced concrete water intake structure in the Yellowstone River. This structure would be located adjacent to the southern pier on the highway bridge. A pump with a capacity of 20 million gallons per day would be included. The pump would be needed because the grade change between the new intake structure and the existing wet well is too flat for gravity feed pipe. Also included in this alternative would be new piping to get the water from the new intake structure and the existing wet well. A 36-inch pipe would be large enough to carry the given discharge (assuming Manning's roughness coefficient, n=0.012, and the pipe slope, s=0.002). The piping would be mounted to the underside of the highway bridge and be sloped toward the wet well. The new intake design was provided by the City of Laurel. No plates are included. This alternative would provide a more reliable water supply by adding capacity; however, additional intakes would not ensure 100-percent water availability. Sedimentation could plug both intakes at the same time".

The alternative described by the COE includes an intake downstream of the south bridge pier which is preferred by the regulatory agencies. However, several modifications maybe required or desirable.

The COE has proposed running a 36-inch diameter pipeline across the Highway 212/310 bridge. Pros and cons of this proposal are as follows:

Pros:

- Pumping out of a new concrete intake and across the bridge would apparently avoid the necessity of rebuilding the existing raw water pump building.
- Avoids the need to install a buried pipe under the Yellowstone River.

Cons:

- MDT has told the City of Laurel that the Highway 212/310 bridge can not support the load of a 36-inch water line.

The COE has proposed that the new intake would be the same as the existing City of Laurel intake.

Pros:

- None

Cons:

- The existing intake design has hydraulic problems.
- The City of Billings no longer uses their intake tower as a primary source of water.

An alternative design for a new intake at the south Highway 212/310 bridge would be to use a screened surface water intake (Appendix C) and a buried raw water pipe.

Pros:

- No pipe on the bridge.
- Regulatory agencies have indicated support for a buried pipe.

Cons:

- The existing raw water pump station would need to be modified or replaced. However, the Public Works Director anticipates the need to install a new raw water pump station as a part of a future phase of work.

The Yellowstone River banks from the Highway 212/310 bridge downstream to the BBWA canal intake appear to be relatively stable. See Appendix D for a photogrammetric analysis of the river morphology from 1942 to 1996. However, changes in the river cross section within those banks have changed over time. The COE (2000) states that "following the floods of 1996 and 1997, the main channel shifted from the left banks (intake side) to a position near the center of the channel". Based on discussions with City of Laurel personnel, river surveys, and HKM knowledge of the site, the main channel has been on the right bank (south side) for 30 years or more.

River cross sections have reportedly been surveyed on numerous occasions:

- COE 1968
  - 37 sections, later used in FEMA FIS 1981
    - Aquoneering obtained 22, mostly d/s of Canyon Creek
- FIS 1983 (date on map)
- MDT 1985 (Appendix E and F)
  - ref[n] in COE and BN scour report (Appendix G)
- HKM 1990
  - ref[n] in BN scour report
- HDR 1991
  - used FIS and MDT data
- Aquoneering/Womak 1999 (Appendix H)
  - Sta. 4 (FEMA Section AK)

These cross sections indicate a river bottom elevation of approximately 3251 feet (NGVD 1929), with the exception of the 1999 survey. The 1999 survey (Aquoneering/Womak, 2000) indicates a minimum channel elevation of 3256 feet (NAVD 1988). NGVD 1929 elevations can be converted to NAVD 1988 elevations in this area by adding 2.65 feet. Therefore, the earlier minimum channel elevations of 3251 feet (NGVD 1929) are equal to 3253.65 feet (NAVD 1988). This is 2.35 feet lower than the elevation measured in 1999. Discussions with Aquoneering indicate a 2 foot error in attempting closure of the river cross section survey. Aquoneering personnel feel that the river bottom should be degrading, therefore, it is assumed that the apparent increase in minimum river bottom elevation is a result of survey difficulties, and not a raising of the river bottom.

MDT has predicted a low water elevation at the Highway 212/310 bridge of 3258 feet (NGVD 1929) or 3260.65 feet (NAVD 1988). HKM surveyors measured the water surface elevation at the bridge on 1-17-02 to be 3261.68 feet (NAVD 1988). Duke Nieskens, the City of Laurel utility plants supervisor, indicates that pump cavitation problems will develop if the water level drops another foot below the present level.

The difference between the reported river bottom elevation and the current water surface is 8.03 feet. If Johnson surface water intake screens (Appendix C) were utilized, there needs to be 1/2 the screen diameter free around the screen. Johnson T-30 tee intakes, increased in length by 10 percent, would have a capacity of 7 MGD, the capacity of the existing pumps. Three of these tee intakes would have a capacity of 21 MGD, the desired future intake capacity for the City of Laurel. Allowing for 1/2 of the screen diameter, or 15 inches clear space below the tee intake would put the top of the tee intake at elevation 3253.65+ 2.50 (30 inches) + 1.25 (15 inches) = 3257.40 feet (NAVD 1988). This leaves 4.28 feet (3261.68 - 3257.40) of water over the top of the tee intake relative to the current drought water level.

During final design, a detailed comparison of a concrete intake tower and surface water intake screens can be made to determine the best type of intake.

4.5.3 Project Costs

TABLE 4-2
COST ESTIMATE FOR ALTERNATIVE A-1
CONCRETE INTAKE WITH PUMPS AND PIPE ON BRIDGE[2]

Item	Unit	Quantity	Cost/Unit	Total Cost
Reinforced Concrete	L.S.	241	$445.44	$107,351
Sheetpiling/Pumping	Each	1	$134,136.00	$134,136
36-inch Sluice Gate	Each	2	$10,893.00	$21,786
Bar Screen	Each	2	$2,100.00	$4,200
Timber Sluice Gate	Each	1	$4,200.00	$4,200
Walkway and Ladder	Each	1	$4,900.00	$4,900
Grouted Anchor Bar	Each	70	$49.00	$3,430
Manhole Steps	Each	36	$25.89	$932
Excavation	C.Y.	633	$10.76	$6,811
Backfill	C.Y.	446	$11.29	$5,035
Pump	Each	1	$111,989.00	$111,989
Pump Installation Cost	Each	1	$2,958.00	$2,958
36-inch Steel Pipe	L.F.	310	$288.05	$89,296
			Subtotal	$497,024
		Contingency	25.0%	$124,256
			Subtotal	$621,280
		Supervison&Administration	6.0%	$37,277
		Engineering&Design	9.0%	$55,915
		Construction Administration	10.0%	$62,128
			Total	$776,600

[2] Source: COE 2000 with construction administration added

TABLE 4-3
COST ESTIMATE FOR ALTERNATIVE A-2
SCREENED INTAKES AND BURIED PIPE[3]

Item	Unit	Quantity	Cost/Unit	Total Cost
Piping				
Mobilization/Demobilization	L.S.	1	$36,000.00	$36,000
Temporary Dike Install	L.S.	1	$95,000.00	$95,000
36-inch Snap Lock Restrained Pipe	L.F.	320	$243.75	$78,000
Temporary Dike Removal	L.S.	1	$14,000.00	$14,000
Dewatering Pipe Trench	L.S.	1	$17,000.00	$17,000
Intake	L.S.	1	$100,000.00	$100,000
Bank Protection	L.S.	1	$8,000.00	$8,000
			Subtotal	$348,000
		Contingency	25.0%	$87,000
			Subtotal	$435,000
		Supervison&Administration	6.0%	$26,100
		Engineering&Design	9.0%	$39,150
		Construction Administration	10.0%	$43,500
			Total	$543,750

The cost for the new water intake at Glendive including screened water surface intakes and new pump building with pumps was $1,300,000. That project is probably representative of the long-term upgrade required at Laurel because it includes both the river intake and a raw water pumping station.

4.6 ALTERNATIVE B

4.6.1 Plan Accomplishments

The alternative is intended to keep sediment away from the city's existing intake. This alternative will not increase the capacity of the intake above the maximum pumping capacity of 7 MGD. This alternative is undesirable to the regulatory agencies.

4.6.2 Detailed Plan

The COE describes the plan as follows (2000)[4]:

---

[3] Source: HKM 2002. Raw water pump station to be performed at a later date and costs not included

[4] Sheets referred to in the quotation are contained in Appendix A

"This alternative consists of placing four bendway weirs at the upstream end of the problem area, as shown on Sheets 2 and 3. In a stream or river with unrevetted banks, a bendway weir is a low-level, upstream-angled stone sill attached to (and keyed into) the outer bank of a bend. The weirs are angled from 5 to 25 degrees upstream, are built of well-graded stone, and have lengths varying from one-quarter to one-half the base flow width of the river or stream. The hydraulic effects of the weirs reduce erosion on the outer bank of the bend by reducing flow velocities near the outer bank and reducing the concentration of currents on the outer bank of the bend, producing a better current through the bend and downstream crossing. In addition, the bendway weir is able to solve many stream alignment problems while simultaneously improving aquatic and stream corridor habitat. In a typical unimproved bend (without bendway weirs), surface currents tend to move from the inside of the bend toward the outside, concentrating flow and velocities along the outer bank of the bend. These higher velocities tend to increase bank erosion. With the use of bendway weirs, water flowing over the weir is redirected at an angle perpendicular to the axis of the weir. The stream's strong secondary currents in the bend are broken up. With the weirs angled upstream, flow is directed away from the outer bank of the bend and toward the point bar (inner part of the bend). This redirection of flow not only occurs at stages slightly higher than the weir crest but at higher stages up to bankfill. Emergent weirs act as spur dikes. The hydraulic effects of bendway weirs on the channel can be experienced three to five times their length downstream. In this case, it would be 450 to 750 feet. It is important to note that the weirs are designed to influence the sediment transport deposition patterns in the vicinity of the intake. They do not change the amount of sediment flowing into or out of the project area and therefore would have negligible effect on the channel downstream from their hydraulic influence. Because of cost, the fewest number of weirs necessary to accomplish the project's purpose should be constructed. Typically, not less than three weirs are used together.

A hydrologic engineering software program (HEC-RAS) was used to establish water surface elevations for the annual flood event on the Yellowstone River. This program allows the designer to perform one-dimension steady-flow calculations. The program contains several hydraulic design features that can be invoked once the basic surface profiles are computed. As soon as the water surface elevations are established, the height of the bendway weir can be computed. The bendway weir's height should be 40 to 60 percent of the annual flood water surface elevation. The HEC-RAS model was also used to evaluate impacts to the water surface elevation. The design produced negligible changes to the channel's water surface profile elevation, as shown in Appendix B. This alternative would manage sediment and this ensure a more reliable water supply".

4.6.3 Project Costs

TABLE 4-4
COST ESTIMATE FOR ALTERNATIVE B
BENDWAY WEIRS[5]

Item	Unit	Quantity	Cost/Unit	Total Cost
Rock	Tons	4155	$30.00	$124,650
Excavation	C.Y.	284	$10.00	$2,840
Fill	C.Y.	50	$10.00	$500
			Subtotal	$127,990
		Contingency	15.0%	$31,998
			Subtotal	$159,988
		Supervison&Administration	6.0%	$9,599
		Engineering&Design	9.0%	$14,399
		Construction Administration	10.0%	$15,999
			Total	$199,984

4.7 ALTERNATIVE C

4.7.1 Plan Accomplishments

The alternative is intended to keep sediment away from the city's existing intake. This alternative will not increase the capacity of the intake above the maximum pumping capacity of 7 MGD. This alternative is undesirable to the regulatory agencies.

4.7.2 Detailed Plan

The COE describes the plan as follows (2000)[6]:

"This alternative consists of placing two spur dikes at the upstream end of the problem area, as shown on Sheets 4 and 5. A spur dike can be defined as an elongated structure

[5] Source: COE 2000 with construction administration added

[6] Sheets referred to in the quotation are contained in Appendix A

having one end on the bank of a stream and the other end projecting towards the river. Spur dikes have been widely used to direct current away from an eroding bank and cause deposition of sediment on the downstream side of the structure.. They are often used in conjunction with other bank protection devices to protect eroding streambanks. They have also been used to enhance aquatic habitats by causing stable pools in unstable, disturbed streams. In general, spur dikes are more beneficial to aquatic habitat resources than other types of bank protection, primarily because their presence causes pool habitat to be created and maintained. The depth and volume of local scour caused by a spur dike is difficult to estimate accurately. These structures are usually most effective along straight or slightly curved streambanks. The stream should also be carrying sufficient sediment to result in deposition behind the structure. This can result in some loss of capacity.

A hydrologic engineering software program (HEC-RAS) was used to establish water surface elevations for the annual flood event on the Yellowstone River. This program allows the designer to perform one-dimensional steady-flow calculations. The program contains several hydraulic design features that can be invoked once the basic surface profiles are computed. As soon as the water surface elevations are established, the height of the spur dike can be computed. The spur dike's height should be 1 foot below the annual flood water surface elevation. The HEC-RAS model was also used to evaluate impacts to the water surface elevation. The design produced negligible changes due to the spur dike's encroachment into the channel's waterflow. This alternative would manage sediment to ensure a more reliable water supply".

4.7.3 Project Costs

TABLE 4-5
COST ESTIMATE FOR ALTERNATIVE C
SPUR DIKES[7]

Item	Unit	Quantity	Cost/Unit	Total Cost
Rock (Dikes)	Tons	11500	$30.00	$345,000
Excavation	C.Y.	142	$10.00	$1,420
Fill	C.Y.	25	$10.00	$250
			Subtotal	$346,670
		Contingency	15.0%	$86,668
			Subtotal	$433,338
		Supervison&Administration	6.0%	$26,000
		Engineering&Design	9.0%	$39,000
		Construction Administration	10.0%	$43,334
			Total	$541,672

4.8 ALTERNATIVE D

4.8.1 Plan Accomplishments

Alternative D will provide 20 MGD of water for the City of Laurel.

4.8.2 Detailed Plan

The plan is the same as the COE's for alternative A except that the intake would be located 6500 feet upstream of the water plant.

[7] Source: COE 2000 with construction administration added

4.8.3 Project Costs

TABLE 4-6
COST ESTIMATE FOR ALTERNATIVE D[8]

Item	Unit	Quantity	Cost/Unit	Total Cost
Reinforced Concrete	L.S.	241	$445.44	$107,351
Sheetpiling/Pumping	Each	1	$134,136.00	$134,136
36-inch Sluice Gate	Each	2	$10,893.00	$21,786
Bar Screen	Each	2	$2,100.00	$4,200
Timber Sluice Gate	Each	1	$4,200.00	$4,200
Walkway and Ladder	Each	1	$4,900.00	$4,900
Grouted Anchor Bar	Each	70	$49.00	$3,430
Manhole Steps	Each	36	$25.89	$932
Excavation	C.Y.	633	$10.76	$6,811
Backfill	C.Y.	446	$11.29	$5,035
Pump	Each	1	$111,989.00	$111,989
Pump Installation Cost	Each	1	$2,958.00	$2,958
36-inch Steel Pipe	L.F.	6500	$288.05	$1,872,325
			Subtotal	$2,280,054
		Contingency	25.0%	$570,013
			Subtotal	$2,850,067
		Supervison&Administration	6.0%	$171,004
		Engineering&Design	9.0%	$256,506
		Construction Administration	10.0%	$285,007
			Total	$3,562,584

4.9 ALTERNATIVE E

4.9.1 Plan Accomplishments

Alternative E will provide 20 MGD of water for the City of Laurel.

4.9.2 Detailed Plan

The plan is the same as the COE's for Alternative A except that the intake would be located 1800 feet downstream of the water treatment plant.

[8] Source: COE 2000 with construction administration added

4.9.3 Project Costs

TABLE 4-7
COST ESTIMATE FOR ALTERNATIVE E[9]

Item	Unit	Quantity	Cost/Unit	Total Cost
Reinforced Concrete	L.S.	241	$445.44	$107,351
Sheetpiling/Pumping	Each	1	$134,136.00	$134,136
36-inch Sluice Gate	Each	2	$10,893.00	$21,786
Bar Screen	Each	2	$2,100.00	$4,200
Timber Sluice Gate	Each	1	$4,200.00	$4,200
Walkway and Ladder	Each	1	$4,900.00	$4,900
Grouted Anchor Bar	Each	70	$49.00	$3,430
Manhole Steps	Each	36	$25.89	$932
Excavation	C.Y.	633	$10.76	$6,811
Backfill	C.Y.	446	$11.29	$5,035
Pump	Each	1	$111,989.00	$111,989
Pump Installation Cost	Each	1	$2,958.00	$2,958
36-inch Steel Pipe	L.F.	1800	$288.05	$518,490
			Subtotal	$926,219
		Contingency	25.0%	$231,555
			Subtotal	$1,157,773
		Supervison&Administration	6.0%	$69,466
		Engineering&Design	9.0%	$104,200
		Construction Administration	10.0%	$115,777
			Total	$1,447,216

4.10 ALTERNATIVE F

4.10.1 Plan Accomplishments

Alternative F would provides 20 MGD of water capacity for the City of Laurel. However, it leaves the intake in its current location.

[9] Source: COE 2000 with construction administration added

4.10.2 Detailed Plan

The plan is described as follows (M&M, 1997, Alt. 1):

> "Place four submersible trash pumps (one 2,000 gpm and three 3,000 gpm) inside the existing intake structure. With the pump intakes near the bottom of the structure, potential vortexing problems should be almost totally eliminated. The submersible pumps would be designed to discharge directly into the two existing 20" lines. New pipe would be routed from the existing header outside the low-lift pump building, directly to the water plant's Parshall flume. Install new bar screens over the 36" square openings, as well as other modifications to minimize wintertime slush and ice problems. The submersible pumps are designed to handle solids, so slush, sand, and ice will have minimal impact on the pump itself. Cenex's raw water pumps will remain as is."
>
> "The submersible pumping system will allow the direct pumping of water from the intake structure to the water plant. Direct pumping will eliminate the potential for air trapping and accumulation in the raw water piping, and will eliminate one of the possible air intake areas. During the winter months when the Yellowstone River is carrying slush and ice, precautions will need to be carried out and design features incorporated into the modifications to the existing intake structure in order to minimize possible ice and slush problems with the pumps. Submersible pumps are designed to deal with solids such as the ice and slush. The temporary suction line which is now installed each winter would not be necessary in the future. The bar screens will protect the submersible pumps from large debris."

4.10.3 Project Costs

TABLE 4-8
COST ESTIMATE FOR ALTERNATIVE F[10]

Item	Unit	Quantity	Cost/Unit	Total Cost
Submersible Trash Pumps				
2000 gpm	Each	1	$40,000.00	$40,000
3000 gpm	Each	3	$43,600.00	$130,800
Concrete	C.Y.	125	$550.00	$68,750
Earthwork	C.Y.	100	$20.00	$2,000
Screens	L.S.	1	$25,000.00	$25,000
Model	L.S.	1	$20,000.00	$20,000
30-inch Piping	L.F.	120	$150.00	$18,000
			Subtotal	$304,550
	Contractor Misc. Costs		20.3%	$61,824
	Project Contingency		20.3%	$61,824
			Subtotal	$428,197
	Engineering Fees		16.8%	$71,937
			Total	$500,134

4.11 ALTERNATIVE G

4.11.1 Plan Accomplishments

Alternative G would provides 20 MGD of water capacity for the City of Laurel. However, it leaves the intake in its current location.

4.11.2 Detailed Plan

The plan is described as follows (M&M, 1997, Alt. 2):

> "Model the existing intake structure to determine the best means of limiting vortex potential. Construct vortex breakers or other improvements required to allow up to 10.0 mgd intake (per side). Install the bar screen over the 36" square openings and add 20 to 25 ft of 24: circular intake screens to the existing pump suction lines. Use the two

[10] Source: M&M 1997

existing 2,000 gpm raw water pumps and add three new 3,000 gpm pumps to the gallery or just outside the gallery. Replace all piping from 20" intake lines, through the pumps, and up to the Parshall flume."

"Continuing with vertical turbine and trash pumps in the existing pump building will offer some significant improvements over what currently exists. The piping from the intake manifold through to the water treatment plant will all be replaced. This will eliminate one of the possible air intake conditions. In addition, air release mitigation measures could be designed into the pumping system to minimize future air locks. The intake structure modifications would result in increased screen area and other measures to prevent possible vortexing conditions. River icing and slush problems would be minimized and the temporary suction line which is installed each winter would not be necessary.

4.11.3 Project Costs

TABLE 4-9
COST ESTIMATE FOR ALTERNATIVE G[11]

Item	Unit	Quantity	Cost/Unit	Total Cost
3000 gpm Vertical Turbine Pumps	Each	3	$43,600.00	$130,800
30-inch Piping	L.F.	100	$150.00	$15,000
Concrete	C.Y.	125	$550.00	$68,750
Concrete Removal	L.F.	35	$75.00	$2,625
Excavation	C.Y.	100	$20.00	$2,000
Model	L.S.	1	$20,000.00	$20,000
Vortex Breakers	L.S.	1	$10,000.00	$10,000
Screens	L.S.	1	$25,000.00	$25,000
			Subtotal	$274,175
	Contractor Misc. Costs		21.1%	$57,851
	Project Contingency		21.1%	$57,851
			Subtotal	$389,877
	Engineering Fees		15.4%	$60,041
			Total	$449,918

[11] Source: M&M 1997

4.12 ALTERNATIVE H

4.12.1 Plan Accomplishments

Alternative H would provide 20 MGD capacity for the City of Laurel. However, it leaves the intake in its current location.

4.12.2 Detailed Plan

The plan is described as follows (M&M, 1997, Alt. 3)[12]:

> "This alternative is essentially the same as Alternative No. 2 except the 20" lines would discharge into a wetwell (approx. diameter = 96") located next to the raw water pump building, and the raw water pumps would draw out of this wetwell. This alternative would not require either vortex breaker construction or modifications to the intake structure. *Note: The two 20" lines have more than sufficient gravity flow capacity for feeding a new wetwell.*"

> "Construction of a wetwell between the intake structure and the existing pump building offers the same technical merit as Alternative No. 2. The primary difference is this alternative will incorporate a new structure which will require additional maintenance."

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[12] Reference to Alternative No. 2 in the quotation are to Alternative G in this study.

4.12.3 Project Costs

TABLE 4-10
COST ESTIMATE FOR ALTERNATIVE H[13]

Item	Unit	Quantity	Cost/Unit	Total Cost
3000 gpm Vertical Turbine Pumps	Each	3	$43,600.00	$130,800
30-inch Piping	L.F.	200	$150.00	$30,000
Earthwork	C.Y.	100	$8.00	$800
Concrete	C.Y.	30	$550.00	$16,500
Screens	L.S.	1	$25,000.00	$25,000
Model	L.S.	1	$20,000.00	$20,000
			Subtotal	$223,100
	Contractor Misc. Costs		16.3%	$36,365
	Project Contingency		16.4%	$36,588
			Subtotal	$296,054
	Engineering Fees		14.9%	$44,112
			Total	$340,166

4.13 ALTERNATIVE I

4.13.1 Plan Accomplishments

Alternative I would provide 20 MGD for the City of Laurel.

4.13.2 Detailed Plan

This plan is described as follows (M&M, 1997, Alt. 4)[14]:

> "Abandon the existing tower-style intake system entirely and design a new intake system similar to that used as the Billings water treatment plant. Construction of an earth holding pond instead of an intake structure would involve constructing an inlet along the river that would include a trash screen and collection pond. This type of system was preferred by the city of Billings' water plant operators who have entirely abandoned their

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[13] Source: M&M 1997

[14] It is HKM's understanding the Billings has not entirely abandoned their tower type intake structure, however, it is no longer their primary intake.

tower-type intake structure in favor of using the pond intake system year-round. This alternative is obviously land-intensive and an appropriate site would need to be found and the purchase negotiated as there is limited land availability next to the plant. In addition, to land availability, there is concern with the water quality of the area groundwater due to the refinery complex in the area. Water stored in an unlined earthen pond could pick up additional contaminants. The distance from the pond intake to the plant would greatly affect the total system cost due to the amount of the large diameter piping required. The connecting pipe would be about 30" in diameter which could cost up to $150/ft."

4.13.3 Project Costs

TABLE 4-11
COST ESTIMATE FOR ALTERNATIVE I[15]

Item	Unit	Quantity	Cost/Unit	Total Cost
Earthwork	C.Y.	30000	$8.00	$240,000
Screens	L.S.	1	$25,000.00	$25,000
3000 gpm Vertical Turbine Pumps	Each	3	$43,600.00	$130,800
Model	L.S.	1	$20,000.00	$20,000
30-inch Piping	L.F.	6500	$150.00	$975,000
			Subtotal	$1,390,800
		Contractor Misc. Costs	21.2%	$294,850
		Project Contingency	21.2%	$294,850
			Subtotal	$1,980,499
		Engineering Fees	16.2%	$320,841
			Total	$2,301,340

4.14 NO ACTION - ALTERNATIVE J

4.14.1 Plan Accomplishments

The City of Laurel will have the current intake capacity of 7 MGD and will have to continue to perform work in the river to keep the existing intake functional.

4.14.2 Detailed Plan

[15] Source: M&M 1997

No action will be taken outside of continual O&M.

4.14.3 Project Costs

No cost.

4.15 ALTERNATIVES CONSIDERED, BUT ELIMINATED

4.15.1 Infiltration Gallery

Two to three pods would be constructed, each valved and piped separately to the water treatment plant. Each pod would be located strategically across the river so as to cover possible active channel meanders. Each pod would be constructed with hydraulic capability to produce three times the design year peak.

The pods would require oversize excavation in bedrock to a depth of 10 to 15 feet below river bottom (brb). Collector(s) in each pod would consist of stainless steel well screen set at a minimum of 5 feet brb per standard infiltration gallery design practice. Screen and sand pack design would also be performed according to standard infiltration gallery design practice coupled with standard gravity slow sand filtration design procedures.

There are significant design unknowns and risks for this alternative. First, success of the system will be dependent on the location of the active channel. Second, each pod will be a bathtub basin like structure in bedrock with all production dependent primarily on the vertical or near vertical infiltration of water over the pod. Each of the pods sand pack will be subject to plugging which will reduce the yields of the pods unless the sand pack in each pod can be effectively backwashed without sending the sand pack downstream via the river. Third, there may be environmental/discharge permit considerations with respect to increased turbidities in the river if an effective back wash system could be designed.

MDT bridge plans (Appendix E) indicate the thickest alluvium is near the center of the channel between stations 139+82 (14.6 feet) and 140+60 (12.7 feet). This is only 78 feet wide and the longitudinal extent is unknown without additional geotechnical investigation.

It does not appear an infiltration gallery can be reasonably designed to provide 20 MGD.

4.15.2 Groundwater Wells

The Laurel Water Treatment Plant is located on unconsolidated Quaternary alluvial and terrace deposits overlying the cretaceous Colorado shale. Typically, the alluvium and terrace deposits contain materials varying from silt and sand to well sorted sand and gravel containing large cobbles (Gosling and Pashley, Jr., 1973) (Appendix I).

The amount of ground water that can be produced from these deposits is determined largely by the type and thickness of saturated material tapped by a well. These deposits are heavily utilized in the Yellowstone River Valley between Laurel and Billings for single household wells, some commercial and institutional uses. Typical maximum yields that can be expected from properly located, designed, and constructed wells are 50 to 60 gpm.

The relatively shallow deposits and limited saturated thickness in the vicinity of the Laurel Water Treatment Plant do not make ground water a viable source for the high production required for the City of Laurel (20 MGD/13,889 gpm). The Colorado shale, which underlies the alluvial and terrace deposits at the site, is not considered an aquifer. Thickness of the shale is reported to vary between 2000 and 2500 feet in the area (Gosling and Pashley, Jr., 1973).

Appendix J provides information regarding wells in the area.

4.16 SUMMARY OF THE ALTERNATIVES

Table 4-12, "Comparison of Alternatives", summarizes the environmental differences and effects of the alternatives identified in this study.

TABLE 4-12
COMPARISON OF ALTERNATIVES

ENVIRONMENTAL PARAMETERS	ALTERNATIVE A PROPOSED ACTION	ALTERNATIVE B	ALTERNATIVE C	ALTERNATIVE D	ALTERNATIVE E	ALTERNATIVE F	ALTERNATIVE G	ALTERNATIVE H	ALTERNATIVE I	ALTERNATIVE J NO ACTION
1. DESCRIPTION										
a. Water source	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River	Yellowstone River
b. Intake	New surface water intake	NA	NA	Reinforced concrete structure	Reinforced concrete structure	Existing	Existing	Existing	Inlet/earth holding pond	No intakes
c. Location	At water plant	U/S of HW 212/310 bridge	U/S of HW 212/310 bridge	6500 ft u/s of water plant	1800 ft d/s of water plant	At water plant	At water plant	At water plant	At water plant	
d. Water capacity										
-Current	7MGD or	7MGD	7MGD							7MGD
-Future	15MGD/5MGD			15MGD/5MGD	15MGD/5MGD	15MGD/5MGD	15MGD/5MGD	15MGD/5MGD	15MGD/5MGD	
e. Service area	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery	Laurel/Cenex Refinery
f. Feet of pipeline	320	NA	NA	6500	1800					None
g. Bendway weirs	NA	4	NA	NA	NA	NA	NA	NA	NA	
h. Spur dikes	NA	NA	2	NA	NA	NA	NA	NA	NA	
i. New pumps	Now or future phase					4 submersible trash pumps	3 submersible trash pumps	New wetwell and pumps	New pumps@holding pond	
j. Project cost	$500,000 - $780,000	$200,000	$550,000	$3,570,000	$1,450,000	$500,000	$450,000	$340,000	$2,300,000	No cost
2. CLIMATE / AIR QUALITY	Temporary construction related dust and fumes	Same as Alternative A	Same as Alternative A	Ssme as Alternative A	Same as Alternative A	Same as Alternative A	Same as Alternative A	Same as Alterntive A	Same as Alternative A	No change in air quality
3. GEOLOGY / SOILS	None. Riverbed construction	Minimal bank disturbance due to weir construction	Minimal bank disturbance due to spur dike construction	Temporary disuption related to pipeline installation	Same as Alternative D	None	None	Temporary disturbance due to construction of wetwell	New earthen holding pond construction. Change in land use	No change None
4. SURFACE WATER	Minimal. Design diversions less than 0.2 percent of average annual flow of Yellowstone River	Minimal Design diversions less than 0.2 percent of average annual flow of Yellowstone River	Same as Alternative B	Same as Alternative A	Same as Alternative A	Same as Alternative A	Same as Alternative A	Same as Alternative A	Same as Alternative A	Quality and quantity remains the same
5. GROUNDWATER	None	None	None	None	None	None	None	None	None	None
6. VEGETATION										
a. Wetlands	None	Minimal due to weirs	Minimal due to dikes	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	New pond constructed	No change
b. Riparian woodland	None	Minor riparian	Minor riparian	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	Unknown	No change
c. Grasslands	None	None	None	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	Unknown	No change
d. Cropland	None	None	None	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	None	No change
7. FISH/WILDLIFE										
a. Fisheries	Temporary	Potential long term adverse habitat effects	Same as Alternative B	Temporary	Temporary	Temporary	Temporary	Temporary	Temporary	No change
b. General wildlife	None	None	None	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	None	No change
c. T&E(threatened and endangered) species	None	None	None	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	None	No change
8. ESTHETICS	Temporary construction	Temporary construction	Temporary construction	Temporary pipeline construct.	Temporary pipeline construct.	Temporary	Temporary	Temporary construction	Temporary construction	No change
9. CULTURAL RESOURCES	None	None	None	Temporary pipeline construct.	Temporary pipeline construct.	None	None	None	Unkown	No cultural resources would be affected
10. LAND USE CHANGES	None	None	None	None	None	None	None	None	Change to pond	No change
11. PROS / CONS										
a. Ability to supply water	Good	Uncertain	Uncertain	Good	Good	Poor	Poor	Poor	Good	Poor
b. Ability to be permitted	Good	Unacceptable	Unacceptable	Good	Good	Good	Good	Good	Good	Unacceptable
c. Negative impacts on river	Good	Unacceptable	Unacceptable	Good	Good	Good	Good	Good	Good	Unacceptable
d. Cost	Good	Good	Good	Poor	Poor	Good	Good	Good	Poor	Good

5.0 AFFECTED ENVIRONMENT

5.1 GENERAL

The following sections discuss the short-term (within one year of construction), and long-term (greater than one year) effects of the ten construction alternatives, plus the no action alternative, on the environment. Impacts on climate and air quality, geology and soils, surface water resources, vegetation, fish and wildlife (including endangered species), social and economic conditions, esthetics, and cultural resources of the project area will be addressed. Each section includes a description of the existing environment followed by an assessment of the impacts of the alternatives.

For the purposes of this discussion, alternatives will be grouped together where impacts of construction do not vary significantly. The "No Action Alternative" (Alternative J) is assumed to be a continuation of the current practice of annually maintaining the berm that the City of Laurel constructed to channel water into the existing water intake.

5.2 CLIMATE AND AIR QUALITY

5.2.1 Description

The Laurel Water Supply Mitigation Study project area is located along the Yellowstone River immediately south of the City of Laurel. The site is in the Yellowstone River bottoms, at an elevation of approximately 3250 feet. The temperatures in the valley are warmer in the summer and milder in the winter than is typical of the rest of Yellowstone County. The Billings Airport has a January mean daily temperature of 23.3 degrees F and a July mean daily temperature of 74.7 degrees. The average annual precipitation is approximately 14 inches (Appendix K).

The CENEX oil refinery is found approximately 1000 feet northwest of the project area, and has a significant effect on the local air quality.

5.2.2 Impacts of Alternatives A-J

No alternative would affect the overall climate of the project area. For most of the proposed alternatives, construction would not result in an appreciable quantity of dust being released into the atmosphere due to the wet soil conditions in the construction area. The two alternatives that require pipeline installation outside of the floodway (E and F); water would be used to suppress construction dust. Fumes from construction equipment would have a minimal effect on air quality given the proximity of the project to the oil refinery. The No Action Alternative (J) would have more of a long-term air quality impact due to the annual maintenance/reconstruction of the existing berm with heavy equipment.

5.3 GEOLOGY AND SOILS

5.3.1 Geology

The project area lies in an unglaciated portion of the Missouri Plateau of the northern part of the Great Plains Province. Sedimentary rocks, consisting primarily of sandstone underlie the site. River gravel, with depths from two to more than ten feet, overlay the bedrock in the river channel, and on the terraces above the river channel. The Yellowstone River has cut into the bedrock more deeply on the south side of the river than the north.

5.3.2 Soils

The 1972 NRCS soil survey of Yellowstone County shows the soils on the north side of the river to be Hysham-Laurel silty clay loams. The soil on the south side of the river is mapped as Haverson-Hyshem loams. These alluvial soils consist of approximately 50 inches of loams, silt loams and silty clay loams over loose sand and gravel (Appendix K).

5.3.3 Alternatives A-C

The construction work for these alternatives would take place in the river channel, with minimal bank disturbance. Alternative A and would require construction of a new intake and burying pipe in the river bottom near the highway bridge. A coffer dam to allow the construction of a new intake and a pipe trench below the scour depth of the river would cause temporary disruption of the stream bottom. Sediment in the river will be increased during the construction period, but the long-term impacts will be minimal. The impacts on fish and wildlife will be discussed in a later section.

Alternatives B and C involve the construction of four weirs or two berms at the upstream end of the project area. Construction of these structures in the channel will increase the downstream sediment in the water in the short term. The long-term impacts will be the changes in the flow regime of the river above the highway bridge, as well as in the stretch of river immediately below the bridge. Changes in the river flow will cause changes in the deposition of gravel downstream from the berms or weirs. State and federal regulatory agencies are opposed to the construction of weirs and dikes due to the potential negative impacts on the river.

5.3.4 Alternatives D and E

These two alternatives would construct a new intake either 6,500 feet above or 1,800 feet below the existing intake, and would require pipelines in the river and in the terrace soils above the river. Construction of a concrete intake would require a temporary cofferdam to be installed, and a trench to be dug to the bank. These activities would result in temporary increased sediment in the water below the construction. Long-term impacts are expected to be minor changes in the river flows around the new intake structures. The pipelines to the pump house would cause ground disturbance for only a few months, or one growing season. Approximately one acre of land would be disturbed per 1000 feet of trench excavation (@ 6.6acres for Alternative D and 1.8 acres for Alternative E). In areas of trenching, topsoil would be stockpiled and replaced after the pipe installation is completed. Backfill would be compacted or left slightly mounded to allow for settling. Local, state and federal highway guidelines would be followed when pipelines are placed in road ROW. Construction would be completed quickly to limit impacts. Reseeding and mulching would be completed on excavated areas to minimize erosion and sedimentation into the river. In addition, standard erosion control practices (silt fence, and straw bale dams) would be used.

5.3.5 Alternatives F and G

These alternatives consist of the rehabilitation of the existing intake through the installation of new pumps and appurtenant works. The impacts would be a temporary increase of sediment in the water below the construction area. The riverbed would be restored to its approximate original contour, so long-term impacts would occur.

5.3.6 Alternative H

This alternative would construct a new 96-inch wetwell next to the existing pump house. The pipeline from the existing river intake would not be modified. Therefore, the only environmental impact would be from the construction of the wetwell between the pump house and the river. All soil material from the excavation would be removed from the site to prevent sediment contribution to the river. The excavated material would either be removed during construction or the stockpiled material would be enclosed with silt fence to minimize erosion and sedimentation until it could be removed from the site. Short-term impacts would be minimal, and there would be no long-term environmental impacts.

5.3.7 Alternative I

This alternative would abandon the existing intake, and construct an earthen holding pond with an inlet from the river. The impacts would be excavation of a pond (the size would be determined by the as yet undetermined design criteria) near the existing pump house. It is anticipated that that the excavated material would be used to construct the berms around the pond. Topsoil would be stockpiled and spread on the berms and standard erosion control techniques would be utilized (silt fences, straw bale dams, and runoff diversion ditches as necessary). The berms would be re-vegetated as soon as possible after construction was completed. A new surface water inlet would be constructed from the river to the pond. A concrete structure with gates would be required, as would a short open canal or pipeline.

The most significant long-term impacts would be the conversion of vegetated terrace lands to a pond. The short-term impacts would include increased sedimentation from the construction of the water inlet and dust created from construction of the pond. The dust would be controlled with water application as necessary.

5.4 SURFACE WATER RESOURCES

5.4.1 Description

The average annual flow of the Yellowstone River at the Billings gage is approximately 5,101,000 acre feet for the period of 1929 through 2000. Current design flows for the existing intake are 7MGD (22 acre feet per day or 7840 acre-feet per year.) This quantity is approximately 1 tenth of one percent of the river's average annual flow, and would have no significant impact on the flow of the Yellowstone River (Appendix L).

5.4.2 Alternatives B, C, and J

These alternatives utilize the same design flows as the existing system, and would have no additional impact on the surface water resources of the Yellowstone River.

5.4.3 Alternatives A, D, E, F, G, H, and I

These alternatives anticipate a design flow of 20MGD to provide water to Laurel and the CENEX refinery. A diversion of 20MGD is equal to approximately 61 acre-feet per day or 22,400 acre-feet per year. This flow is approximately four tenths of one percent of the average annual flow of the Yellowstone River, and would have no significant impact on the annual flow of the river.

5.5 GROUNDWATER RESOURCES

5.5.1 Description

No groundwater is utilized at present nor is any groundwater use included in any of the presented alternatives.

5.5.2 Alternatives A-J

This project will result in no short or long-term impacts to the ground water resources in or near the project area.

5.6 WATER QUALITY

5.6.1 Description

None of the alternatives would change the treatment or source of water to be supplied to the City of Laurel. Therefore, the only water quality impacts would be those associated with the short-term construction of the various alternatives of pipeline and intake construction. These impacts were addressed in a previous section.

5.6.2 Alternatives A-J

No long-term impacts are anticipated for any alternative.

5.7 VEGETATION

5.7.1 Description

Much of the streambank is rip-rapped with little or no vegetation. The uncultivated portion of the area is vegetated with mid-grass prairie consisting of western and bluebunch wheatgrasses, and greenneedle grass. Woody vegetation consists of willows and cottonwoods. The cultivated portion is typically pasture, corn and small grains.

5.7.1.1 Alternatives A, F, G, and J

These alternatives would involve construction in the river channel and minor bank disturbance. The banks are rip-rapped, with little or no vegetation. Therefore, there will be no short-term or long-term vegetative impacts in the project area.

5.7.1.2 Alternatives B, and C

These alternatives require the construction of weirs or dikes on the upstream edge of the project area. A small length of natural riverbank would be modified by each of these structures with the ensuing loss of riparian vegetation. The long-term impacts on the vegetative community would be minimal.

5.7.1.3 Alternatives D and E

These two alternatives involve the construction of pipelines from river intakes to the pumping plant. The vegetative impacts would include those associated with pipeline construction from the riverbank to the pumping plant (6,500 feet for Alternative D and 1,800 feet for Alternative E). It is anticipated that Alternative E would be constructed primarily in a silty range site area on the low terraces of the Yellowstone River. The uncultivated portion of the area is vegetated with mid-grass prairie consisting of western and bluebunch wheatgrasses, and greenneedle grass. Woody vegetation consists of willows and cottonwoods. The cultivated portion is typically pasture, corn and small grains.

The short-term impacts would be only those associated with trenching and pipe laying. The topsoil would be stockpiled and replaced, and the native vegetation restored to approximate the natural condition, or as per the land owners wishes. For cultivated fields, restoration would bring the land back to its approximate pre-construction condition. No long-term impacts on the vegetation would occur.

Alternative E would require an 1,800 foot pipeline through a range site similar to that described for Alternative D. The short-term impacts would be construction related, but because the disturbed area would be restored, there would be no long-term vegetative impacts

5.7.1.4 Alternative I

The alternative that would build an earthen holding pond would result in the most significant long-term vegetative impacts. This pond would permanently convert the low terrace range vegetation, described in Alternative E, to an open water pond. The acreage of this pond is yet to be determined. The berms of the pond would be re-vegetated with native grasses or non-natives that are adapted to the bottomland ecosystem.

For all alternatives that require ground disturbance, the contractor will be required to follow the Montana Weed Law (80-7-701) and the county Noxious Weed Control Act to minimize the introduction of additional noxious weeds.

5.7.2 Wetlands

Wetlands are found in the project area on the river bottoms above and below the existing river intake. The typical vegetation is grasses, cottonwoods, willows, buckbrush, wild roses, and snowberry. Only those alternatives, which would require extensive excavation or other land disturbance, would have a potential impact on the area wetlands.

5.7.2.1 Alternatives B and C

The construction of weirs and dikes would disturb a small riparian bank area at each site. The long-term impacts would be the loss of a few feet of riverbank vegetation and local changes in the riparian banks due to the change in flow regime.

5.7.2.2 Alternatives A, D, F, G, H, and I, and J

These alternatives involve working only in areas of the riverbank that have been highly modified through riprap and fill. There would be no short or long-term impacts on the area's wetlands.

5.7.2.3 Alternatives D and E

These alternatives include the placement of buried pipelines in the low terraces of the Yellowstone River. The actual routing of the pipelines is unknown at this time, and it is assumed that the majority of the route will be outside of the river floodway. However, it is likely that the pipelines will cross small natural or man-induced wetlands. If wetlands cannot be avoided, mitigation measures will be undertaken to assure minimal long-term impacts. One or more of the following protective measures will be used to protect the integrity of the affected wetlands.

1. Pipelines would be placed on road shoulders or existing berms with the trench bottom placed at an elevation above that which would adversely affect the existing water levels in the wetland.
2. Impermeable backfill would be placed in trenches to restore an impermeable layer where necessary.
3. Where permeable bedding is used, cutoff collars will be installed around the pipe on both sides of a wetland to prevent draining of the wetland through the permeable material.
4. Construction in saturated soils will utilize supporting platforms such as landing mats or planking to prevent rutting of the soils. All supporting materials would be removed after construction is completed.

If these measures are followed, no long-term impacts to the wetlands will occur.

5.7.2.4 Alternative I

The location of the earthen pond in this alternative is unknown. It is assumed that the pond would be constructed on a terrace above the river floodway and would not be built in a wetland. Therefore, no long-term impacts are anticipated.

5.7.3 Threatened and Endangered Species

Only one plant species in Yellowstone County is listed by the Montana Natural Heritage Program as being a species of special concern- the Persistent-sepal Yellow cress (Rorippa calycina). It is unknown whether this species inhabits any sites in the project area.

5.7.3.1 Alternative A

This alternative would require work on the river bank and river bottom near the existing highway bridge abutment and water treatment plant. This area has been highly modified by previous construction activities and the river bank is armored with rip-rap. There is a very low probability that Rorippa calycina is present on this site.

5.7.3.2 Alternatives B-J

If this species is encountered, the area would be avoided, or appropriate mitigation measures would be taken to minimize the construction impacts on the plant.

5.8 FISH AND WILDLIFE

5.8.1 Fisheries

The Montana Department of Fish, Wildlife and Parks has classified the Yellowstone River as a Class 2 stream. Class 2 waters are high value for fisheries resources. This segment of the river includes habitat for numerous trout whitefish, channel cats, sucker species and is managed as a trout stream. No protected or endangered fish species are listed for this segment of the river (Appendix N).

5.8.2 General Wildlife

Wildlife in the project area include; whitetail deer, mule deer, coyote, red fox, raccoon, muskrat, badger, mink, porcupine, beaver, striped skunk, and many species of small mammals (Appendix O).

5.8.3 Threatened and Endangered Species

One federally listed threatened or endangered species; the bald eagle (Haliaeetus leucocephalus) can be a resident of the project area.

5.8.4 State Listed Species

The Montana Natural Heritage Program lists the bald eagle as a species of special concern.

5.8.5 Threatened and Endangered Species Use of Area

Bald eagles are common along this segment of the Yellowstone River as either migrants or residents.

5.8.6 Impacts of Alternatives A-J

5.8.6.1 Fish

Alternative J, the no action alternative, is defined as the current practice of maintaining a berm, which diverts a large portion of the river's flow to the north side of the river. This berm maintains the water surface at a level adequate to allow the existing intake to operate. This practice requires a major change in the flow of the Yellowstone River, and requires frequent operations by heavy equipment in the river channel to repair the berm. A permanent solution to allow the discontinuation of this temporary fix for Laurel's water supply problem is the purpose of performing this study.

This alternative has had deleterious effects on fish habitat in this stretch of river channel.

All other alternatives involve construction or modification of water intakes, and several alternatives would require laying of a buried pipeline through a portion of the river channel. Fisheries impacts will be minimized by the avoidance of high runoff, or critical spawning periods.

Short-term impacts will be those associated with construction in the stream channel such as temporary cofferdams and increased sedimentation. Long-term impacts are expected to be negligible.

The fisheries impacts of Alternatives B and C (weirs and dikes) would contribute to the cumulative impacts of such structures that are continually being constructed in the river and are opposed by state and federal regulatory agencies.

5.8.6.2 General Wildlife

Construction practices that would have minor impacts on wildlife will be implemented. No long-term impacts are anticipated for any alternative.

5.8.6.3 Threatened and Endangered Species

If nesting bald eagles are encountered, construction will be delayed until the chicks have fledged. The most opportune construction period is during low water, which would likely occur after nesting is finished for the year. No long-term impacts are anticipated for any of the alternatives.

5.9 ESTHETICS

5.9.1 Description

The project area is includes the highway bridge, a rail road bridge, a campground, the City of Laurel water treatment plant, and the CENEX refinery. Operation and maintenance, as well as periodic construction at these facilities is continual.

5.9.2 Alternatives A-J

The greatest visual impacts would be during the short-term construction of the facilities envisioned in the various alternatives. New intakes in the river would be visible. However, except for alternatives D and E, the intakes would be adjacent to the highway bridge, and would have very minor visual impact. The pipelines would be either under the riverbed or buried in the riverbanks and would not be visible. The buried portions of the pipelines would be re-vegetated and would result in minimal long-term visual impacts.

5.10 CULTURAL RESOURCES

5.10.1 Description

A cultural resources study was completed by the MDOT prior to the new Highway 212-bridge construction. Due to the long-term modern occupation of the area, significant cultural resources are not expected to be encountered.

5.10.2 Alternative A

The Montana Historical Society has conducted a cultural resource file search for Alternative A. They feel that a recommendation for a cultural resource inventory is unwarranted at this time (see correspondence).

5.10.3 Alternatives B-J

The most likely areas for cultural resources would be the pipeline routes in Alternatives D and E. If one of those alternatives is selected, it may be necessary to perform a limited inventory on the pipeline routes.

5.11 LAND USE CHANGES

5.11.1 Description

The current land use in the area that would be affected under these alternatives consists of a small area of farm land, river bottom land, a highway, railroad, and the water treatment plant.

5.11.2 Alternatives A-H, and J

No changes in land use are anticipated as a result of any of these construction activities. Any changes would be due to construction related activities, and would be temporary in nature.

5.11.3 Alternative I

This alternative involves the construction of an earthen holding pond. The current land use of a few acres near the water treatment plant would be permanently changed to open water.

APPENDIX I – U.S. ARMY CORPS OF ENGINEERS. APRIL 2000. EVALUATION OF THE SEDIMENT DEPOSITION PROBLEMS ALONG THE YELLOWSTONE RIVER NEAR LAUREL, MONTANA.

US Army Corps
of Engineers
Omaha District

Section 22 – Planning Assistance to
States Study

Evaluation of the Sediment Deposition Problems Along the Yellowstone River Near Laurel, Montana

Prepared for the
City of Laurel, Montana

April 2000

Evaluation of the Sediment Deposition Problems Along the Yellowstone River Near Laurel, Montana

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SECTION I – INTRODUCTION

PURPOSE

This study evaluates a long-term solution to the sediment deposition problems experienced by the City of Laurel, Montana, near its water intake in the Yellowstone River. Several alternatives were evaluated with regard to engineering feasibility, costs, and impacts to adjacent and downstream properties.

AUTHORITY

This study was conducted under the Corps of Engineers' Planning Assistance to States (Section 22) Program, authorized by Section 22 of the Water Resources Development Act of 1974, as amended. The study sponsor for this cost-shared study was the City of Laurel, Montana.

PROJECT LOCATION

Laurel's water intake structure is located immediately south of the town, along the Yellowstone River, in Sections 15 and 22, T24, R24E, in Yellowstone County, as shown on Sheet 1.

PROBLEM DESCRIPTION

The City of Laurel's water supply problems are due to sedimentation and channel changes in the Yellowstone River immediately adjacent to the water intake facility. Following the floods of 1996 and 1997, the main channel shifted from the left bank (intake side) to a position near the center of the channel. These channel changes and the subsequent instabilities appear to be the result of an abundance of bed material left behind by the floods. For the past two winters, the City has had to mechanically move sandbar material in order to maintain adequate water supply to its intake facility. This has required emergency Section 404 permits. The City provides water not only for residential and municipal use but also for the CENEX refinery located just south of Laurel. Presently, the City of Laurel removes material from the channel to maintain adequate water supply. However, spring floods redistribute the sandbars, leaving the City with the same problem each winter. The dynamic nature of the sediment deposition patterns makes for an unreliable water supply. Even a loss of 25 percent capacity would be unacceptable for the City.

The Yellowstone River is a braided stream with wooded islands. The form of the river varies throughout its length in relation to the river valley. In general, when the river flows along a valley wall, it will continue to follow the wall until the valley changes direction. The main channel tends to migrate to the outside of the bends. Bedrock exists in the channel bottom at several locations, which exerts control on slope and form. The meanders will often flip abruptly from one side of the valley to the other, often after extreme flood events. The river is approximately 500 feet wide where it flows under U.S. Highway 212/310 and the Burlington Northern Railroad bridges. The channel's radius of curvature is approximately 2200 feet upstream from the highway/railroad bridges. After the river bends left, it takes a straight line path under the bridges then turns right after exiting the bridges, as shown on Sheet 1. A more detailed discussion of the Yellowstone River geomorphology was provided by Aquoneering of Laurel, Montana, and is attached as Appendix A.

A site visit took place on February 11, 1999, and the following observations were made.

- On the point bar immediately upstream from the intake (right bank), the sediments appeared to be relatively stable.

- There appeared to be a thin armoring layer of very large cobbles (6 inches and larger). Therefore, it is unlikely that a large amount of this material will move across the channel and cause problems for the intake.

- The point bar located along the left bank approximately 1 mile upstream from the intake was covered with a large amount of loose sand and gravel and will likely move downstream with the first unconfined high flows. There is a good chance that this material could settle out near the intake.

A hydrographic survey was done in July of 1999.

DESIGN CONSIDERATIONS

The design considerations required for a project to protect the City of Laurel's water supply include the following:

- Directing river flows toward the City's water intake structure to ensure an adequate water supply.

- Protecting the Billings Bench Water Association's irrigation system intake structure that is approximately 1800 feet downstream from the City of Laurel's water intake structure. (Any design considered must not move river sediments such that the sediments impair the irrigation system.)

- Preventing adverse impacts to the boat ramp that is approximately 800 feet downstream from the City's water intake structure. (Any design considered must ensure that the main channel's flow not be moved away from the boat ramp.)

SECTION II – ALTERNATIVES

Three alternatives to address the erosion at the study site were evaluated. These alternatives are described in the following paragraphs.

ALTERNATIVE 1 – BENDWAY WEIRS

This alternative consists of placing four bendway weirs at the upstream end of the problem area, as shown on Sheets 2 and 3. In a stream or river with unrevetted banks, a bendway weir is a low-level, upstream-angled stone sill attached to (and keyed into) the outer bank of a bend. The weirs are angled from 5 to 25 degrees upstream, are built of well-graded stone, and have lengths varying from one-quarter to one-half the base flow width of the river or stream. The hydraulic effects of the weirs reduce erosion on the outer bank of the bend by reducing flow velocities near the outer bank and reducing the concentration of currents on the outer bank of the bend, producing a better current through the bend and downstream crossing. In addition, the bendway weir is able to solve many stream alignment problems while simultaneously improving aquatic and stream corridor habitat. In a typical unimproved bend (without bendway weirs), surface currents tend to move from the inside of the bend toward the outside, concentrating flow and velocities along the outer bank of the bend. These higher velocities tend to increase bank erosion. With the use of bendway weirs, water flowing over the weir is redirected at an angle perpendicular to the axis of the weir. The stream's strong secondary currents in the bend are broken up. With the weirs angled upstream, flow is directed away from the outer bank of the bend and toward the point bar (inner part of the bend). This redirection of flow not only occurs at stages slightly higher than the weir crest but at higher stages up to bankfill. Emergent weirs act as spur dikes. The hydraulic effects of bendway weirs on the channel can be experienced three to five times their length downstream. In this case, it would be 450 to 750 feet. It is important to note that the weirs are designed to influence the sediment transport deposition patterns in the vicinity of the intake. They do not change the amount of sediment flowing into or out of the project area and therefore would have negligible effect on the channel downstream from their hydraulic influence. Because of cost, the fewest number of weirs necessary to accomplish the project's purpose should be constructed. Typically, not less than three weirs are used together.

A hydrologic engineering software program (HEC-RAS) was used to establish water surface elevations for the annual flood event on the Yellowstone River. This program allows the designer to perform one-dimension steady-flow calculations. The program contains several hydraulic design features that can be invoked once the basic surface profiles are computed. As soon as the water surface elevations are established, the height of the bendway weir can be computed. The bendway weir's height should be 40 to 60 percent of the annual flood water surface elevation. The HEC-RAS model was also used to evaluate impacts to the water surface elevation. The design produced negligible changes to the channel's water surface profile elevation, as shown in Appendix B. This alternative would manage sediment and thus ensure a more reliable water supply.

Table 1 shows the cost estimate for this alternative. Rock quantities were estimated using a figure of 1.55 tons/cubic yard. Based on the operation and maintenance (O&M) costs for similar projects, the annual O&M costs for this alternative are estimated to be $5,000.

Table 1
Cost Estimate for Alternative 1 – Bendway Weirs

Item	Unit	Quantity	Cost/Unit	Total Cost
Rock	Tons	4,155	$30	$124,650
Excavation	C.Y.	284	10	2,840
Fill	C.Y.	50	10	500
			Subtotal	$127,990
			Contingency (15%)	19,200
			Supervision and Administration (S&A) (6%)	7,700
			Engineering and Design (E&D) (9%)	11,510
			Total	$166,400

ALTERNATIVE 2 – SPUR DIKES

This alternative consists of placing two spur dikes at the upstream end of the problem area, as shown on Sheets 4 and 5. A spur dike can be defined as an elongated structure having one end on the bank of a stream and the other end projecting towards the river. Spur dikes have been widely used to direct current away from an eroding bank and cause deposition of sediment on the downstream side of the structure. They are often used in conjunction with other bank protection devices to protect eroding streambanks. They have also been used to enhance aquatic habitats by causing stable pools in unstable, disturbed streams. In general, spur dikes are more beneficial to aquatic habitat resources than other types of bank protection, primarily because their presence causes pool habitat to be created and maintained. The depth and volume of local scour caused by a spur dike is difficult to estimate accurately. These structures are usually most effective along straight or slightly curved streambanks. The stream should also be carrying sufficient sediment to result in deposition behind the structure. This can result in some loss of capacity.

A hydrologic engineering software program (HEC-RAS) was used to establish water surface elevations for the annual flood event on the Yellowstone River. This program allows the designer to perform one-dimensional steady-flow calculations. The program contains several hydraulic design features that can be invoked once the basic surface profiles are computed. As soon as the water surface elevations are established, the height of the spur dike can be computed. The spur dike's height should be 1 foot below the annual flood water surface elevation. The HEC-RAS model was also used to evaluate impacts to the water surface elevation. The design produced negligible changes due to the spur dike's encroachment into the channel's waterflow. This alternative would manage sediment to ensure a more reliable water supply.

Table 2 shows the cost estimate for this alternative. Rock quantities were estimated using a figure of 1.55 tons/cubic yard. Based on O&M costs for similar projects, the estimated annual O&M costs for this alternative are $5,000.

Table 2
Cost Estimate for Alternative 2 – Spur Dikes

Item	Unit	Quantity	Cost/Unit	Total Cost
Rock (Dikes)	Tons	11,500	$30	$345,000
Excavation	C.Y.	142	10	1,420
Fill	C.Y.	25	10	250
			Subtotal	$346,670
			Contingency (15%)	52,000
			S&A (6%)	20,800
			E&D (9%)	31,200
			Total	$450,670

ALTERNATIVE 3 – NEW INTAKE STRUCTURE

This alternative consists of placing a new reinforced concrete water intake structure in the Yellowstone River. This structure would be located adjacent to the southern pier on the highway bridge. A pump with a capacity of 20 million gallons per day would be included. The pump would be needed because the grade change between the new intake structure and the existing wet well is too flat for gravity feed pipe. Also included in this alternative would be new piping to get the water from the new intake structure and the existing wet well. A 36-inch pipe would be large enough to carry the given discharge (assuming Manning's roughness coefficient, n = 0.012, and the pipe slope, s = 0.002). The piping would be mounted to the underside of the highway bridge and be sloped toward the wet well. The new intake design was provided by the City of Laurel. No plates are included. This alternative would provide a more reliable water supply by adding capacity; however, additional intakes would not ensure 100-percent water availability. Sedimentation could plug both intakes at the same time.

Table 3 shows the cost estimate for this alternative. Estimated annual O&M costs for this alternative would be similar to those for the existing water intake structure.

Table 3
Cost Estimate for Alternative 3 – New Intake Structure

Item	Unit	Quantity	Cost/Unit	Total Cost
Reinforced Concrete	L.S.	241	$ 445.44	$107,352
Sheetpiling and Pumping	Each	1	134,136.00	134,136
36" Sluice Gate	Each	2	10,893.00	21,786
Bar Screen	Each	2	2,100.00	4,200
Timber Sluice Gate	Each	1	4,200.00	4,200
Walkway and Ladder	Each	1	4,900.00	4,900
Grouted Anchor Bar	Each	70	49.00	3,430
Manhole Steps	Each	36	25.89	932
Excavation	C.Y.	633	10.76	6,812
Backfill	C.Y.	446	11.29	5,035
Pump	Each	1	111,989	111,989
Pump Installation Cost	Each	1	2,958	2,958
			Subtotal	$407,730
			Contingency (25%)	101,932
			S&A (6%)	30,580
			E&D (9%)	45,869
			Total	$586,111

Piping from Second Pier on Bridge to Water Treatment Plant
(Alternative 3 from this report)

36" Steel Pipe	L.F.	310	288.05	$89,297
			Contingency (25%)	22,324
			S&A (6%)	6,697
			E&D (9%)	10,046
			Total	$ 128,364

Item	Unit	Quantity	Cost/Unit	Total Cost
Piping 6500 Feet Upstream from the Water Treatment Plant (Alternative 5 from Morrison-Maierle report)				
36" Steel Pipe	L.F.	6500	$ 288.05	$1,872,325
			Contingency (25%)	468,081
			S&A (6%)	140,424
			E&D (9%)	210,636
			Total	$ 2,691,466
Piping 1800 Feet Downstream from the Water Treatment Plant (placed next to the Billings Bench Water Association's irrigation system intake structure)				
36" Steel Pipe	L.F.	1800	288.05	518,490
			Contingency (25%)	129,623
			S&A (6%)	38,887
			E&D (9%)	58,330
			Total	$ 745,330

TOTAL COMBINED COSTS

Location	Structure Cost	Piping Cost	Total Cost
Next to Bridge	$ 586,111	$ 128,364	$ 714,475
6500 Feet Upstream	586,111	2,691,466	3,277,577
1800 Feet Downstream	586,111	745,330	1,331,441

In August 1997, a report written by Morrison-Maierle, Inc., from Billings, Montana, discussed the problems associated with the water treatment plant along with the intake structure. This report is attached as Appendix C. The Morrison-Maierle report projected costs for the recommended improvements. Table 1.1 on page 7 of that report states that a new intake structure would cost $500,000. The Morrison-Maierle report goes on to list five different alternatives based on their conclusions for expanding the raw water intake system capacity to 20 million gallons per day. The alternative that most closely matches Alternative 3, described in this Section 22 report, is Alternative 5 of the Morrison-Maierle report, as stated in Appendix C (with the following exceptions).

- The Morrison-Maierle report indicates the design of the intake structure would be built deeper and include special construction to avoid vortexing and improved screening. Alternative 3 from this report matches the existing intake structure.

- The Morrison-Maierle report indicates the design of the intake structure 6200 feet farther upstream than does Alternative 3 from this report. Adding 6200 feet of piping to Alternative 3 would increase the cost by $2,563,130, for a total of $3,277,577. This figure is close to the $2,480,000 figure shown in paragraph 2.2.3 in the Morrison-Maierle report.

Another alternative would be to move the intake structure to the same location as the Billings Bench Water Association's irrigation system intake structure that is approximately 1800 feet downstream from the City of Laurel's current water intake structure. The cost of construction for this relocation would be $1,331,441. Moving the intake structure either upstream or downstream from the bridge would not completely solve the sedimentation problems that currently plague the existing structure. Some river-training structures would most likely be needed at the alternate locations. Locating the intake structure next to the second pier of the bridge would be the most compatible alternative intake design, because in the long term, this alternative would be the least intrusive to the Yellowstone River (i.e., require the least amount of river structures). The cost of construction for the City of Laurel would be $714,475.

SECTION III - RECOMMENDATIONS

Alternatives 1 and 2 would move the sedimentation deposits down the Yellowstone River. Both alternatives would also move the deep part of the river channel back to the area immediately adjacent to the existing water intake facility. Alternative 3 would involve the installation of a new water intake structure close to the right bank of the river, where the deeper portion of the current channel is located.

Bendway weirs that are properly maintained provide good sediment management by redirecting the flow toward the problem area. Disadvantages of bendway weir construction can include reduced channel capacity and the possibility of moving the erosion elsewhere. However, the model indicates little change in water surface elevations and a low potential for increased erosion. Nonetheless, the bank in question is currently protected by riprap. Bendway weirs are usually constructed with little disruption to riparian communities. Effects on wildlife species are usually insignificant. The primary benefit is the redistribution of the channel velocities.

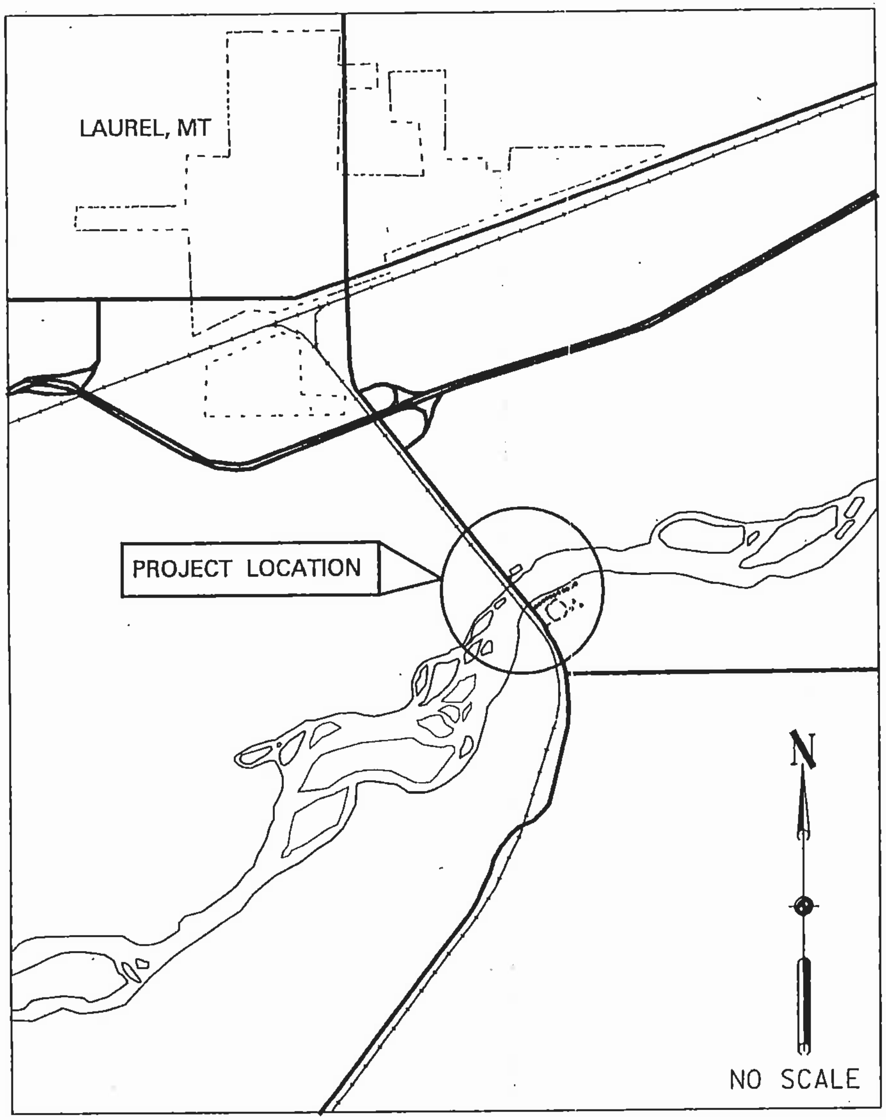
Alternatives 1 and 2 would involve structures that are located just upstream from the railroad bridge. There is a concern that this might cause debris to collect (get hung up) between the rock structures and the bridge in a flood event. The bendway weir would be a better alternative because the height of the bendway weir would be approximately one-half as high as the spur dike, thus creating a larger opening for the debris to flow through.

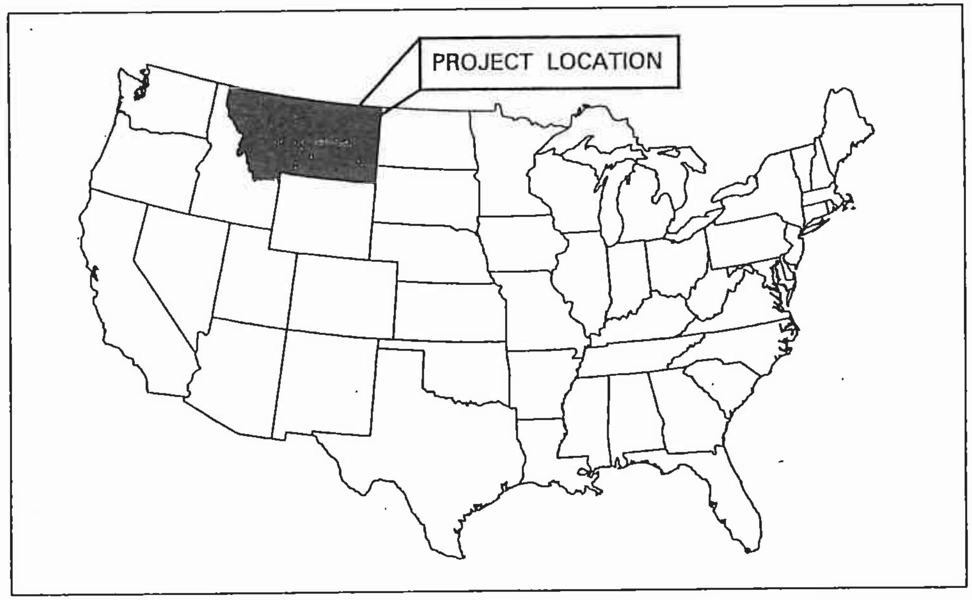
Spur dikes would not interfere with access to the stream. After the stream has adapted to the initial project, dikes can be extended farther into the stream if necessary to fully achieve project objectives; whereas with bendway weirs, modification of the initial alignment is likely to be much more expensive. Spur dikes are more vulnerable to floating debris during high-water flows, since spur dikes present abrupt obstacles to flow; whereas bendway weirs will allow much of the floating debris to pass through the project reach in the same situation.

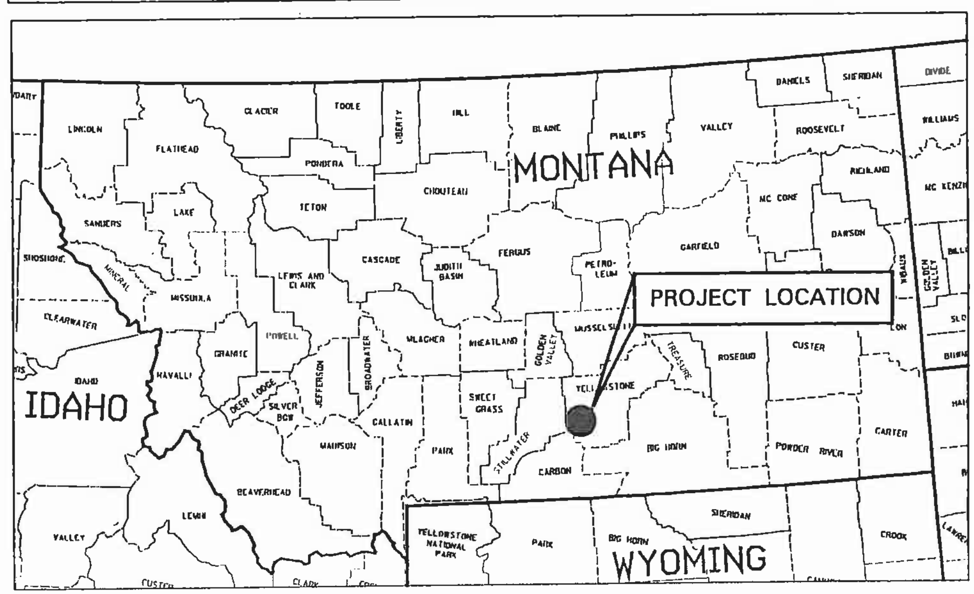
Alternatives 1 and 2 would manage the sediment transport through the river and, if properly maintained, should work over the full range of flow conditions. Alternative 3 would provide adequate capacity for nearly all flow conditions; however, if the intakes were to become plugged or covered with sediment, the amount of in-channel work needed to restore capacity would be greater than for the existing intake.

Alternative 3 would be the most costly of the three alternatives to construct. Alternative 2 would be more costly than Alternative 1 to construct. Because the bendway weirs would be the least costly alternative and would provide a slightly better factor of safety, they are the recommended solution to the water intake problem for the City of Laurel.

DRAWINGS

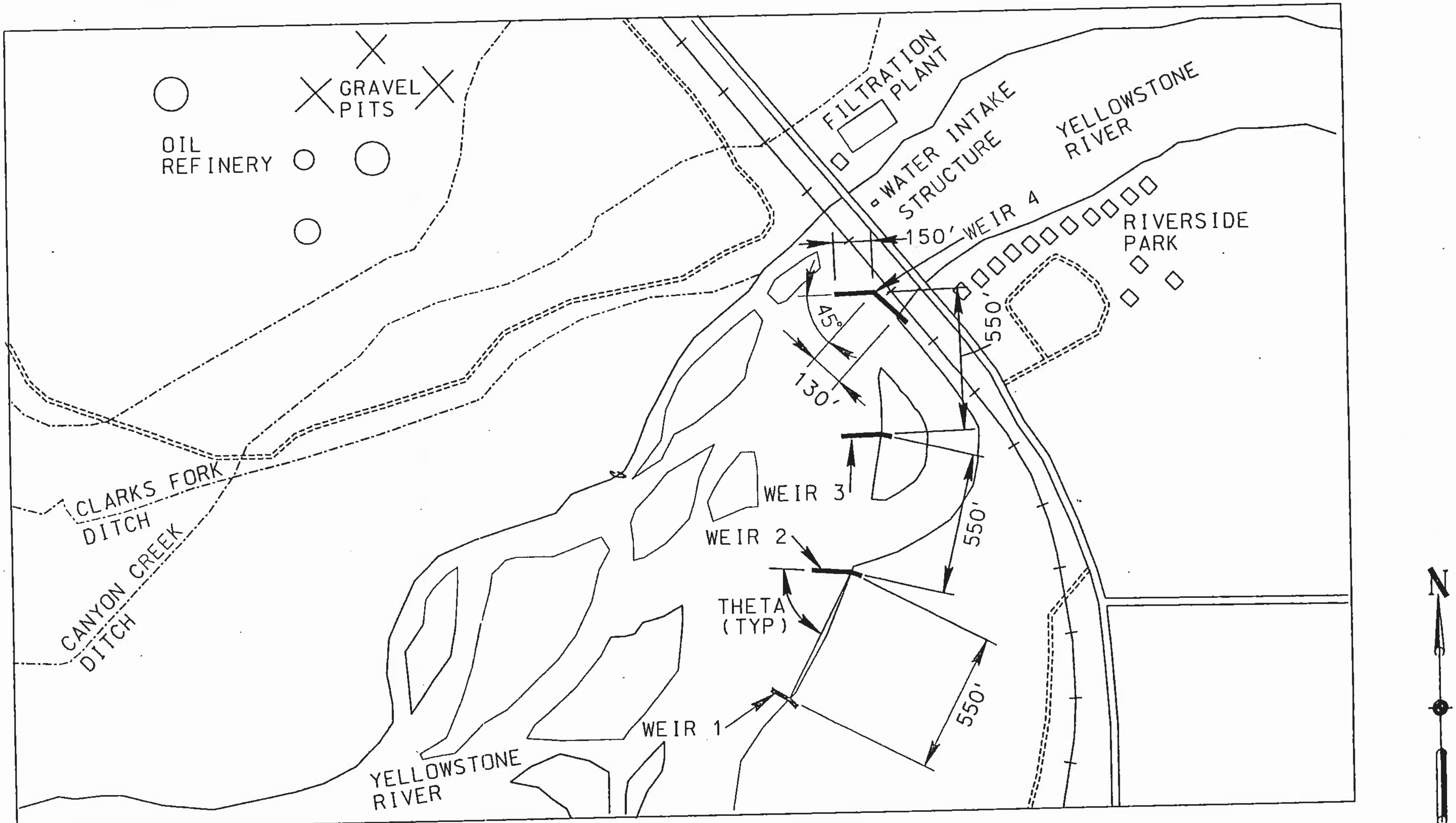






Sheet No. 1	Computer File: loc.dgn	Spec. No. DACW45-99-B-00XX	U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA	YELLOWSTONE RIVER; LAUREL, MONTANA SECTION 22 STUDY LOCATION MAP
	Date: SEPT. 1999	Contract No. DACW45-00-00xx		
	Drawing Code: PUBDATA\RICKP\LAUREL			

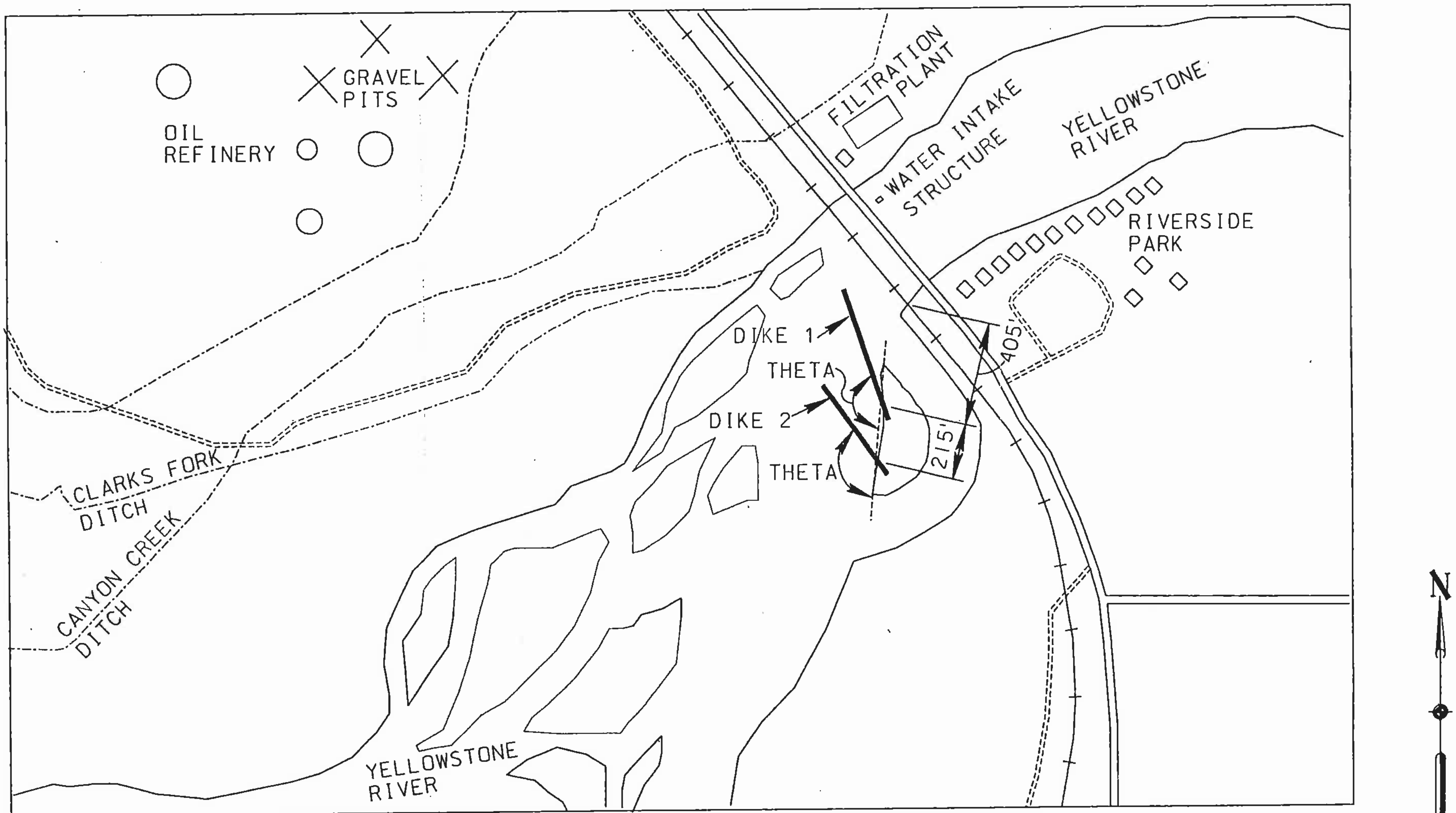
Submitted by:	Designed by: R.G.P.	Checked by: J.I.R.
Chief SED & CH STAB Section	Reviewed by: J.I.R.	Drawn by: R.G.P.



NOTE: THE ₵ OF KEY (LK) OF WEIR 4 IS LOCATED 40' UPSTREAM FROM THE ₵ OF THE RAIL ROAD BRIDGE WHERE IT CROSSES THE RIGHT BANK OF THE RIVER.

SCALE: 1 INCH = 600 FEET
300' 0 300'
(APPROXIMATE)

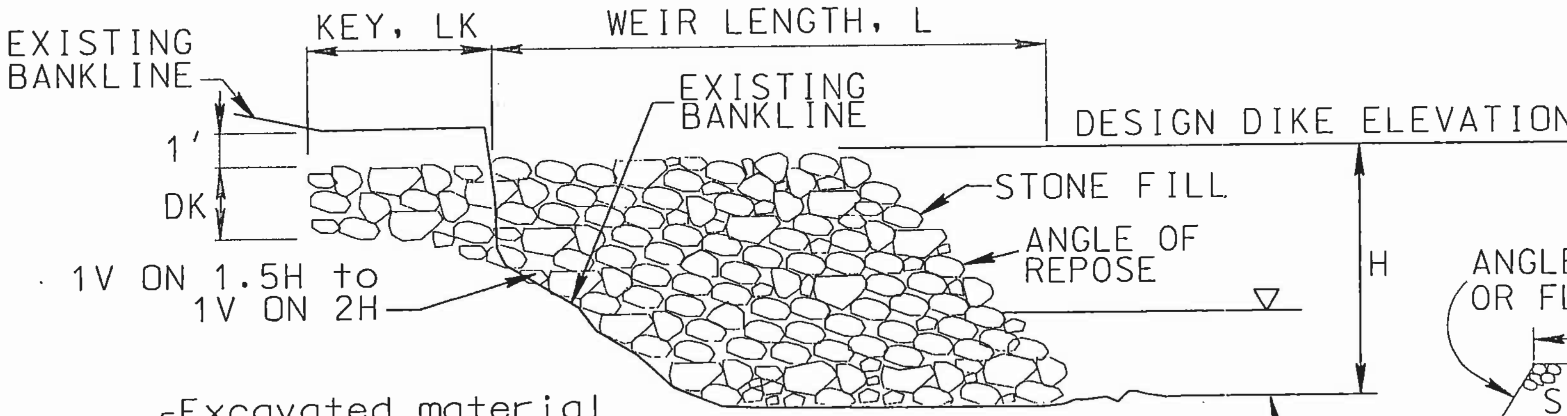
Sheet No. 2	Computer File: weirplan.dgn Date: SEPT. 1999 Drawing Code: PUBDATA\RICKP\LAUREL	Spec. No. DACW45-99-B-00XX Contract No. DACW45-00-00xx	U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA	YELLOWSTONE RIVER; LAUREL, MONTANA SECTION 22 STUDY SITE PLAN SHEET (WITH BENDWAY WEIRS)	Submitted by: Chief SED & CH STAB Section	Designed by: R.G.P. Reviewed by: J.I.R.	Checked by: J.I.R. Drawn by: R.G.P.



NOTE: THE ₵ OF KEY (LK) OF DIKE 1 IS LOCATED 405' UPSTREAM FROM THE ₵ OF THE RAIL ROAD BRIDGE WHERE IT CROSSES THE RIGHT BANK OF THE RIVER.

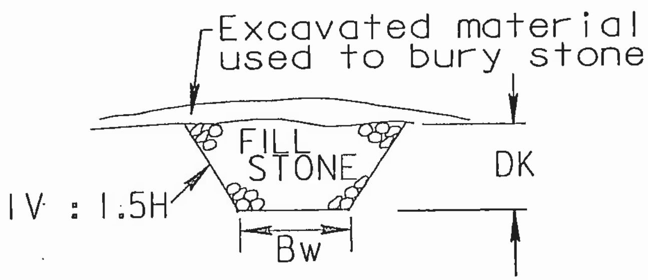
SCALE: 1 INCH = 600 FEET
300' 0 300'
(APPROXIMATE)

Sheet No. 4	Computer File: dikeplan.dgn	Spec. No. DACW45-99-B-00XX	U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA	YELLOWSTONE RIVER; LAUREL, MONTANA SECTION 22 STUDY SITE PLAN SHEET (WITH SPUR DIKES)	Submitted by: Chief SED & CH STAB Section	Designed by: R.G.P. / Checked by: J.I.R.
	Date: SEPT. 1999	Contract No. DACW45-00-00xx				Reviewed by: J.I.R. / Drawn by: R.G.P.
	Drawing Code: PUBDATA\RICKP\LAUREL					



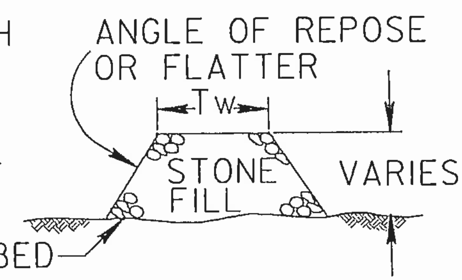
SPUR DIKE TYPICAL SECTION

NO SCALE



REFUSAL & KEY TYPICAL SECTION

NO SCALE



SPUR DIKE TYPICAL SECTION

NO SCALE

STRUCTURE	LENGTH, L**	SPACING, S	HEIGHT, H	THETA	DESIGN DIKE ELEVATIONS	WIDTH, Tw	KEY, LK ***	WIDTH, Bw	KEY, DK	ANNUAL FLOOD W.S.	STONE, tons
DIKE 1	450'	215'	VARIES	155°	3267.0	5'	20'	5'	6.5'	3270.5	6500
DIKE 2	350'		VARIES	140°	3267.0	5'	20'	5'	6.5'	3270.3	5000

** See site plan sheet for layout alignment of each dike.
*** 20' Riprap Key, with additional random fill material to connect to high bank

Sheet No. 5	Computer File: DIKE.dgn; Date: SEPT. 1999; Drawing Code: PUBDATA\RICKP\LAUREL	Spec. No. DACW45-99-B-00XX; Contract No. DACW45-00-00xx	U S ARMY ENGINEER DISTRICT CORPS OF ENGINEERS OMAHA, NEBRASKA	YELLOWSTONE RIVER; LAUREL, MONTANA SECTION 22 STUDY SPUR DIKES TYPICAL DETAILS	Submitted by: Chief SED & CH STAB Section	Designed by: R.G.P.; Checked by: J.I.R.; Reviewed by: J.I.R.; Drawn by: R.G.P.

APPENDIXES

APPENDIX A

YELLOWSTONE RIVER GEOMORPHOLOGY

By: Aquoneering, Laurel, Montana

The Yellowstone River is a braided stream with wooded islands. The form of the river varies throughout its length in relation to the river valley. In general, when the river flows along a valley wall, it will continue to follow the wall until the valley changes direction. The main channel tends to migrate to the outside of the bends. Bedrock exists in the channel bottom at several locations, which exerts control on slope and form. The meanders will often flip abruptly from one side of the valley to the other, often after extreme flood events. These flood events seem to be cyclic, probably related to the approximate 22 year sunspot cycles and associated weather patterns. Change of river must be a consideration in any long life structure such as this intake. The river will tend to one side of the channel or the other over time, with different effects upon the intake. The morphology of the river can be quantified by factors such as channel length and slope, bed material, sinuosity and various ratios, such as width/depth, most related to bankfull discharge. Bankfull discharge is assumed to be the flow that results in channel forming properties. Bankfull discharge has been found to be the 1.5 year return interval for most rivers and appears to be applicable to the Yellowstone River as well. We have found that river training works function best when designed with the forces presently at work in the river at bankfull flow.

We have found that the radius of training structures work best if matched to the typical meander bend radius present in nearby river reach. We looked at reach from above Park City to the confluence with the Clarks Fork River (work sheet appended). The meander bend radius ranges from 3,000 to 4,000 feet, with an average of about 3,350 feet. Where the river is against bedrock valley walls, the radius tends to increase and the river meanders and braids less. This information would indicate that the radius through the river training structures proposed for the Laurel intake should be around 3,350 feet to work with the river.

HEC-RAS runs at bankfull flow are appended with width/depth (W/D) ratios noted. The ratios range from over 100 to around 54 at the bridges and intake. The Rosgen classification of this reach is D-4 and a width/depth ratio of over 40 is common. These high W/D ratios indicate instability and rapid movement of the channel. We have found a typical width of 500 to 525 feet and a typical depth of 8.5 to 9.0 feet at bankfull flow. From this data a W/D of 60 to 70 is typical for this reach. A suggested design goal is to train the channel above the bridge to about a ratio of 60. A profile was acquired through this reach during the fall of 1999. From this information we find a bed slope of 0.0017543. The bed is scoured deeply under the bridge and the bed flattens downstream. probably from aggradation through this reach. We note that the railroad and highway bridge constriction confine the braided system to a single channel downstream of the bridges. This has been observed in other locations as well (see Chapter 22 of "Gravel Bed Rivers in the Environment" WRP, 1998 for example). This observation may be a factor in selecting an alternate intake downstream from the bridges as discussed later.

Transport of sediment past the intake location is an important but difficult consideration. A gradation was performed on a large sample obtained from the recent channel excavation for the intake. About 1/2 of sample had gravel, cobbles and boulders exceeding 1 inch in size up to 10 to 12 inches. The remaining sizes were in the small gravel sand sizes with about 5%, of the sample falling into the silt and clay sizes. It appears that the pavement size d_{50} is about 200 mm and the subpavement d_{50} is about 50 mm. The Billings gage data indicates that sediment movement, both suspended and bedload, becomes significant at flows over 10,000 cfs. A peak suspended sediment concentration of 5,000 mg/1 is not uncommon at Billings. Calculations using the methods of Yang indicate bankfull sediment movement of over 100,000 tons/day of which about 1/2 is suspended and 1/2 bedload. At a 100 year flood event, over 500,000 tons/day is calculated of which suspended is 300,000 and bedload of about 200,000 tons/day. Even though these calculations are not calibrated, they do show considerable movement of material past the intake. It is important that sediment movement be controlled to keep the intake open.

HYDRAULIC CALCULATIONS

This section deals with flows. A Log-Pearson Type IIT Duration-Frequency analysis was performed on Billings gage data. The 1.5 year recurrence interval is about 34,700 cfs, assumed to bankfull flow. A similar analysis was completed for flows on the Clarks Fork, using Edgar and Rock Creek gage data. The 1.5 year value for the Clarks Forks is about 7,200 cfs. Subtracting out the Clarks Fork value yields about 27,500 cfs at the reach at the Laurel intake. An annual seven day minimum low flow of about 800 cfs is reported in the USGS summary statistic for the Billings station. A similar value of about 100 cfs is reported for the Clarks Fork River. Thus, the intake should function with about 700 cfs in the river to be reliable. A 100-year flow of about 80,000 cfs seems to be accepted for the Billings gage. This results is about 65,000 cfs at the Laurel intake, subtracting Clarks Fork flows. We note that the MDOH designed the bridge for 69,900 cfs based work performed by Engineering Inc.

ADDITIONAL ALTERNATIVES

We would suggest consideration be given to a second, auxiliary intake located adjacent to the BBWA intake, located about 1,600 feet downstream. Examination of historic aerial photographs shows this location to be quite stable, probably due to constriction of river by the bridges above. We do have some concern with the upstream mid-channel bar moving into the intake. However, any efforts by the BBWA to keep the intake open will benefit this auxiliary intake as well.

We would also encourage examination of training of river upstream from the proposed bendway weirs as well. This training would direct flows more to upstream right abutment of the bridges. Thus, the series of bendway weirs proposed would be more effective at keeping the existing intake open at low flows.

BRIDGE SCOUR CONSIDERATIONS

HDR Engineering, Inc. completed a fairly extensive study of expected scour of the piers for the Railroad Bridge. They also considered the effects of the new 4-lane highway bridge piers. This study indicates that there are problems with scour at this location. It is important to place the bendway weirs such that scour holes do not overlap those of the bridge piers. It is also important to improve the south, approach to the bridges, which we believe the bendway weirs will accomplish. In any event, the BN-SF and MDOT will have considerable interest in any river training activity at this location.

APPENDIX B

HEC-RAS Output Computations for the Yellowstone River at Laurel, Montana, with Annual Flood Flow (42,200 cfs)

River Sta.	Energy Grade Elev.	Water Surface Elev.	Vel Head	Friction Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
	(ft msl)	(ft msl)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
4600	3272.85	3271.60	1.25	1.31	0.08	24.47	42169.38	6.16	508.86
3972	3271.47	3270.48	0.99	0.75	0.15	177.12	42013.27	9.60	648.53
3461	3270.57	3270.07	0.50	0.52	0.07	1197.36	34824.32	6178.33	1143.00
3194	3269.98	3268.82	1.17	0.29	0.02	121.76	41969.73	108.51	500.00
2970	3269.67	3268.28	1.39	0.03	0.00	445.11	41245.87	509.03	480.00
2960	Bridge								
2950	3269.30	3268.23	1.07	0.20	0.02	507.16	39349.88	2342.97	515.51
2771	3269.08	3268.08	1.00	1.44	0.01	20.17	42117.02	62.81	513.27
1781	3267.63	3266.65	0.98			64.21	42130.15	5.64	668.37

HEC-RAS Output Computations for the Yellowstone River at Laurel, Montana, with Average Daily Flow (6,932.1cfs) Without Bendway Weirs

River Sta.	Energy Grade Elev.	Water Surface Elev.	Vel Head	Friction Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
	(ft msl)	(ft msl)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
4600	3265.47	3265.13	0.35	1.27	0.02		6932.1		493.07
3972	3264.18	3263.91	0.26	1.11	0.00		6932.1		422.27
3461	3263.06	3262.79	0.28	0.88	0.00		6510.70	421.40	656.91
3194	3262.19	3261.88	0.31	0.38	0.01		6932.10		467.90
2970	3261.79	3261.33	0.46	0.04	0.00	20.75	6771.09	140.26	412.54
2960	Bridge								
2950	3261:45	3261.24	0.21	0.14	0.00	14.47	6722.25	195.38	468.98
2771	3261.31	3261.10	0.21	1.27	0.01		6932.10		467.79
1781	3260.03	3259.70	0.33				6932.10		420.46

HEC-RAS Output Computations for the Yellowstone River at Laurel, Montana, with Average Daily Flow (6,932.1cfs) With Bendway Weirs

River Sta.	Energy Grade Elev.	Water Surface Elev.	Vel Head	Friction Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
	(ft msl)	(ft msl)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
4600	3265.48	3265.14	0.34	1.24	0.03		6932.10		493.11
3972	3264.22	3263.96	0.26	0.97	0.01		6932.10		422.36
3461	3263.24	3263.01	0.23	0.73	0.01		6475.01	457.09	664.58
3194	3262.29	3262.01	0.29	0.35	0.02		6932.10		468.29
2970	3261.79	3261.33	0.46	0.04	0.00	20.75	6771.09	140.26	412.54
2960	Bridge								
2950	3261.45	3261.24	0.21	0.14	0.00	14.47	6722.25	195.38	468.98
2771	3261.31	3261.10	0.21	1.27	0.01		6932.10		467.79
1781	3260.03	3259.70	0.33				6932.10		420.46

APPENDIX C

FINANCING FUTURE WATER SYSTEM TAPS AND EXTENSIONS

By: Morrison-Maierle, Inc., Billings, Montana

APPENDIX J – MORRISON-MAIERLE, INC. JULY 1997. FINANCING FUTURE WATER SYSTEM TAPS AND EXTENSIONS

DRAFT

JUL 1 6 1997

FINANCING FUTURE WATER SYSTEM TAPS AND EXTENTIONS

SUBMITTED TO:

CITY OF LAUREL
115 WEST FIRST STREET
PO BOX 10
LAUREL, MT 59044

SUBMITTED BY:

MORRISON-MAIERLE, INC.
2020 GRAND AVENUE
BILLINGS, MONTANA 59102
(406) 656-6000

MAY 1997 - Initial Draft
JULY 1997 - Final Draft

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

This study is an extension of the 1994 Water Treatment and Distribution Master Plan prepared for the City of Laurel. The 1994 Plan established the basis for a number of water treatment plant and distribution system improvements being designed for 1997 and 1998 construction, and examined water distribution improvement needs for future developer growth.

From the Master Plan and current development demands being place on the city water system, the City has identified two general concerns which must be further examined:

- The raw water intake for the water treatment plant - issues include its present capacity, whether it can be expanded, and the necessary improvements required for expansion.
- Financing future system improvements - prioritize necessary improvements to the water treatment plant, the distribution system, and storage to meet the demands of future service taps and extensions.

1.2 APPROACH

The City of Laurel requested an engineering evaluation to look at the following specific issues:

Raw Water Supply

- Summarize the existing water treatment plant's raw water intake capacity
- Evaluate whether the intake can be expanded to 20 million gallons per day (mgd)
- Identify necessary improvements for 20 mgd capacity expansion

Service Area

- Summarize the general service area and correlate with the 1994 Master Plan
- Update the service area and demand since the 1994 Master Plan completion

Water Usage Demands

- Summarize present average day, maximum day, and peak hour water demands
- Identify present residential, commercial, and industrial fire flow requirements
- Summarize future residential, commercial, and industrial peak day demands and fire flow requirements

Model Water System

- Model the water system to include treatment plant, storage, and distribution system
- Analyze the system's ability to meet present water demands
- Identify impacts from future water taps and extensions including Cenex's tap request
- Analyze and identify water plant, storage, and distribution system improvements necessary to accommodate projected future water taps and extensions

Improvement Alternatives and Costs

- Recommend improvements necessary to meet future water demands
- Determine probable cost for future water demand improvements

Financing Recommended Improvements

- Establish cost basis for assessing future water taps and extensions
- Develop a general financing prototype for system development fees

1.3 GENERAL FINDINGS OF THIS STUDY

1.3.1 Introduction

The existing water distribution system is for the most part the same as when the 1994 Master Plan was completed. Scenarios which were not addressed in the 1994 Master Plan, but are now items of concern for the City of Laurel are:

1. Extension of water service to the Laurel Airport.
2. Capacity of service to three potential industrial or large commercial centers.
3. Ability of the existing intake structure to produce 20 mgd of treated water.

The three potential development scenarios were first investigated separately. The impacts from each scenario was calculated. The scenarios were then pieced together until the year 2015 had all three scenarios in place. The impacts to the capacity of the water treatment plant, distribution system and intake structure were also evaluated. The recommendations for improvements provide the City of Laurel with valuable information for handling future development into the year 2015.

1.3.2 Findings of this Study

- The raw water intake structure's firm capacity is approximately 4.9 mgd with the largest pump out of service.
- Intake has problems with air entrainment, thus, disrupting the operation of the pumps.
- The raw water intake capacity is the limiting factor for the City of Laurel's ability to meet future projected water demands.
- Capacity of intake during winter months is limited to one 18" perforated pipe. This significantly reduces the capacity of the water treatment plant during the winter months.
- The distribution system has a few areas which are limited in their capabilities of producing the recommended needed fire flows. Some of these areas are addressed in the 1994 Master Plan.
- A number of existing 4" mains which service fire hydrants are recommended to be replaced with 6" mains.
- Hydraulic problem areas presented in the 1994 Master Plan still effect the existing water distribution system.
- Zone 1 growth commercially, industrially, and residentially are limited until pressure Zone 2 is completed.
- Marginal pressure in Cherry Hills subdivision is due to water service coming from the Zone 1 distribution system. This subdivision and nine other subdivisions should be re-piped to be include in service by pressure Zone 2.
- Growth in West Zone 2 is limited until the Zone 2 reservoir and service loop is constructed.
- Water service to the Laurel Airport requires construction of a new storage reservoir and booster station and a new pressure zone (Zone 3).

1.3.3 Projected Cost Estimates for Recommended Improvements

Table 1.1 presents the projected cost estimates for the improvements to the water treatment plant, water distribution system, and intake structure to handle projected future development into the year 2015.

Table 1.1 Cost Estimates for Improvements	
City-Wide Existing Water Distribution System Improvements	
Immediate Needs	$472,400
Future Water Distribution & Storage Improvements	
Zone 1	$708,600
Zone 2	$2,194,700
Zone 3	$2,354,100
Future Water Treatment Plant Improvements	
Intake Structure	$500,000

1.3.4 Extension or Tapping Fee

The projected improvement costs have been broken down so the City of Laurel can begin implementing an extension or tapping fee dependent upon the pressure zone. This fee will be charged to anyone who wishes to extend water service to their new or existing development. The fee will be based on improvements needed for the existing water distribution system in order for the system to adequately provide the requested water service.

Table 1.2 presents the extension or tapping fee associated with each pressure zone.

Table 1.2
Extension or Tapping Fee Dependent on Pressure Zone

	Developer Fee/ERU	Typical Residential Charge per Lot
Zone 1	$2,219	$4,438
Zone 2	$2,454	$4,908
Zone 3	$1,833	$3,666

2 RAW WATER SUPPLY

2.1 WATER TREATMENT PLANT RAW WATER INTAKE

2.1.1 General Description

The water treatment plant intake system consists of the Yellowstone River intake structure, piping from the intake structure to the raw water pumps, the pumps, and discharge piping from the raw water pumps to the treatment plant's Parshall flume. Water is pumped from the river intake structure to the water treatment plant using a combination of three low service pumps. Pump number 1 and number 2 each have a capacity of 2,000 gpm. Pump number 3 has a capacity of 1,400 gpm. Pump number 1 is a turbine type pump, while pumps 2 and 3 are trash pumps. When all pumps are operated simultaneously, the City has a raw water production of approximately 7 mgd (4,850 gallons per minute (gpm)).

The Cenex Refinery has two raw water pumps housed in the same pump building as the City's raw water pumps. The suction line to these pumps is manifolded into the same intake piping that services the City's raw water intake pumps. Cenex's pumps are sized at 2,000 and 1,200 gpm. When operated simultaneously, they have an approximate pumping rate of 3,000 gpm.

The intake structure is located in the Yellowstone River, just east of an existing bridge pier. Water passes through two screened intake openings and into two 20" pipelines that run from the intake structure to the raw water pumps located in the basement of the intake building on the river bank. The intake piping consists of a manifold for distribution of water to any of three Laurel intake pumps or the two Cenex raw water pumps. Figure 2-1 is a schematic of the intake structure.

Several elevations of the intake process were measured by Morrison-Maierle in 1996. Below are the results for those elevations with other elevations estimated (est) based on comparison of known elevations and old drawing dimensions, or drawings by the Montana Department of Transportation (MDT) for the new South Laurel Bridge across the Yellowstone River:

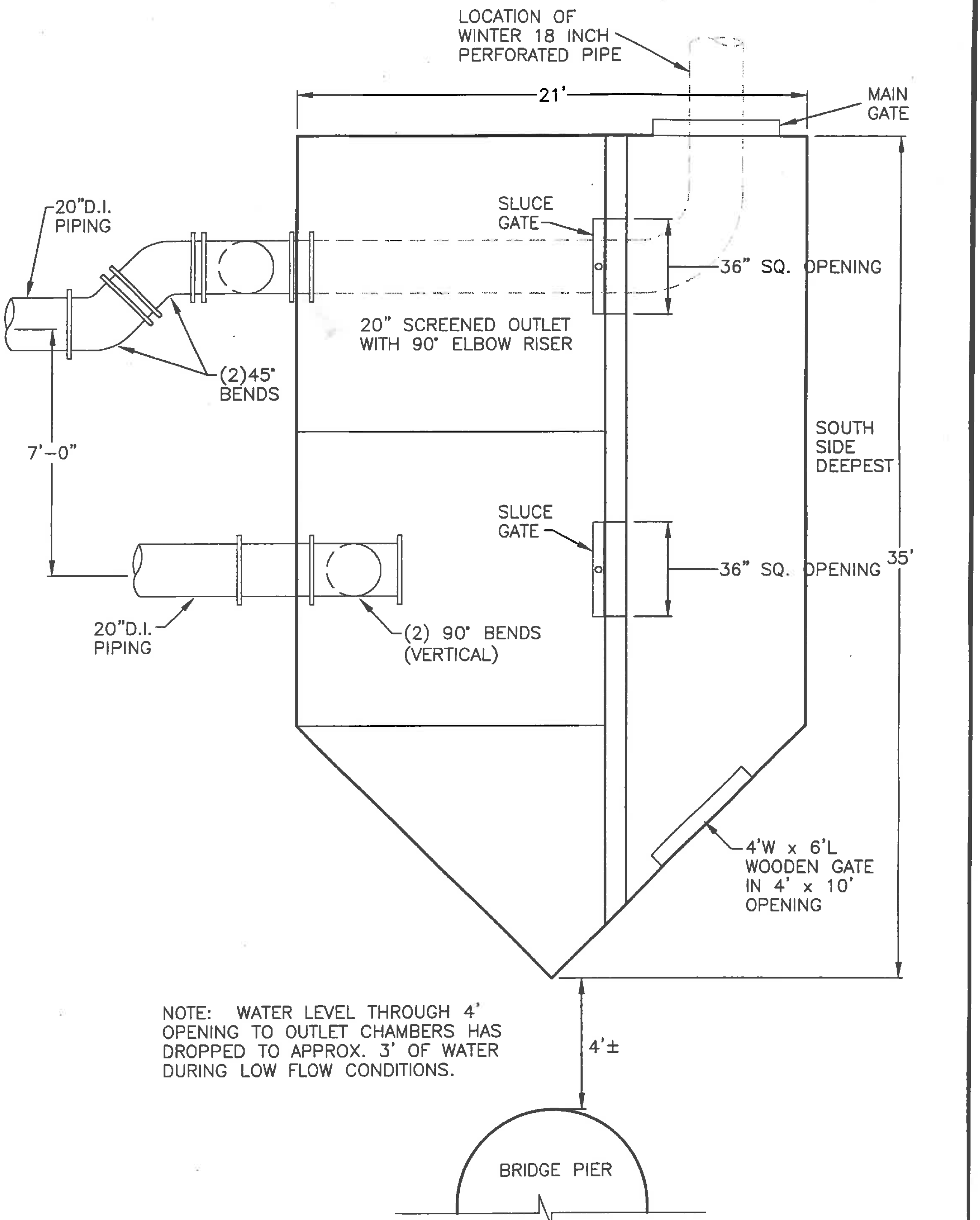
Yellowstone River:

- Elevation on 12/85 at flow of approximately 2,000 cubic feet per second (cfs) (MDT)	3262.0 ft
- Lowest point of channel (MDT)	3251.0 ft
- Predicted lowest water level	3258.0 ft*
- Flood level (MDT)	3272.3 ft

Intake Structure:

- Top	3273.3 ft
- Bottom	3247.0 ft
- Estimated top of 20" pipe inside of intake structure. The second 20" pipe similar, but reduces to 16" at intake structure.	3252.0 ft.

Top of inlet piping entering raw water pump building	3259 ft



EXISTING LAUREL INTAKE

FIGURE 2-1

Raw water pumps:	
- Bottom impeller	3264 ft (est)
Water level in plant Parshall flume (raw water pump discharge)	3280.8 ft
Approximate total change in elevation, low water level to discharge:	3280.8-3258.0 = 22.8 ft

**The lowest level anticipated at the river was approximated by noting that the river gage at Billings drops just under 1 ft (from 2.20 ft to 1.4 ft) as the river flow drops from about 2700 cfs to 800 cfs (USGS, 1997). The lowest recorded flow for the Yellowstone was 430 cfs for December 12, 1932. The actual gage level for that 1932 low-flow is not available since gage levels during ice conditions are not reliable. This study assumes that low flow at Laurel would result in a drop of 4 ft below the level at December of 1985. Such a conservative assumption is necessary as the stream geometry may be dissimilar for the given dates and locations.*

2.1.2 Existing Intake Problems

In 1995, there was a major fire in the Laurel downtown area. To fight the fire, the City ran the water plant at full capacity. During this period, the water level in the sedimentation basins showed a significant drop, as the intake system could not keep up with plant treatment capacity, nor the capacity of the high service pumps (8.8 mgd, firm rating).

A second problem is that air enters the intake system during periods when the river is low and demands are high. This causes the raw water pumps to air-lock and no water can be pumped into the plant.

During the winter months when demand drops substantially, at least one of the two main intake structure cells will become clogged with slushy ice. This icing problem is due to the water entering the intake being in a slushy, icy condition. A solution was reached by connecting an 18" perforated pipe directly to the east 20" intake pipe while the west 20" line is shut off. The perforated pipe extends downstream and has not demonstrated problems with freezing or collection of debris. During the warmer months the perforated pipe is removed and the intake structure returned to normal operational status.

One final problem did not become evident until the record high water levels of the Yellowstone River in June of 1997. During this period, the eastern most suction chamber of the intake structure was filled with sand to a depth where the 20" intake line was totally submerged. This made the east 20" intake line useless. In addition, large tree branches and limbs were deposited in both suction chambers. The average size of the large branches was 3" in diameter by 2 ft long.

The intake structure was designed with a direct flow-through collection chamber. This chamber has a wooden gate on the upstream side and a slide gate on the downstream side. Flow passing through this chamber will discharge into the intake suction chambers upon demand. Two problems currently exist with this chamber:

1) The original construction drawings for this chamber show bar screens (3/8" x 2" bar spaced at 3" centers) across the 36" square openings between the flow-through chamber and the suction chambers. These bar screens are not in place allowing large debris to enter the suction chambers.

2) The wooden gate on the upstream side is 4 ft wide by 6 ft high and slides up and down in a 4 ft by 10 ft hole. As a result, this gate cannot be totally shut except during low flow conditions. During the 1997 high water levels in the Yellowstone River, if this gate could have been closed, the sand loading in the two suction chambers could have been greatly reduced.

2.1.3 Capacity of the Intake Structure

The City has requested that the ability to increase the capacity of the raw water intake be examined. The desired raw water capacity is:

City Treated Supply	15 mgd	(10,400 gpm)
Cenex Raw Water	5 mgd	(3,500 gpm)
Total	20 mgd	

The ability to expand the intake system can be divided into four areas:

1) capacity of intake structure to allow sufficient water to enter and be screened.
2) ability to avoid drawing air into the system.
3) capacity of pumps (interdependent on intake piping capacity).
4) ability to proportionally increase the winter intake without creating problems with debris or freeze-up.

2.1.3.1 Existing Capacity

The existing intake structure has two 36" square intake openings. Water flows through these openings into the two suction chambers. There are no screens or bar racks across these two openings to inhibit their capacity.

The two 20" raw water intake lines are screened with 28" square screens having ½" openings. The screens fit directly over the 20" intake lines. The effective area of the screens is limited to the diameter of the pipe, roughly 2 ft² for a 20" diameter. The generally accepted standard for design velocity through a screen is 0.5 ft/s in order to avoid problems with frequent clogging due to materials adhering to the screens. At the 0.5 ft/s velocity, each intake is rated at 0.7 mgd. The City of Laurel currently draws water in at several times the recommended flowrate for the existing screens. No major problems have been noted as a result, other than the screens need to be cleaned frequently. One of the reasons that the pumps are not able to operate at their design flowrate may be to some degree due to headloss through the screens.

2.1.3.2 Improvement Alternatives

In order to increase the intake capacity to 20 mgd, reduce frequency of required cleaning, and lower headloss, it is suggested that additional screening be applied in the intake. Screening alternatives consist of either traveling screens or stationary screens.

The Laurel intake structure was originally designed to have stationary bar screens over the intake openings between the flow-through chamber and the two suction chambers. Each intake opening was screened to protect the 20" intake lines from large debris. Recommended average design velocity across a bar screen is 1 foot/second (ft/s), however, peak velocities as high as 2 to 4 ft/s have been used. The lower the velocity, the more self-cleaning a bar screen is. If each of the 36" square intake openings was screened, then at the 1 ft/s average design rate, each intake gate (effective opening 32" x 36") would have a rated capacity of 5.17 mgd. The two gates combined provide a 10.35 mgd total recommended capacity. The peak recommended flow capacity for short periods of time could approach, but, should not exceed 25 mgd (2.5 ft/s).

The City of Billings' original tower-style intake structure was constructed in a manner similar to that of the Laurel structure. The Billings intake used a traveling screen and experienced many problems similar to those facing Laurel. Freezing problems and algae build-up were noted as the main causes for concern. The Billings plant's traveling screen was 4 ft wide, with triangular openings at about ¼". When all was working well, the operators felt the screen offered a capacity of over 20 mgd. Using standard calculations for screen design, allowing for 0.5 ft/s through the effective screen area, and noting that the minimum depth of water across the screen of about 8 ft, it would be within reason to assume such a screen could provide Laurel 7 to 10 mgd (effective velocities through the screen at just over 0.5 ft/s) during low water, and 12 to 20 mgd during high water. It should be noted that the effective screen area of the Billings screen is about sixteen times that of the existing Laurel screens. And overall screen width of 8 ft would be necessary for Laurel.

Although a traveling screen is perhaps one of the most reliable and effective types of screen for screening surface water, it is not reliable during winter months. The previously mentioned traveling screen at Billings was extremely difficult to use during winter months even though it was totally enclosed in a heated building. Laurel may wish to use a traveling screen, but would need to provide other means of screening during winter months.

Stationary double-tee, circular screens (see Figure 2-2) could be installed inside the two suction chambers in combination with the bar screens. The bar screens would remove the large debris and the circular screens, the smaller floating debris. The existing screens on the two 20" intake lines would need to be removed and new circular screens provided with a companion flange and bolt them to the existing intake lines. An alternative location is to locate the circular screens directly in the river. In either case, it is recommended that the City consider installing permanent double-tee type screens on either the inside or the south side of the intake structure. According to Dave Michaels, Utilities Superintendent, the south side of the intake maintains perhaps the deepest section of the river channel. While this provides the optimum condition of water intake, it also is a route for large debris to follow during flood events. Although some kind of diversion, such as a 3 ft high by 3 ft wide bar rack with 1 ft spacing, would be needed to provide minimum protection to such screens, it is fortunate that the screens will be at the deepest section of the river and should not come into contact with large tree trunks, rather only the roots that drag the river bottom.

The screens proposed would be similar to circular screen used in wells. At the 0.5 ft/s intake velocity and a 250 slot screen (¼" spacing), approximately 20 to 25 ft of 24" diameter screen would be needed. The screens require a minimum water depth of 3.5 ft over the screen and 1.5 ft

Efficient Surface-Water Intake Screens

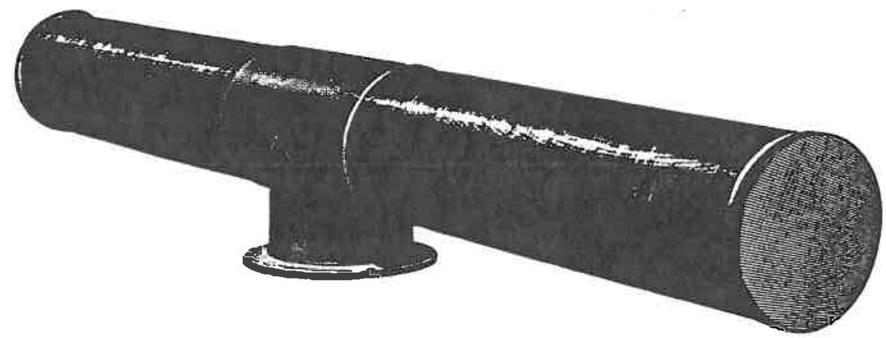
Johnson Screens serve as efficient and economical intake devices in rivers, lakes, and reservoirs. They replace timber cribs, concrete caissons, and other old-style intake structures developed decades ago.

More recently, knowledgeable consulting engineers have designed surface-water intakes utilizing Johnson Screens as the essential elements to obtain excellent hydraulic efficiency and an economical installation. Johnson Screen intakes also make it possible to arrange for hydraulic backwashing and cleaning. Backwashing of the screens effectively loosens debris that tends to accumulate around the intake under adverse conditions. This system is superior to one which uses screen panels which must be removed from the structure for cleaning purposes.

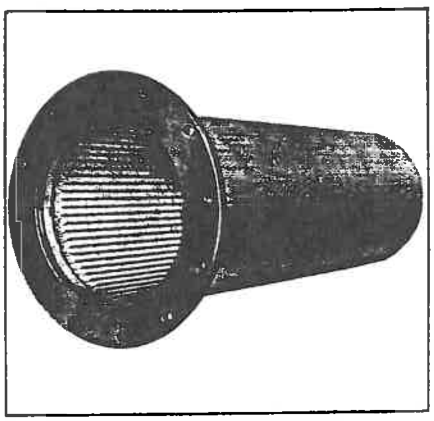
Use Screens In Pairs

An excellent submerged intake structure can be designed by using a section of Johnson Screen at the extremity of the intake conduit. These screens are often used in pairs with valving arrangements that permit backwashing of one screen while the other is in continuous operation.

Johnson Screens can be mounted on a foundation to hold them at the proper distance off bottom in a stream or lake. Attachment to the foundation can be made in such a way as to permit removal of a screen for inspection when required. If it becomes necessary to change the location of the intake, the whole assembly can be salvaged and reinstalled.



Dual intake unit with flanged tee made of the same metal as the JOHNSON Screens. The outer end of each screen is fitted with a flat screen plate similar to the cylindrical surface, thus providing additional intake capacity.



JOHNSON Intake Screen fitted at one end with companion flange and closure plate at the other end.

Surface-water intakes must be reliable. This requires sturdy construction. Johnson Screens are welded throughout for high strength. They are extremely sturdy. Even when seriously deformed by being accidentally smashed or twisted, the welded structure does not loosen and the screen, though damaged, continues to function.

Entrance velocities on submerged intakes should be limited to less than 0.5 ft per second. The large proportion of open area which is provided by the unique design of Johnson Screens easily provides sufficient intake capacity to keep the entrance velocity below this limiting value.

For example, a 24-inch Johnson Screen, 10 feet long, with 1/4-inch slot openings will handle 12 million gal per day with inlet velocity less than 0.5 ft per sec. This screen provides 37.4 sq ft of open area. One-fourth inch openings provide efficient screening that excludes coarse sediment and the smallest fish.

Varied Screen Design

To exclude finer suspended material, slot openings in a Johnson Screen intake can be made as small as desired, and the V-shape openings effectively minimize clogging.

In designing intake structures, the ideas of the designing engineer can be freely expressed. Diverse conditions encountered require the use of ingenuity and judgment. Where the problem is to admit large volumes of water with minimum head loss, while at the same time excluding extraneous material, the use of Johnson Screens for surface-water intakes is a sound engineering practice.

FIGURE 2-2

below. At the lowest projected river level, submergence will just meet the minimum criteria. With an air cleaning system, the screens cost about $10,000 each before installation.

2.1.4 Air in the System

Air may enter the intake pipes along with the water if a vortex is created. Secondly, air may enter through pipe joints that are not submerged at locations where pump draw creates negative pressure. Testing for each of these conditions will need be completed during a period when the river is low.

<u>Vortex</u> - Numerous studies were examined regarding the predictability and design for vortexes. Since every intake is different, either in geometry or flow, there is no standard method of design. Indeed, nearly all research suggests that improvements for existing intakes or design of new intakes should consider modeling the system in a laboratory. The cost of such modeling was estimated at about $15,000 (Sanks, 1989, pg 312), though costs have probably increased about 20% since that time. An extensive discussion of the modeling of pumping pits may be found by referencing "Modeling in Design of Pumping Pits" from the Journal of the Hydraulics Division (Tullis, 1979). Mathematical methods for predicting minimum submergence of intakes to avoid vortexing will be discussed later in this report. However, due to the high cost associated with expansion of the existing intake system, it would be very prudent to model proposed improvements before actually beginning design.

A vortex develops when a swirl of water develops from the intake pipe or pump impeller, and travels up to the water surface. A vortex will draw air into the intake pipe which may lead to pump inefficiency, loss of suction, or damage to the pump. The development of the vortex is dependent primarily on sump geometry and inlet velocity. There are two main methods of intake 1) vertical bellmouth to the sump floor (a turbine pump or sump pump inlet, or an inverted 90 degree elbow) and 2) a horizontally mounted exit pipe. The preferred method of design for a suction line leading to a remote pump would be an inverted elbow (Sanks, 1979, pg 310). All researchers agree that pipe intakes should be bell shaped.

A standard intake structure with sump geometry not conducive to the formation of vortices would be expected to avoid vortices as long as critical submergence was maintained. The critical submergence is that depth of water above the intake (either the bell opening or pump intake, as the case may be), that must be maintained to avoid the swirling motion of water that will lead to vortexing. In cases of non-conventional sump design, critical submergence can only be predicted with actual modeling in a lab.

The minimum submergence has been found to be proportional to the inlet diameter and the Froude number[1]. The Froude number is a dimentionless number that relates fluid velocity to flow restriction (diameter), that is:

$$Fr = v/(gd)^{0.5},$$

where Fr = Froude number
v = velocity of water entering inlet (ft/s)
d = pipe diameter (ft), and
g = the gravitational constant (32.2 ft/s^2)

The ratio of critical submergence (s) to the pipe diameter (d) is found to be proportional to the Froude number for the intake (Reddy, 1972). For intake systems where a bell was used, but other conditions were less than ideal, the equation is:

$$s/d = 1 + Fr, \text{ or}$$

$$s = d(1+Fr).$$

A very rough estimate of minimum submergence can be made for Laurel with the minimum improvement of adding a bell to the inlet. The entrance velocity into each inlet line should be held below 2.5 ft/s. At a 12 mgd demand (7.5 city/4.5 Cenex), a 30" bell diameter would be required for each line, and at the future 20 mgd rate, a 36" bell would be required on each line.

The minimum submergence of the mouth of a horizontal bell inlet, bell mouth parallel to the structure wall, for a combined 12 mgd flow and the proposed 20 mgd flow, are:

$$s_6 = (30/12) \times [1+(2.0/(32.2 \times 2.5)^{0.5})] = 3.1 \text{ ft}$$

$$s_{10} = (36/12) \times [1+(2.2/(32.2 \times 2.5)^{0.5})] = 3.7 \text{ ft}$$

This submergence depth, plus the extra 5" of bell diameter, when added to the top of pipe elevation (3253.7 ft), brings the minimum required elevation to 3257.5 ft. The minimum elevation projected for the Yellowstone River is 3258.0 ft.

It should be noted that such a bell should not be installed in the current intake due to insufficient bottom clearance. It is recommended that the clearance from the bell bottom to the bottom of the inlet chamber be ½ of that bell diameter (Chang, 1968, pg 401), the combination of which would require the intake bottom to be lowered about 1.5 ft below its current depth. What the above exercise does tell us is that unless the water level is being maintained at least 4 to 5 ft above the top of the pipe, there is a good chance that a vortex may occur. As discussed earlier, the minimum submergence calculated here is only to give a benchmark of approximate depth. Modeling should be conducted of proposed improvements before the City invests in

[1] It is interesting to note that the Froude number is also used in calculating the ability of water to entrain air bubbles at high points in a pipeline (Kalinske, 1948).

construction. Such modeling may be done at various universities such as Utah State in Logan, Utah.

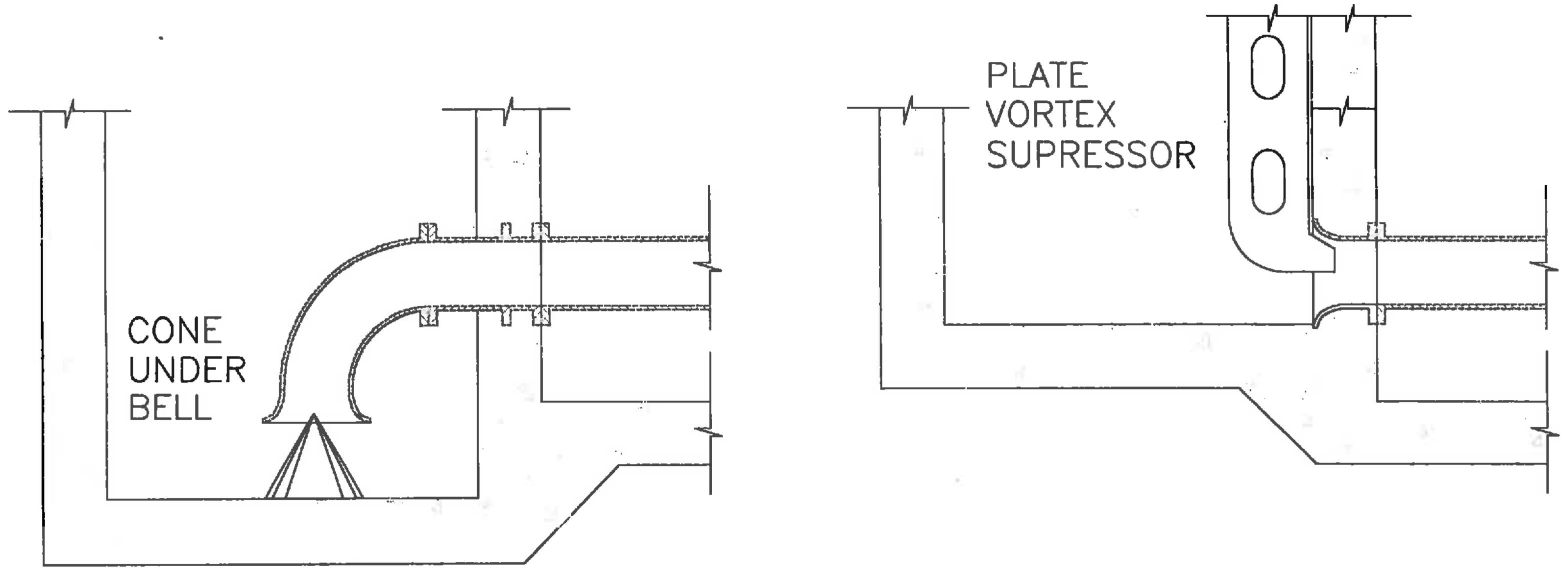
The alternative bell setup is an inverted 90 degree, flared elbow. This will reduce the minimum required depth of water in an intake structure, since the bell is parallel to the water surface and below the pipe enter line by approximately 18". Here also a ½ bell diameter clearance is also required. If the bottom of the intake is to be torn out and a new, lower floor installed, it would be much more effective to place an inverted elbow with a flared end than to add a horizontal bell.

If the City wants to be able to run all pumps this summer and minimize the chance of vortexing, it may wish to install a cheap vortex breaker or "raft" as depicted in Figure 2-3.

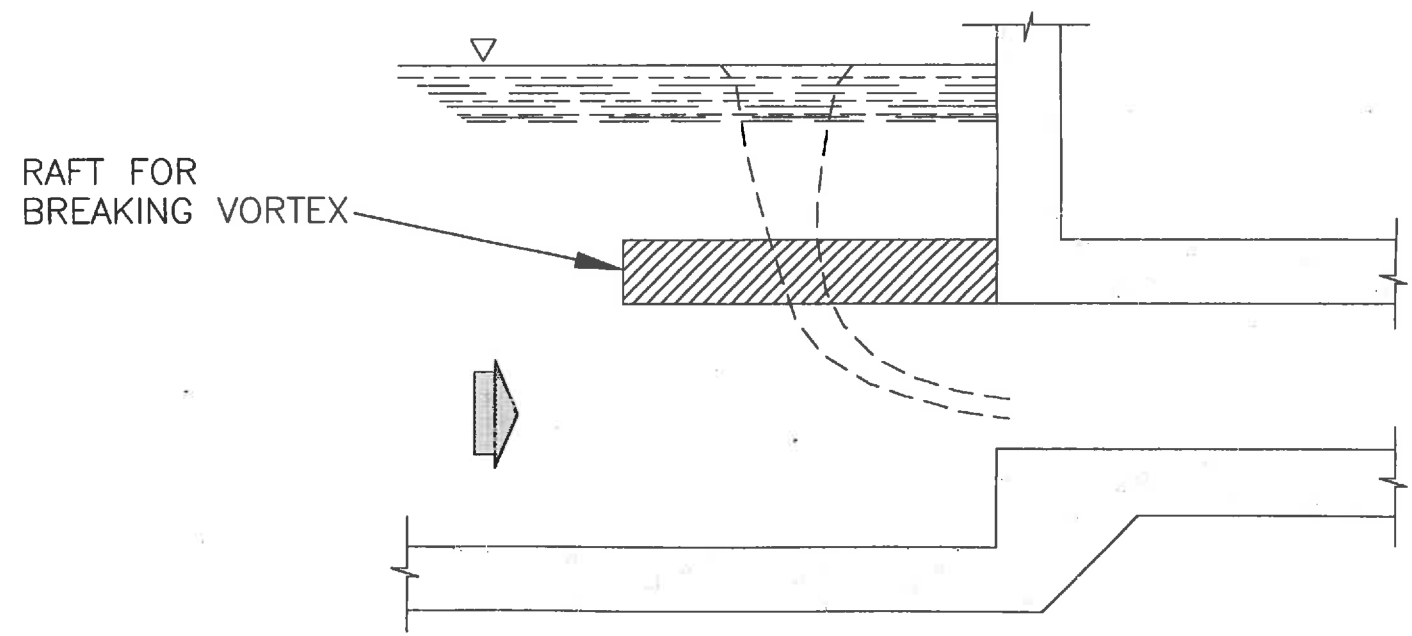
2.1.5 Pipeline from the Intake to the Sedimentation Basins

In February of 1996, due to floating ice damaging the original 14", 16", and 20" intake lines, the City of Laurel installed two 20" ductile iron pipelines from the intake to the shore. Just before reaching the low-lift pumps, the pipes connect to a piping manifold where flow splits into three individual pipes for service to the City of Laurel raw water pumps, and one line that serves intakes for the Cenex Refinery pumps (see Figure 2-4).

The flow velocities through pipelines are normally recommended to be 5 to 6 ft/s under average conditions and under 10 ft/s during peak conditions. Peak velocities in excess of 10 ft/s can be occurring on an intermittent basis without damage to a pipe. As for the two 20" intake lines, each line has a capacity based on velocities of 7.2 mgd and 13 mgd, respectively. Combined, the intake has a 14.4 mgd average and 26 mgd peak capacity rating.

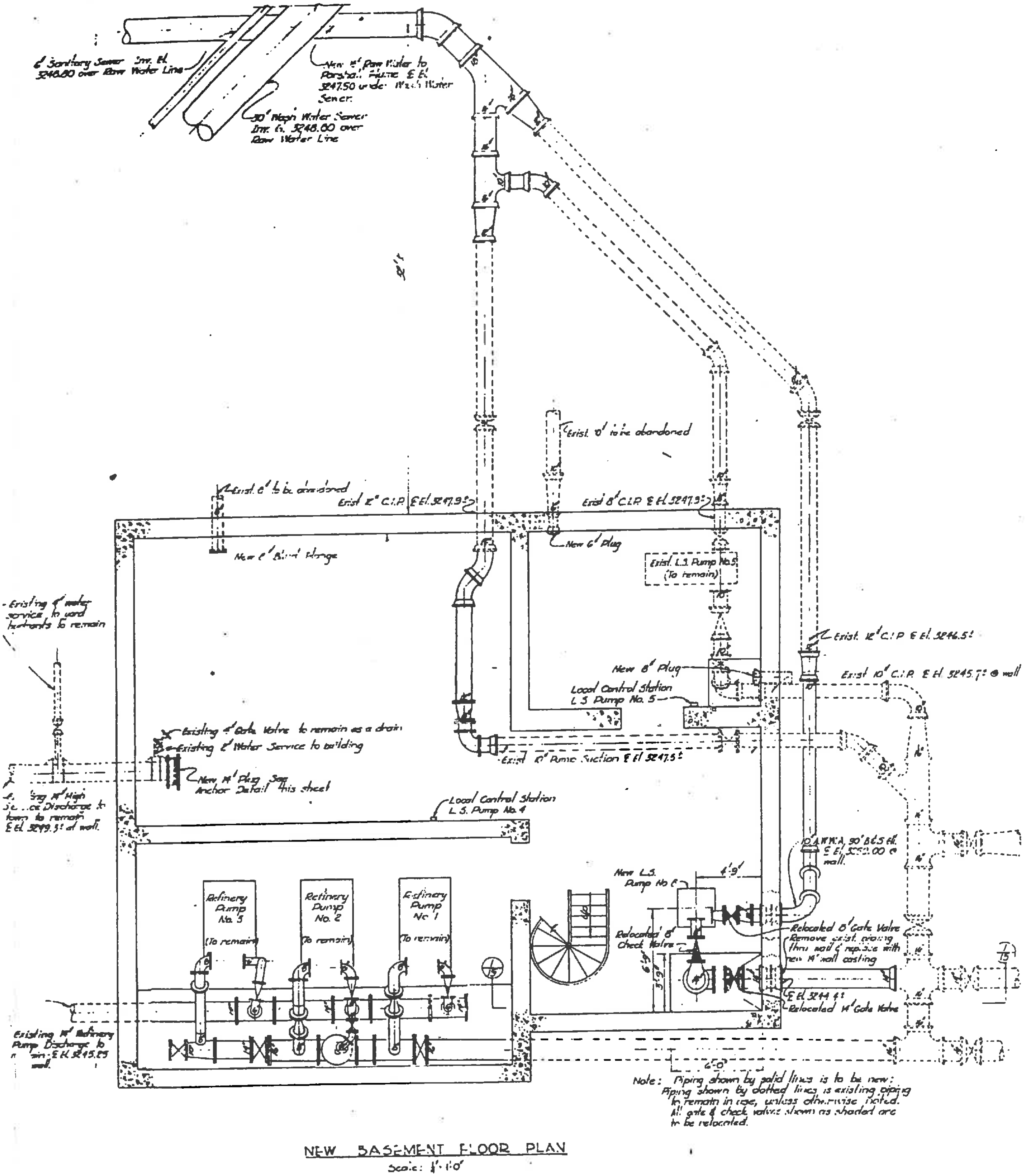


VORTEX SUPRESSORS



VORTEX AT INTAKE

FIGURE 2-3



New 18" Raw Water to Parshall Flume E El. 3247.50 under Wash Water Sewer.
30" Wash Water Sewer Inv. El. 3248.60 over Raw Water Line
Erist. 10" to be abandoned
Erist. 6" to be abandoned
New 6" Blind Flange
New 6" Plug
Erist. L.S. Pump No. 5 (To remain)
Erist. 12" C.I.P. E El. 3246.5±
New 8" Plug
Local Control Station L.S. Pump No. 5
Existing 4" Gate Valve to remain as a drain
Existing 2" Water Service to building
Local Control Station L.S. Pump No. 4
Refinery Pump No. 3 (To remain)
Refinery Pump No. 2 (To remain)
Refinery Pump No. 1 (To remain)
New L.S. Pump No. 6
Relocated 8" Gate Valve
Relocated 8" Check Valve
Relocated 14" Gate Valve
Note: Piping shown by solid lines is to be new; Piping shown by dotted lines is existing piping to remain in use, unless otherwise noted. All gate & check valves shown as shaded are to be relocated.
NEW BASEMENT FLOOR PLAN

FIGURE 2-4

No air can enter the submerged portion of the 20" intake pipelines. Should a leak develop in one of the 20" lines, the draw would not be significant enough to develop a vortex.

It is not as easy to verify that the piping between the non-submerged portion of the intake lines and the pumps is not a source of air. If headloss in the piping between the inlet and the pump exceed the difference in elevation between the intake water level and the pumps, there would be a theoretical possibility of air being drawn into cracks in the pipe, or through leaking pipe joints. There is a slight possibility of this occurring in the manifold after the 20" lines and before the pumps, but, only at extremely low river flow. It is doubtful that air is being drawn into the system from the suction piping because:

- there is very little headloss in the piping at current intake flow of 4 to 5 mgd
- there are no check valves on the pump discharge piping and the discharge piping outlet is at a grade above the pumps, it is unlikely that air could enter from the discharge side

The air-tightness of the piping could be verified by pressure testing the piping from the pumps to the butterfly valve in the 20" lines, provided that a bubble-tight seal can be achieved in the valves. It is not necessary to test the 20" pipe beyond the valve.

If the intake system is to be expanded much beyond its current capacity, it will be necessary to augment piping in the gallery, or wherever the future pumps would be installed. The existing piping inside the low-lift pump gallery is much more limited in capacity than the 20" main feeders. The piping inside the gallery is 10" to 12" cast iron, quite old, and capable of handling maximum flows of 2 to 3 mgd for each of the three lines. Higher flows could cause erosion of the pipe inner walls which are probably already scaled and deteriorated. Expansion of the City's raw water pump intake to 15 mgd will certainly call for a complete overhaul of the pipe manifold system between the 20" lines and the yard piping from the pumphouse to the treatment plant. Expansion of the raw water intake capacity to 15 mgd (city portion) will call for the replacement and upsizing of the following piping:

- The 16" manifold piping and pump suction lines between the new 20" inlet lines and the raw water pump.
- The raw water building piping for the pump intake and discharge.
- The individual pump discharge lines outside the building.
- The 18" common line in the yard between the raw water pump building and the plant's Parshall flume.

One means of greatly reducing the chance for air entering the intake piping would be to install the intake pumps at the intake structure. Such a layout would allow the existing low-lift gallery to be avoided completely with water being pumped directly to the plant.

2.1.6 Capacity of the Pumps

The following is a list of capacity and pump type at the Laurel Intake:

Pump 1	turbine pump	2,000 gpm	(2.88 mgd)
Pump 2	trash pump	2,000 gpm	(2.88 mgd)
Pump 3	trash pump	1,400 gpm	(2.02 mgd)

The Montana Department of Environmental Quality Circular WQB-1, paragraph 6.3, which addresses pumping facilities, requires that:

> *"At least two pumping units shall be provided. With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system."*

The maximum day demand identified in the 1994 Master Plan was 5.18 mgd. With the largest pump out of service, the plant has a firm capacity of 4.9 mgd. Expansion of the City intake capacity to 15 mgd will require the upsizing of the 1,400 gpm pump and the addition of two more pumps.

If constant speed pumps are installed, a general recommendation for the pump size is:

- Two pumps, which each can meet the average day conditions (the two existing 2,000 gpm pumps should satisfy this criteria).
- Three new 3,000 gpm pumps (two for peak day service and one for standby).

In lieu of constant speed pumps, an alternative would be to install variable speed pumps. Under this scenario, the City should consider four pumps of 3,500 gpm capacity and the use of variable frequency drives.

2.2 PROPOSED ALTERNATIVES

2.2.1 Alternatives

The following conclusions have been drawn regarding expansion of the intake to 15 mgd city use and 20 mgd when combined with Cenex Refinery raw water demands:

1) The City's existing raw water pumps will need be upsized from their current capacity of 7.76 mgd (4.90 from capacity with the largest pump out) to 15 mgd.

2) The two 20" intake lines appear be of sufficient size to allow expansion to 15 mgd average day and 26 mgd peak day demand.

3) The existing piping in the low-lift pump station gallery is in poor condition and will need to be upgraded to get maximum performance from the existing pumps and will need to be up-sized and replaced to expand to 15 mgd.

4) The intake structure cannot safely expand to 20 mgd unless larger debris bar screens and continuous self cleaning intake screens are installed for the two 20" pump suction lines.

5) Air is entering the system during low water flows. Probable causes are either vortexing, occurring at the intake pipe or air entering the system at some point between the 20" intake lines and the raw water pumps.

Based on the above conclusions, three proposals are made for expanding the intake capacity to 15 mgd (city) and 20 mgd (total) as follows:

1) Place four submersible trash pumps (1-2,000 gpm and 3-3,000 gpm) inside the existing intake structure. With the pump intakes near the bottom of the structure, potential vortexing problems should be almost totally eliminated. The submersible pumps would be designed to discharge directly into the two 20" lines. New pipe would be routed from the existing header outside the low-lift pump building, directly to the water plant's Parshall flume. Install new bar screens over the 36" square openings, as well as other modifications to minimize wintertime slush and ice problems. The submersible pumps are designed to handle solids, so slush, sand, and ice will have minimal impact on the pump itself. Cenex's raw water pumps will remain as is.

2) Conduct a model of the existing intake to determine the best means of limiting vortex potential. Construct vortex breakers or other improvements required to allow up to 10.0 mgd intake (per side). Install the bar screen over the 36" square openings and add 20 to 25 ft of 24" circular intake screens to the existing pump suction lines. Use the two existing 2,000 gpm raw water pumps and add three new 3,000 gpm pumps to the gallery or just outside the gallery. Replace all piping from the 20" intake lines, through the pumps, and up to the Parshall flume.

3) This alternative is essentially the same as Alternative No. 2 except the 20" lines would discharge into a wetwell (approx. diameter = 96") located next to the raw water pump building, and the raw water pumps would draw out of this wetwell. This alternative would not require either vortex breaker construction or modifications to the intake structure. Note: The two 20" lines have more than sufficient gravity flow capacity for feeding a new wetwell.

4) Abandon the existing tower-style intake system entirely and create a new intake similar to that used in Billings. Using an earthen pond instead of an intake structure would involve constructing an inlet along the river that would include a trash screen and collection pond. This type of system was preferred by the City of Billings' operators who have entirely abandoned their tower-type inlet structure in favor of using the pond intake system year-round. This alternative is obviously land-intensive and an appropriate site would need to be found and purchase negotiated as there is limited land availability next to the plant. In addition, to land availability, there is concern with the water quality of the area groundwater.

With an oil refinery immediately next door and a slough immediately west of the highway, water stored in an earthen pond could pick up additional contaminants. The distance from the pond intake to the plant would greatly affect the total system cost due to the amount of piping required. The connecting pipe would be about 30" in diameter which could cost up to $150/ft.

5) Construct a new river intake structure. This structure would be most desirable to be located upstream of the 8th Ave. drainage ditch which discharges to the Yellowstone River approximately 6,500 ft west of the water treatment plant. The design of the intake would be deeper and include special construction to avoid vortexing and also improved screening.

6) Do nothing. This last alternative will examine possible consequences of providing no improvements to the intake system.

2.2.2 Costs

The opinion of probable cost of each of the alternatives is:

Alternate	Description	Cost
1	submersible pumps/structure modifications	$500,000
2	new pumps/structure modifications	$450,000
3	new pumps/new pump suction wetwell	$340,000
4	new pumps/earth holding pond	$2,300,000
5	new pumps/new concrete intake structure	$2,480,000
6	Do Nothing	$0

2.2.3 Technical Considerations

The following are some obvious technical issues that are inherent with each of the proposed alternatives:

Alternate No.1 - The submersible pumping system will allow the direct pumping of water from the intake structure to the water plant. Direct pumping will eliminate the potential for air trapping and accumulation in the raw water piping, and will eliminate one of the possible air intake areas. During the winter months when the Yellowstone River is carrying slush and ice, precautions will need be carried out and design features incorporated into the modifications to the modifications to the existing intake structure in order to minimize possible ice and slush problems with the pumps. Submersible pumps are designed to deal with solids such as the ice and slush will present. The temporary suction line which is installed each winter would not be necessary in the future. The bar screens will protect the submersible pumps from large debris.

Alternate No. 2 - Continuing with vertical turbine and trash pumps in the existing pump building will offer some significant improvements over what currently exists. The piping from the intake manifold through to the water treatment plant will all be replaced. This will eliminate one of the possible air intake conditions. In addition, air release measures could be designed into the pumping system to minimize future air locks. The intake structure modifications would result in increased screen area and other measures to prevent possible vortexing conditions. River icing and slush problems would be minimized and the temporary suction line which is installed each winter would not be necessary.

Alternate No. 3 - Construction of a wetwell between the intake structure and the existing pump building offers the same technical merit as Alternate No. 2. The primary difference is this alternative will incorporate a new structure which will require additional maintenance.

Alternate No. 4 - Issues for consideration with the construction of an earth holding pond are numerous and will require careful consideration. An earth holding pond does much to make the quality of the water entering the plant much more consistent by allowing the removal of larger matter and grit. Screening also accomplishes this, but screens require frequent cleaning. Ponds require considerable area, which the City currently does not have on the plant site. With a refinery directly to the north and a slough to the west, the possibility of outside contamination to the water sitting in the holding pond also exists. Depending upon what additional contaminants might enter the water as it sits in the holding pond, the conditions of treatment required by the plant could change.

Alternate No. 5 - The City has indicated that if a new intake structure was to be constructed, the structure should be located upstream of the storm and area drainage ditch which enters the Yellowstone River in the 8th Ave. area. This will require approximately 6,500 feet of line to be run from the new intake to the plant. Easements, distance, and maintenance considerations make this alternative somewhat questionable.

Alternate No. 6 - The primary justification for doing nothing to the current raw water intake would be that a new water treatment plant at a new location was to be built. With the City investing $2.5 million directly into the existing treatment plant for modifications, a new plant is not in the immediate future.

2.3 RECOMMENDED ALTERNATIVE AND IMPROVEMENTS

Of the six alternatives, alternatives 1 and 2 have the most merit. As it is not the intention of this report to establish the preliminary design criteria for each of these alternatives, these two will be treated equally and it is recommended that the City carefully consider both alternatives in the future.

A summary of the major issues which are believed that will be required for each of the two alternatives include:

Alternate No.1

- install (1) 2,000 gpm submersible pump in the existing intake structure.
- install (3) 3,000 gpm submersible pumps in the existing intake structure.
- install 120 lf of 30" yard piping with necessary valves and fittings. Abandon existing yard piping.
- install stationary bar screens over the two 36" square openings to the pump suction chambers.
- modify the 4 ft wide gate on the upstream side of the intake structure.

Alternate No. 2

- modify the suction and discharge piping to the existing 2,000 gpm raw water pump.
- add three new 3,000 gpm raw water pumps.
- install 24 lineal feet (lf) of 24" diameter circular intake screen, inside the existing intake structure, to the pump suction lines.
- install 100 lf of 30" yard piping with the necessary valves and fittings. Abandon existing yard piping.
- install stationary bar screens over the two 36" square openings to the pump suction chambers.
- modify the 4 ft wide gate on the upstream side of the intake structure.

PAGES 21-42 EXCLUDED

NOT APPLICABLE TO THIS STUDY

6 DEVELOPMENT OF NECESSARY IMPROVEMENTS

6.1 IMPROVEMENTS NECESSARY TO ACCOMMODATE PROJECTED FUTURE WATER DEMANDS

Completion of improvements necessary for each zone will reduce the peak demand felt at the water plant by providing storage exclusively for each zone. The storage reservoirs will supply the fire flow demand and provide flow during peak day events. These reservoirs equalize the impacts of the peak day on the system and allow the system to meet future demands efficiently.

In the year 2015, if the population matches that which was predicted and all three zones are completed, then the City of Laurel should have experienced growth commercially, industrially, and residentially without noticeable adverse effects to the system (low pressure, low fire flow, water use restrictions, etc.).

6.1.1 Water Treatment Plant

Improvements currently proposed to the water treatment plant will provide sufficient capacity (10 mgd) to meet the City's projected 2015 needs (7.0± mgd). The only plant improvements which will be necessary are those to the raw water intake system to expand it to 20 mgd (15 mgd for the City and 5 mgd for the Cenex Refinery's raw water pumps).

In assessing the benefits associated with each of these projects, their distribution was felt best reflected by:

- <u>Existing Water Plant Project</u>: The $4.1 plant, distribution system, and existing water tank rehabilitation project is of general benefit to all users. A proportionate share of the project is to accommodate future growth. Assigning percentages to these benefits is at best, an educated estimation. However, based on knowledge of the project, the proportionate benefits used to establish the spread of the cost is recommended to be:

  75% - General City-wide benefits, revenue through user charges
  25% - Zone 1, 2, and 3 growth related, revenue by impact fees (see Chapter 7).

- <u>Raw Water Intake</u>: The improvements to the water plant's raw water intake is approximately of 50% benefit to the existing system users, and 50% for new added capacity. The proportionate benefit is:

  50% - General City-wide benefit, revenue through user charges
  50% - Zone 1, 2, and 3 growth related, revenue by impact fees.

6.1.2 Water Distribution System

<u>Zone 1</u>
The existing water distribution system is at the point where improvements are needed to handle the increase in growth projected for the next 20 years. Not all of these improvements must take

PAGES 44-56 EXCLUDED

NOT APPLICABLE TO THIS STUDY

LAUREL WATER SYSTEM FUTURE IMPROVEMENTS
OPINION OF PROBABLE COSTS -- RAW WATER INTAKE STRUCTURE
June 1997

Item	Quantity	Unit Price		Total Price
Alternative #1				
Submersible Trash Pumps				
2000 gpm	1	$40,000	each	$40,000
3000 gpm	3	$43,600	each	$130,800
Concrete	125	$550	cu.yd.	$68,750
Earthwork	100	$20	cu.yd.	$2,000
Screens	1	$25,000	l.s.	$25,000
Model	1	$20,000	l.s.	$20,000
30" Piping	120	$150	l.f.	$18,000
20% Contractor Misc. Costs				$61,725
20% Project Contingency				$61,725
Estimated Construction Cost				$428,000
Engineering Fees				$72,000
Total Project Cost				$500,000
Alternative #2				
3000 gpm Vertical Turbine Pumps	3	$43,600	each	$130,800
30" Piping	100	$150	l.f.	$15,000
Concrete	125	$550	cu.yd.	$68,750
Concrete Removal	35	$75	l.f.	$2,625
Excavation	100	$20	cu.yd.	$2,000
Model	1	$20,000	l.s.	$20,000
Vortex Breakers	1	$10,000	l.s.	$10,000
Screens	1	$25,000	l.s.	$25,000
20% Contractor Misc. Costs				$57,925
20% Project Contingency				$57,900
Estimated Construction Cost				$390,000
Engineering Fees				$60,000
Total Project Cost				$450,000

Alternative #3

3000 gpm Vertical Turbine Pumps	3	$43,600	each	$130,800
30" Piping	200	$150	l.f.	$30,000
Earthwork	100	$8	cu.yd.	$800
Concrete	30	$550	cu.yd.	$16,500
Screens	1	$25,000	l.s.	$25,000
Model	1	$20,000	l.s.	$20,000
20% Contractor Misc. Costs				$36,400
20% Project Contingency				$36,500
Estimated Construction Cost				$296,000
Engineering Fees				$44,000
Total Project Cost				$340,000

Alternative #4

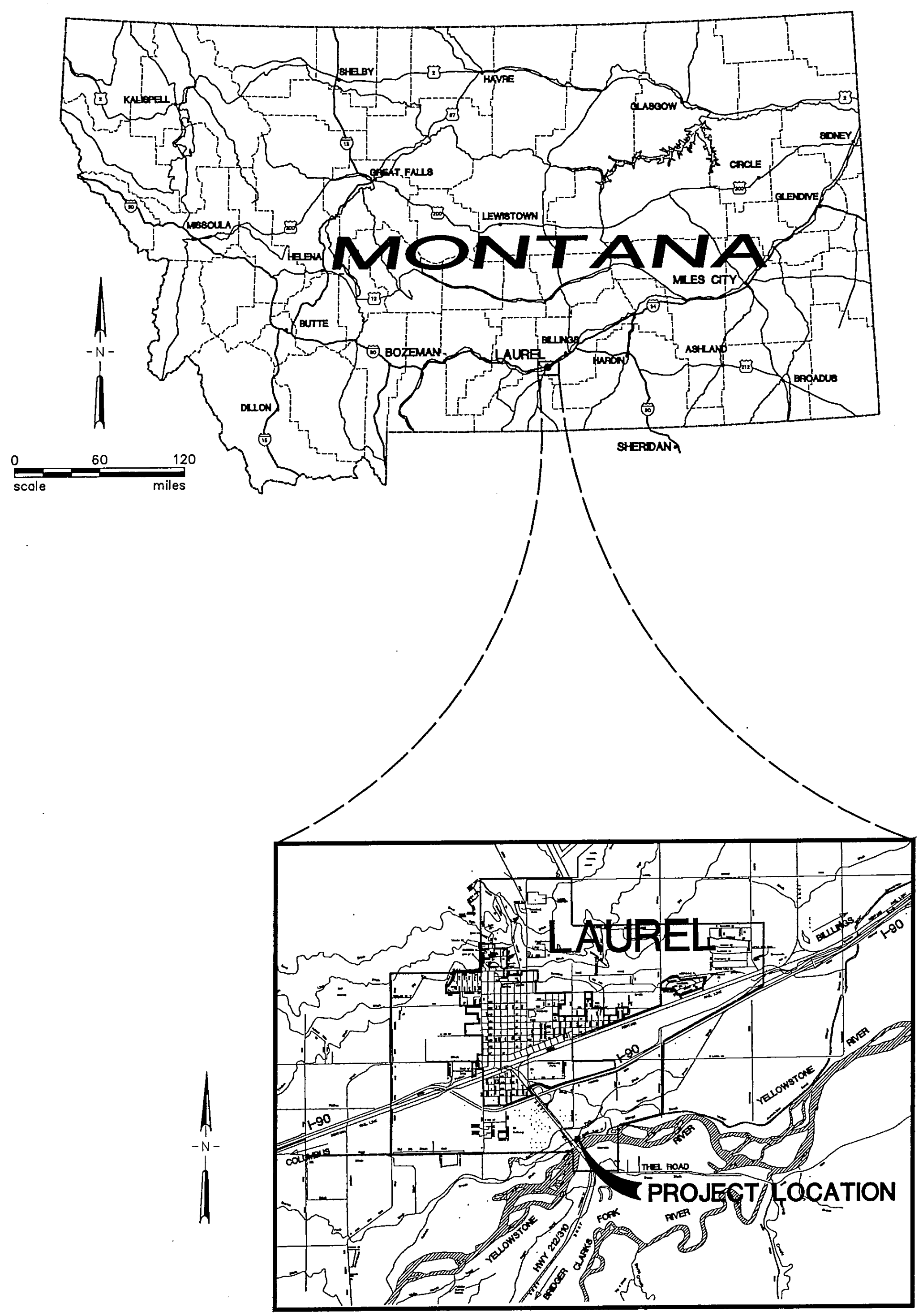
Earthwork	30000	$8	cu.yd.	$240,000
Screens	1	$25,000	l.s.	$25,000
3000 gpm Vertical Turbine Pumps	3	$43,600	each	$130,800
Model	1	$20,000	l.s.	$20,000
30" Piping	6500	$150	l.f.	$975,000
20% Contractor Misc. Costs				$295,000
20% Project Contingency				$294,200
Estimated Construction Cost				$1,980,000
Engineering Fees				$320,000
Total Project Cost				$2,300,000

Alternative #5

Concrete	425	$550	cu.yd.	$233,750
3000 gpm Vertical Turbine Pumps	5	$43,600	each	$218,000
Screens	1	$50,000	l.s.	$50,000
Model	1	$20,000	l.s.	$20,000
30" Piping	6500	$150	l.f	$975,000
20% Contractor Misc. Costs				$328,250
20% Project Contingency				$330,000
Estimated Construction Cost				$2,155,000
Engineering Fees				$325,000
Total Project Cost				$2,480,000

APPENDIX K – CURRENT INTAKE CONSTRUCTION PLANS

Construction Plans for the LAUREL INTAKE AND PUMP STATION for LAUREL, MONTANA



VICINITY MAP

Prepared for :

LAUREL, MONTANA

HKM ENGINEERING

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

PROJ. NO. 6M069.145

SEPTEMBER 2002

MONTANA
CARL J. ANDERSON
7611 PE
LICENSED
PROFESSIONAL ENGINEER

Carl J. Anderson, P.E.7611
Project Manager
HKM Engineering Inc.

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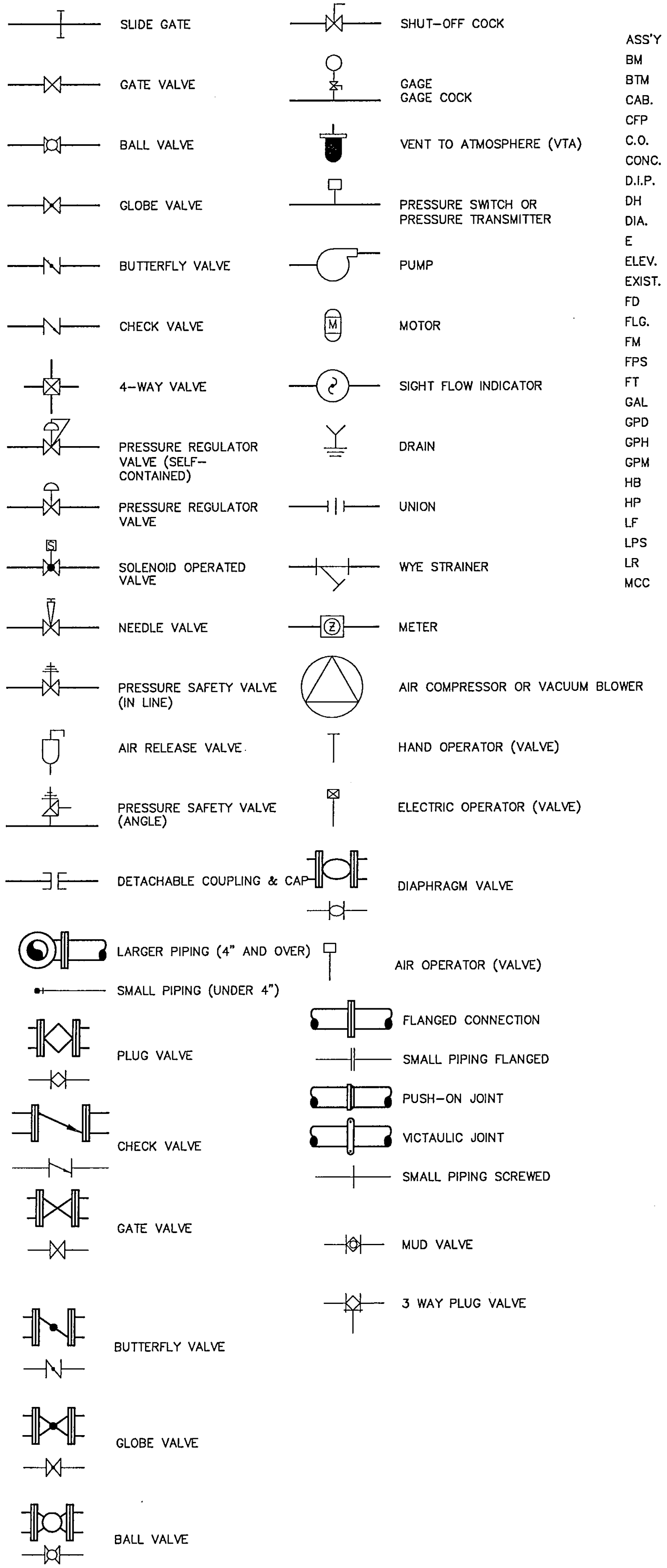
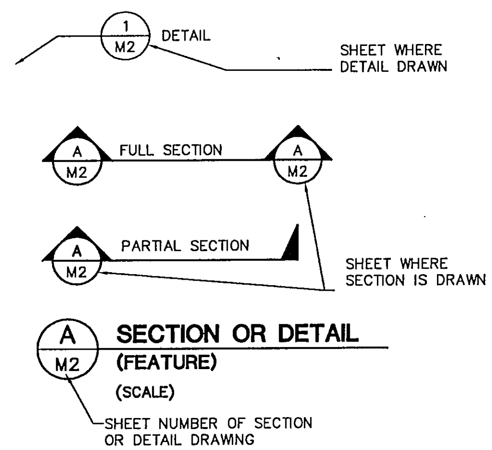
LEGEND



ABBREVIATIONS

ASS'Y	ASSEMBLY	N	NORTHING
BM	BENCH MARK	NPT	NATIONAL PIPE THREAD
BTM	BOTTOM	N.T.S.	NOT TO SCALE
CAB.	CABINET	O.C.	ON CENTER
CFP	CHEMICAL FEED PUMP	PCP	PLANT CONTROL PANEL
C.O.	CLEANOUT	PE	PLAIN END
CONC.	CONCRETE	PSI	POUNDS PER SQUARE INCH
D.I.P.	DUCTILE IRON PIPE	PVC	POLYVINYL CHLORIDE PIPE
DH	DRILL HOLE	PW	POTABLE WATER
DIA.	DIAMETER	PWR	UNDER GROUND POWER
E	EASTING	RED'R	REDUCER
ELEV.	ELEVATION	R/W	RIGHT OF WAY
EXIST.	EXISTING	RW	RAW WATER
FD	FLOOR DRAIN	REST.	RESTORATION
FLG.	FLANGE	RT	RIGHT
FM	FORCE MAIN	SAN	SANITARY SEWER
FPS	FEET PER SECOND	SCH	SCHEDULE
FT	FEET	SP	SLUDGE PUMP
GAL	GALLON	SR	SHORT RADIUS
GPD	GALLONS PER DAY	SURF.	SURFACE
GPH	GALLONS PER HOUR	TEL	UNDER GROUND TELEPHONE
GPM	GALLONS PER MINUTE	TYP.	TYPICAL
HB	HOSE BIBB	UPC	UNIT PROCESS CONTROL
HP	HORSEPOWER	V	VOLT
LF	LINEAL FEET	W	WATER
LPS	LIQUID POLYMER SYSTEM	W/	WITH
LR	LONG RADIUS	W.S.	WELDED STEEL
MCC	MOTOR CONTROL CENTER	WTP	WATER TREATMENT PLANT
		X-ING	CROSSING



SHEET INDEX

DESIGN CRITERIA

INTAKE

EXISTING PEAK DEMAND	6.9 MGD (4,800 GPM)
ESTIMATED FUTURE PEAK DEMAND	20 MGD (13,900 GPM)
NUMBER OF SCREENS	4
SCREEN CAPACITY (EACH)	3,500 GPM
TOTAL SCREEN CAPACITY	14,000 GPM
SOURCE	YELLOWSTONE RIVER
DESIGN LOW WATER STAGE	ELEV.=3260.7
DESIGN HIGH WATER (100-YR FLOOD) STAGE	ELEV.=3272.3

TREATMENT PLANT RAW WATER PUMPS

EXISTING PEAK DEMAND	5.0 MGD (3,500 GPM)
ESTIMATED FUTURE PEAK DEMAND	15 MGD (10,400 GPM)
NUMBER OF PROJECT PUMPS	4 (EXPLANDABLE TO 6)
PROJECT PUMPS (EACH)	
FLOW RATE	2 @ 2,000 GPM, 2 @ 1,000 GPM
TOTAL DYNAMIC HEAD	27 FT
HORSE POWER	2 @ 20 HP (C/S); 2 @ 10 HP (V/S)
TOTAL PROJECT CAPACITY	6,000 GPM (8.6 MGD)
FIRM PROJECT CAPACITY	4,000 GPM (5.8 MGD)

REFINERY RAW WATER PUMPS

EXISTING PEAK DEMAND	1.9 MGD (1,300 GPM)
ESTIMATED FUTURE PEAK DEMAND	5 MGD (3,500 GPM)
NUMBER OF PROJECT PUMPS	3 (EXPLANDABLE TO 4)
PROJECT PUMPS (EACH)	
FLOW RATE	750 GPM
TOTAL DYNAMIC HEAD	107 FT
HORSE POWER	30 HP (V/S)
TOTAL PROJECT CAPACITY	2,250 GPM (3.2 MGD)
FIRM PROJECT CAPACITY	1,500 GPM (2.2 MGD)

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

LEGEND, ABBREVIATIONS, SHEET INDEX AND DESIGN CRITERIA

MONTANA PAUL A. SWENSON 14591 PE LICENSED PROFESSIONAL ENGINEER

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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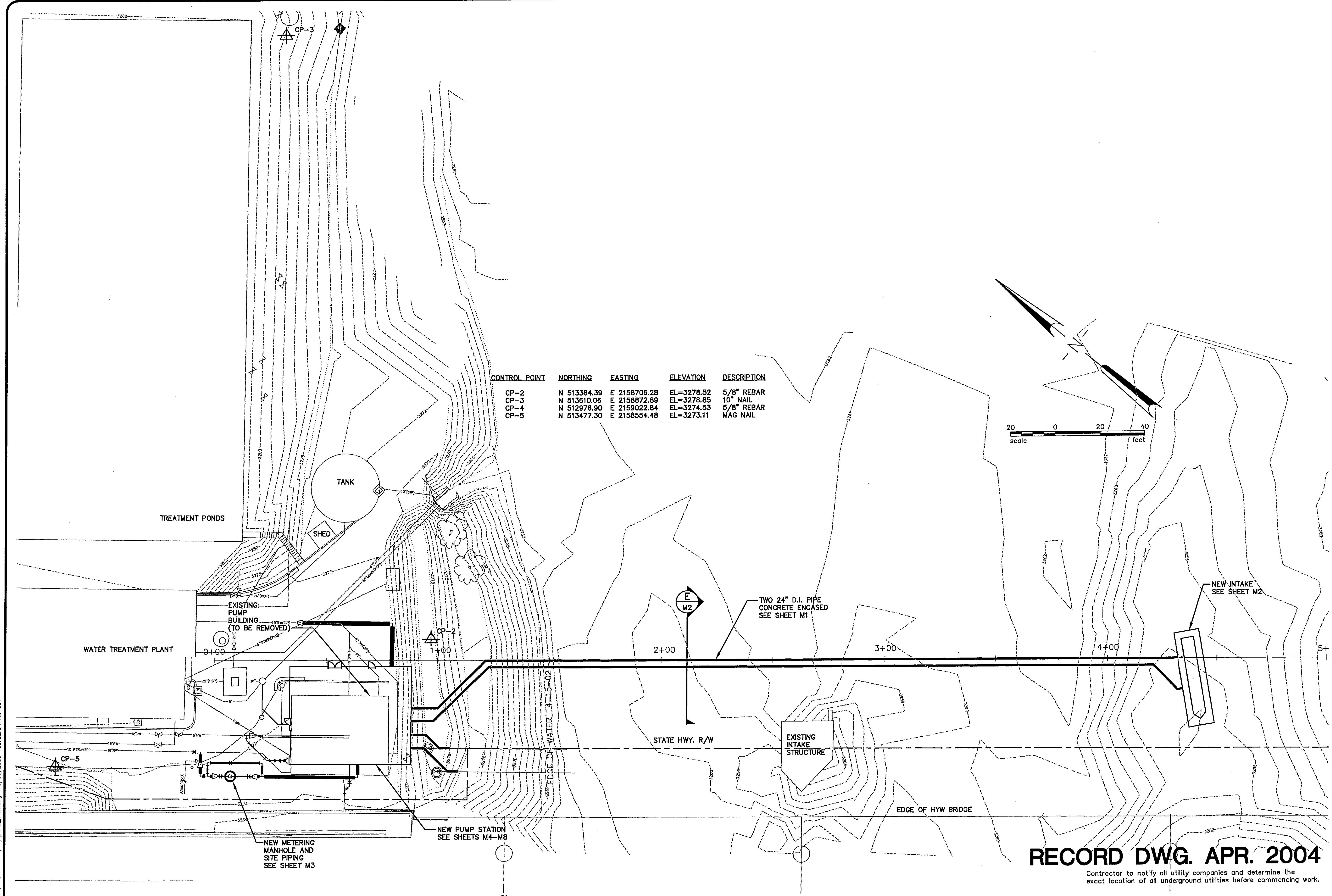

CONTROL POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
CP-2	N 513384.39	E 2158706.28	EL=3278.52	5/8" REBAR
CP-3	N 513610.06	E 2158872.89	EL=3278.85	10" NAIL
CP-4	N 512976.90	E 2159022.84	EL=3274.53	5/8" REBAR
CP-5	N 513477.30	E 2158554.48	EL=3273.11	MAG NAIL

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Contractor to notify all utility companies and determine the exact location of all underground utilities before commencing work.

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

SITE LAYOUT

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HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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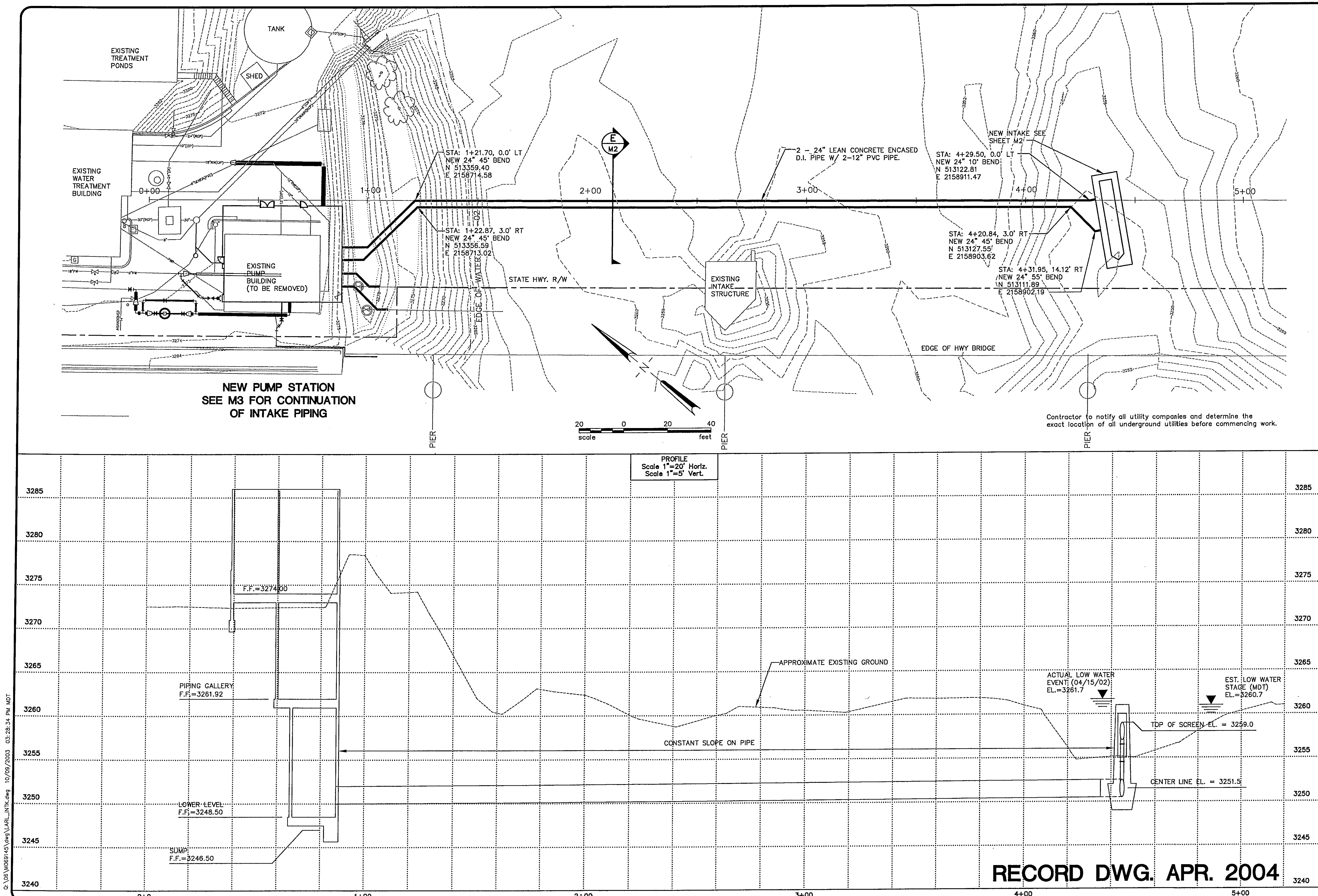

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

INTAKE PLAN AND PROFILE

MONTANA PAUL A. SWENSON 14591 PE LICENSED PROFESSIONAL ENGINEER

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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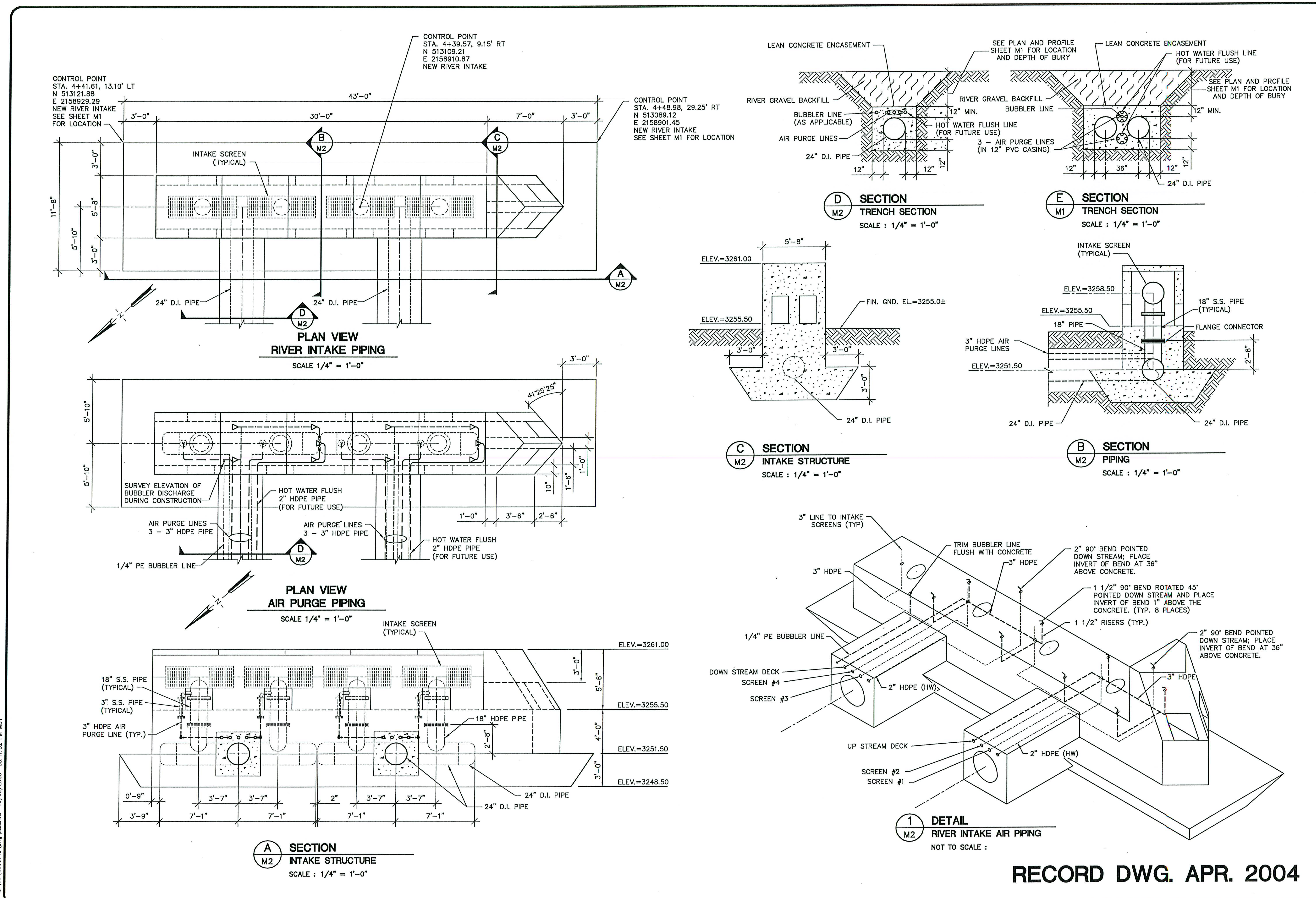

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

INTAKE
DETAILS AND SECTIONS

PAUL A. SWENSON 14591 PE — MONTANA LICENSED PROFESSIONAL ENGINEER

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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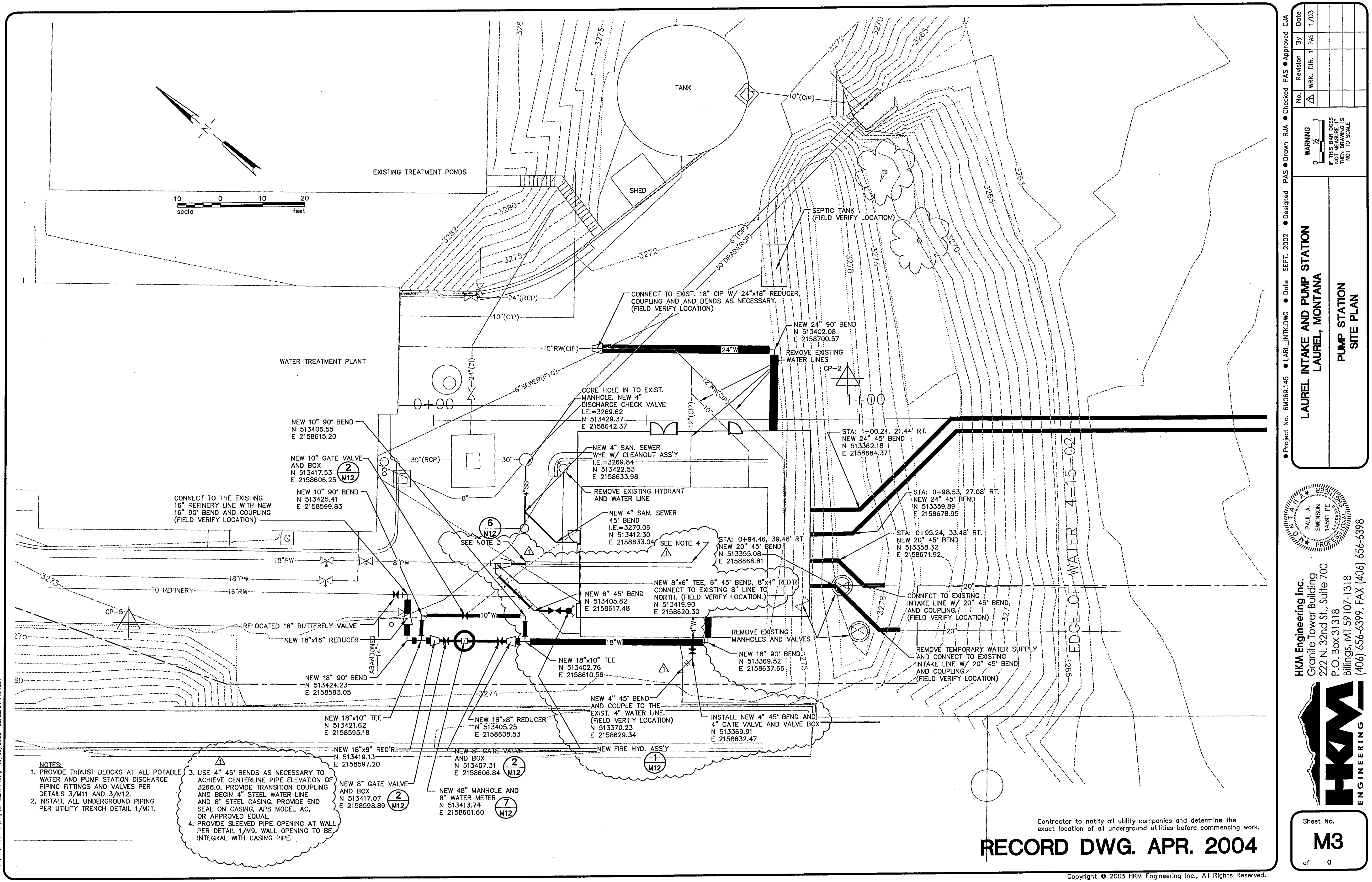
EXISTING TREATMENT PONDS
TANK
SHED
WATER TREATMENT PLANT
SEPTIC TANK (FIELD VERIFY LOCATION)
10 0 10 20
scale feet
CONNECT TO EXIST. 18" CIP W/ 24"x18" REDUCER, COUPLING AND AND BENDS AS NECESSARY. (FIELD VERIFY LOCATION)
NEW 24" 90° BEND N 513402.08 E 2158700.57
REMOVE EXISTING WATER LINES
CP-2
1+00
0+00
CORE HOLE IN TO EXIST. MANHOLE. NEW 4" DISCHARGE CHECK VALVE I.E.=3269.62 N 513429.37 E 2158642.37
NEW 10" 90° BEND N 513406.55 E 2158615.20
NEW 10" GATE VALVE AND BOX N 513417.53 E 2158606.25
NEW 10" 90° BEND N 513425.41 E 2158599.83
CONNECT TO THE EXISTING 16" REFINERY LINE WITH NEW 16" 90° BEND AND COUPLING (FIELD VERIFY LOCATION)
NEW 4" SAN. SEWER WYE W/ CLEANOUT ASS'Y I.E.=3269.84 N 513422.53 E 2158633.98
REMOVE EXISTING HYDRANT AND WATER LINE
NEW 4" SAN. SEWER 45° BEND I.E.=3270.06 N 513412.30 E 2158633.04
SEE NOTE 3
SEE NOTE 4
STA: 1+00.24, 21.44' RT. NEW 24" 45° BEND N 513362.18 E 2158684.37
STA: 0+98.53, 27.08' RT. NEW 24" 45° BEND N 513359.89 E 2158678.95
STA: 0+95.24, 33.48' RT. NEW 20" 45° BEND N 513358.32 E 2158671.92
STA: 0+94.46, 39.48' RT NEW 20" 45° BEND N 513355.08 E 2158666.81
NEW 8"x6" TEE, 6" 45° BEND, 8"x4" RED'R CONNECT TO EXISTING 8" LINE TO NORTH. (FIELD VERIFY LOCATION.) N 513419.90 E 2158620.30
NEW 6" 45° BEND N 513405.82 E 2158617.48
CONNECT TO EXISTING INTAKE LINE W/ 20" 45° BEND AND COUPLING. (FIELD VERIFY LOCATION)
REMOVE EXISTING MANHOLES AND VALVES
REMOVE TEMPORARY WATER SUPPLY AND CONNECT TO EXISTING INTAKE LINE W/ 20" 45° BEND AND COUPLING. (FIELD VERIFY LOCATION)
EDGE OF WATER 4-15-02
TO REFINERY
CP-5
RELOCATED 16" BUTTERFLY VALVE
NEW 18"x16" REDUCER
ABANDONED 14"
NEW 18" 90° BEND N 513424.23 E 2158593.05
NEW 18"x10" TEE N 513402.76 E 2158610.56
NEW 18" 90° BEND N 513369.52 E 2158637.66
NEW 4" 45° BEND AND COUPLE TO THE EXIST. 4" WATER LINE. (FIELD VERIFY LOCATION) N 513370.23 E 2158629.34
INSTALL NEW 4" 45° BEND AND 4" GATE VALVE AND VALVE BOX N 513369.91 E 2158632.47
NEW 18"x10" TEE N 513421.62 E 2158595.18
NEW 18"x8" REDUCER N 513405.25 E 2158608.53
NEW FIRE HYD. ASS'Y
NEW 18"x8" RED'R N 513419.13 E 2158597.20
NEW 8" GATE VALVE AND BOX N 513407.31 E 2158606.84
NEW 8" GATE VALVE AND BOX N 513417.07 E 2158598.89
NEW 48" MANHOLE AND 8" WATER METER N 513413.74 E 2158601.60
NOTES:
1. PROVIDE THRUST BLOCKS AT ALL POTABLE WATER AND PUMP STATION DISCHARGE PIPING FITTINGS AND VALVES PER DETAILS 3/M11 AND 3/M12.
2. INSTALL ALL UNDERGROUND PIPING PER UTILITY TRENCH DETAIL 1/M11.
3. USE 4" 45° BENDS AS NECESSARY TO ACHIEVE CENTERLINE PIPE ELEVATION OF 3266.0. PROVIDE TRANSITION COUPLING AND BEGIN 4" STEEL WATER LINE AND 8" STEEL CASING. PROVIDE END SEAL ON CASING, APS MODEL AC, OR APPROVED EQUAL.
4. PROVIDE SLEEVED PIPE OPENING AT WALL PER DETAIL 1/M9. WALL OPENING TO BE INTEGRAL WITH CASING PIPE.
Contractor to notify all utility companies and determine the exact location of all underground utilities before commencing work.
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LAUREL INTAKE AND PUMP STATION LAUREL, MONTANA
PUMP STATION SITE PLAN
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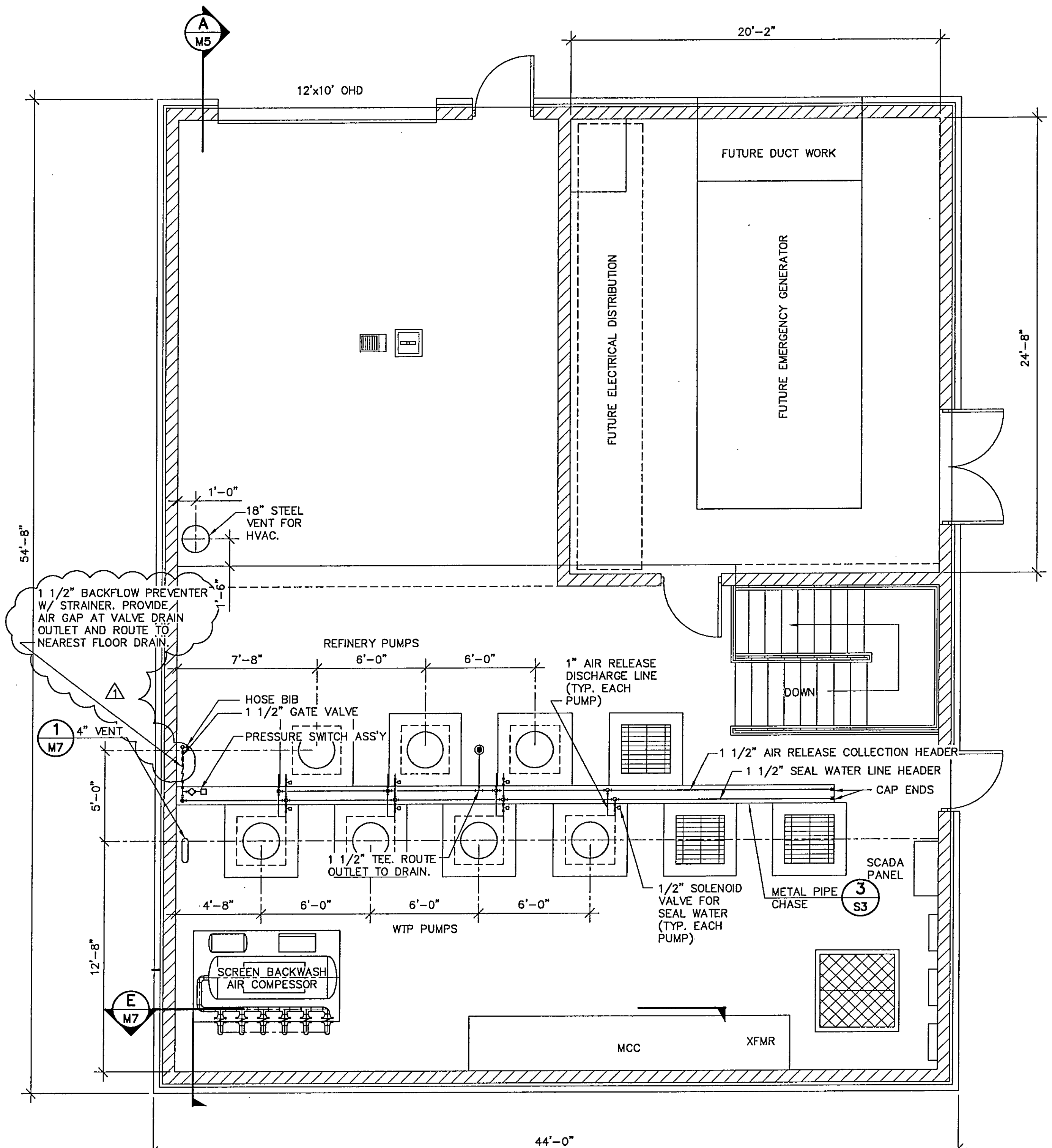
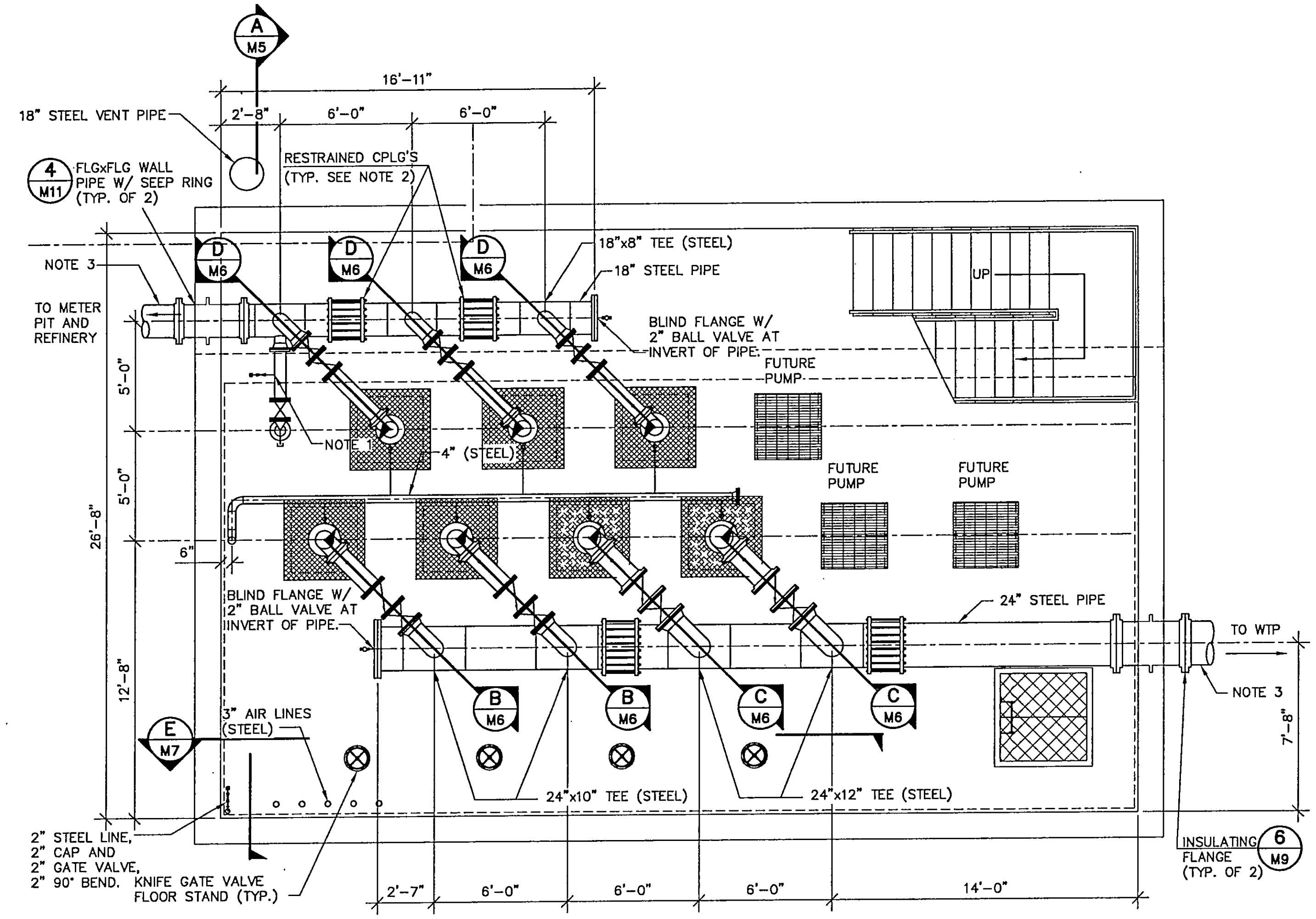


MAIN FLOOR
PLAN VIEW

SCALE: 1/4"=1'-0"



NOTES:
1. 2" SERVICE SADDLE WITH 2" GATE VALVE, 2" STEEL STUB AND 2" CAP.
2. SEE SPECIFICATION SECTION 15060-2.01.C.4 AND DETAIL 5/M10.
3. BEGIN D.I. PIPE; PLACE COUPLING WITHIN 5 FEET OF BUILDING WALL.

PIPE GALLERY
PLAN VIEW

SCALE: 1/4"=1'-0"

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

PUMP STATION
MAIN FLOOR AND PIPING GALLERY PLAN VIEWS

PAUL A. SWENSON 14591 PE MONTANA LICENSED PROFESSIONAL ENGINEER

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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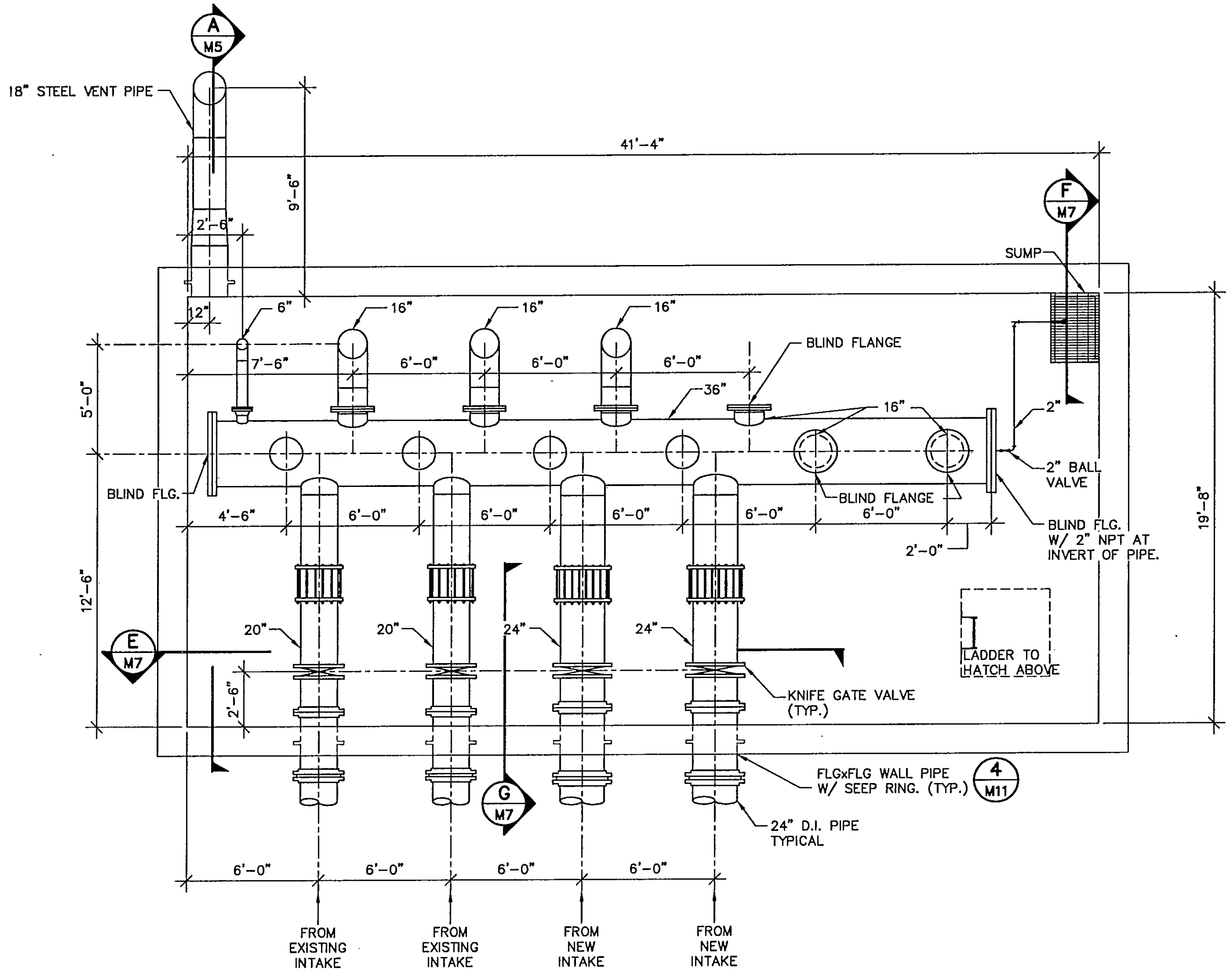
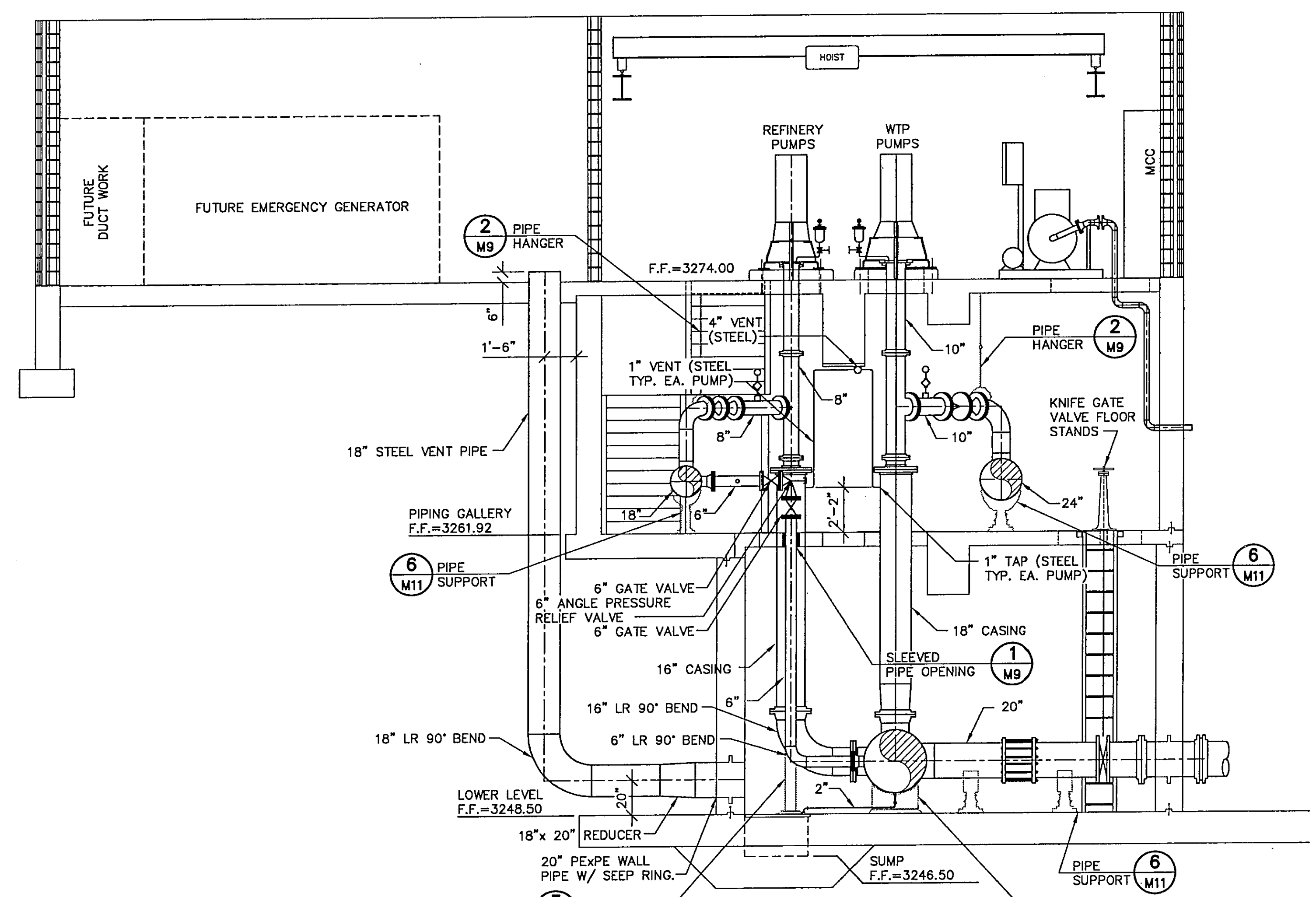


LOWER LEVEL PLAN VIEW

SCALE: 1/4"=1'-0"



A
M4
A
M5

SECTION PUMP STATION

SCALE : 1/4"=1'-0"

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

PUMP STATION
LOWER LEVEL PLAN VIEW AND SECTION

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HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

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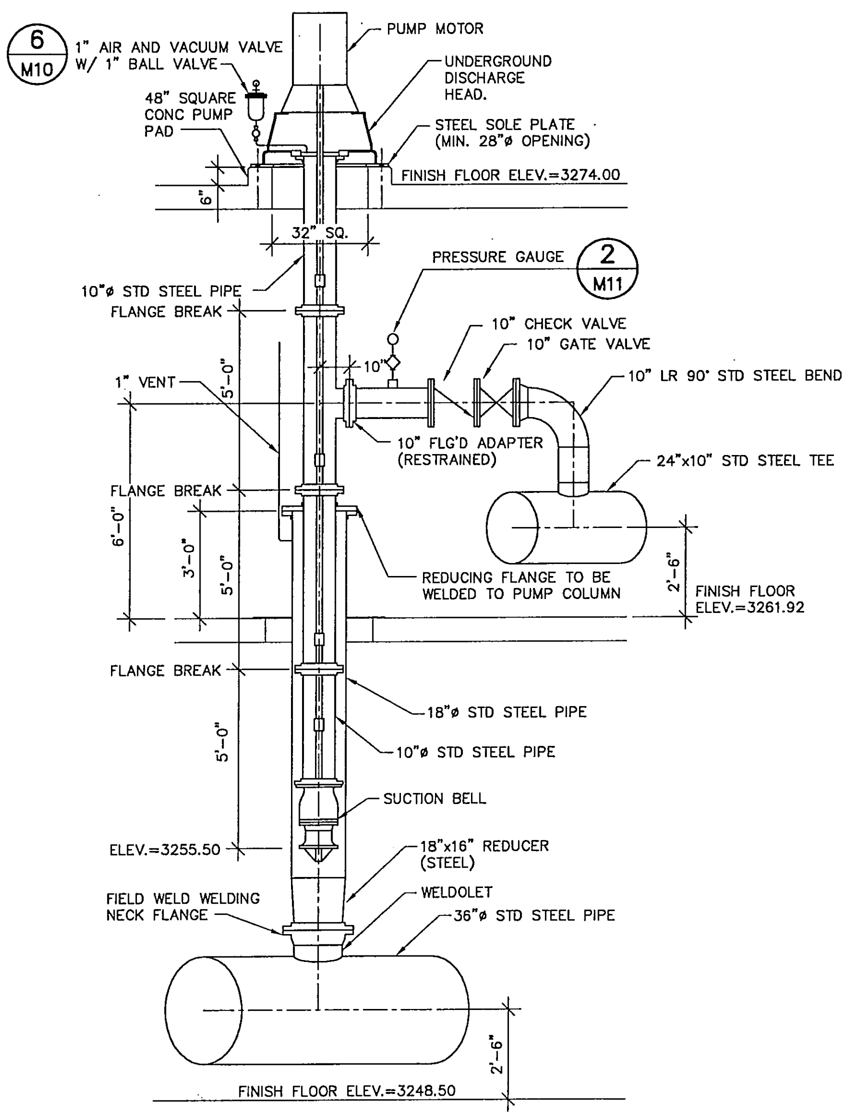
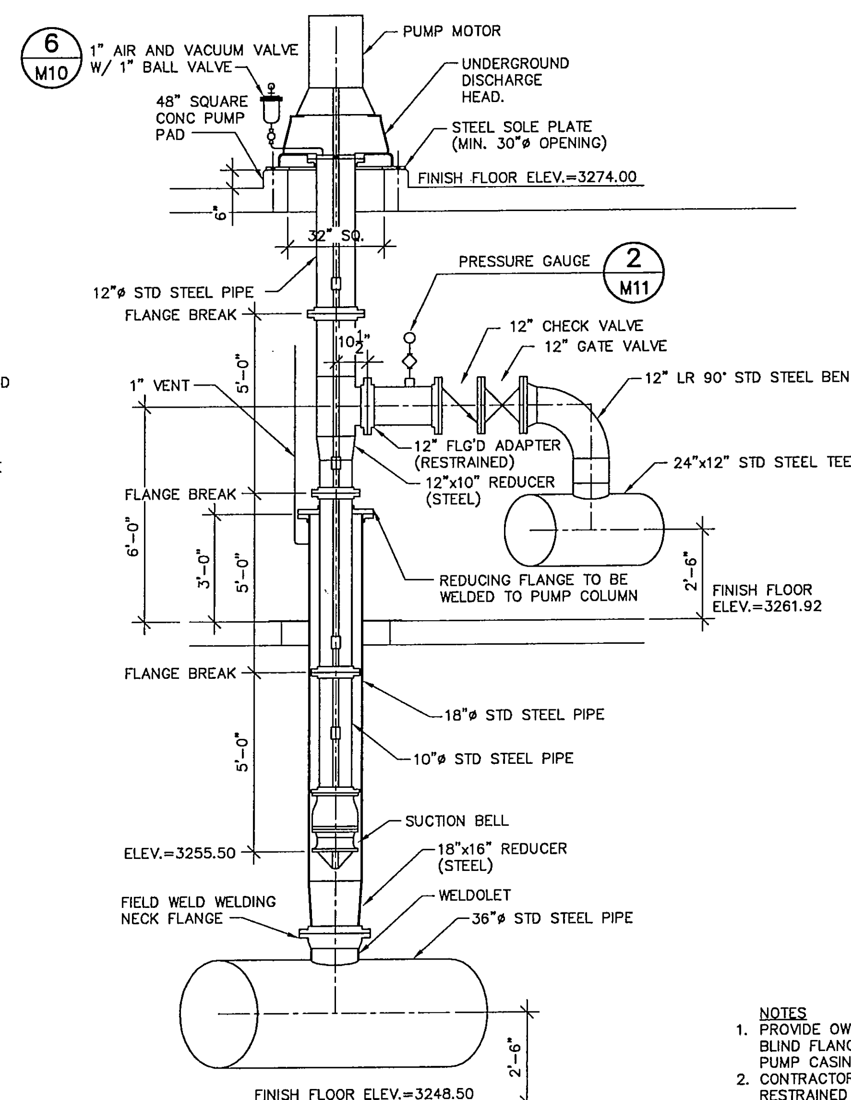


B
M4
SECTION
PUMP A PIPING

1 0 1 2 3 4 5 6 7
scale feet

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

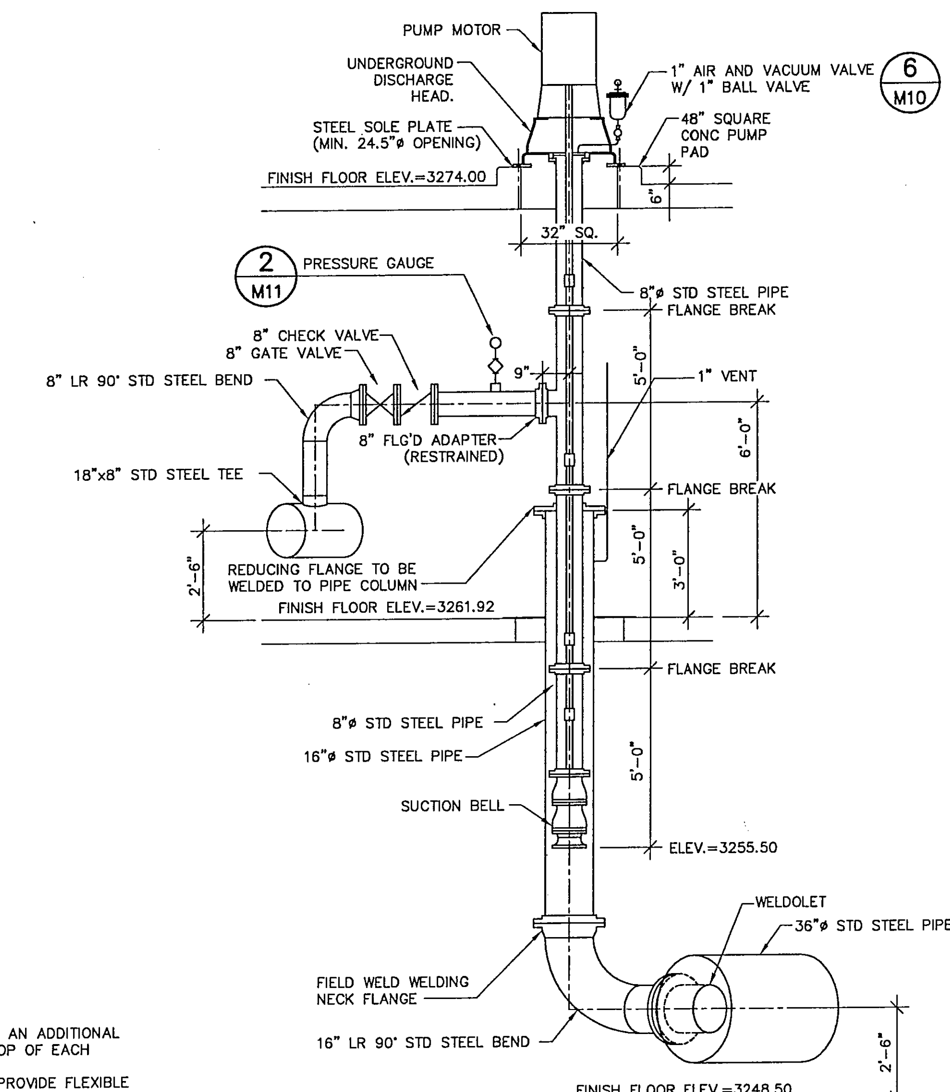


C
M4
SECTION
PUMP B PIPING

1 0 1 2 3 4 5 6 7
scale feet

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

NOTES
1. PROVIDE OWNER WITH AN ADDITIONAL BLIND FLANGE FOR TOP OF EACH PUMP CASING.
2. CONTRACTOR SHALL PROVIDE FLEXIBLE RESTRAINED COUPLINGS ON EACH PUMP CASING AND DISCHARGE LINE TO MATCH INSTALLED PIPING WITH FLANGES SUPPLIED ON PUMPS.



D
M4
SECTION
PUMP C PIPING

1 0 1 2 3 4 5 6 7
scale feet

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

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LAUREL INTAKE AND PUMP STATION
LAUREL, MONTANA

PUMP STATION SECTIONS

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HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
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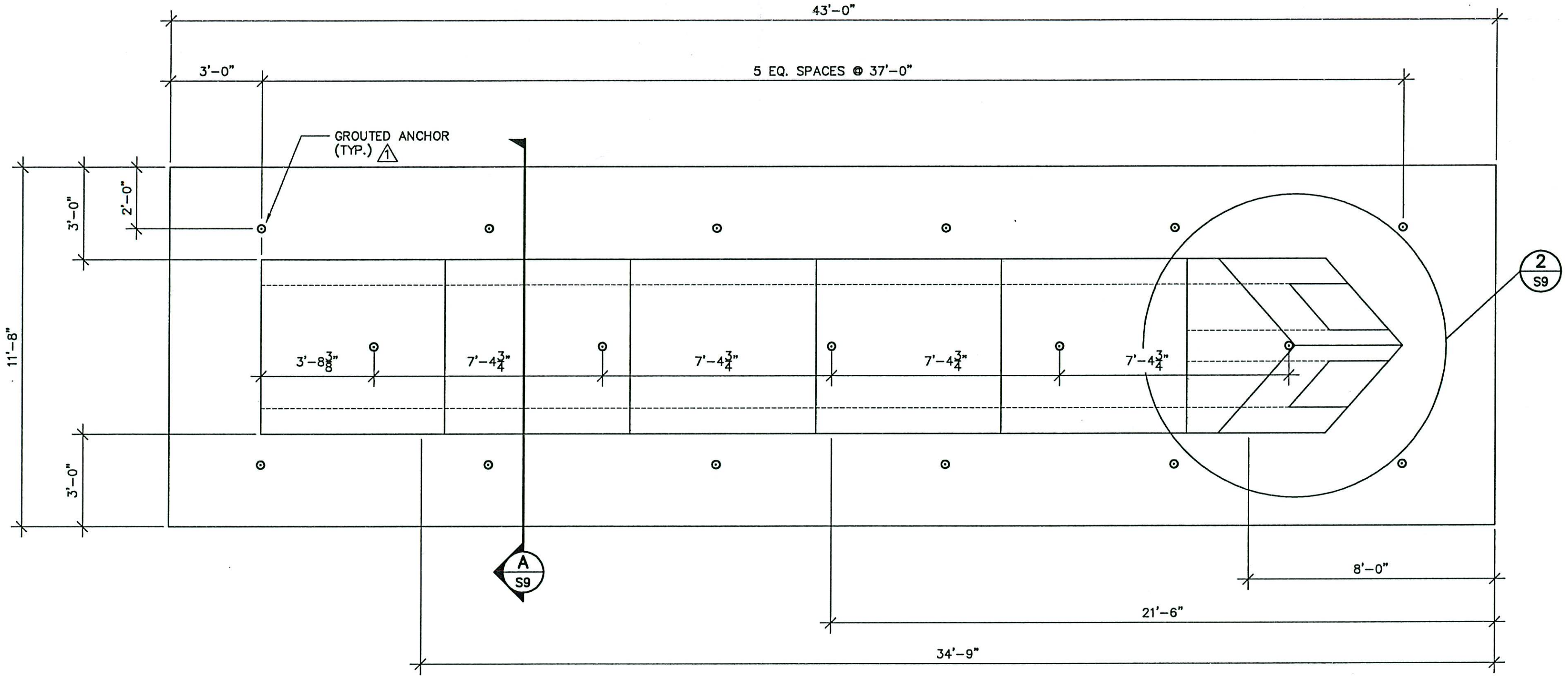
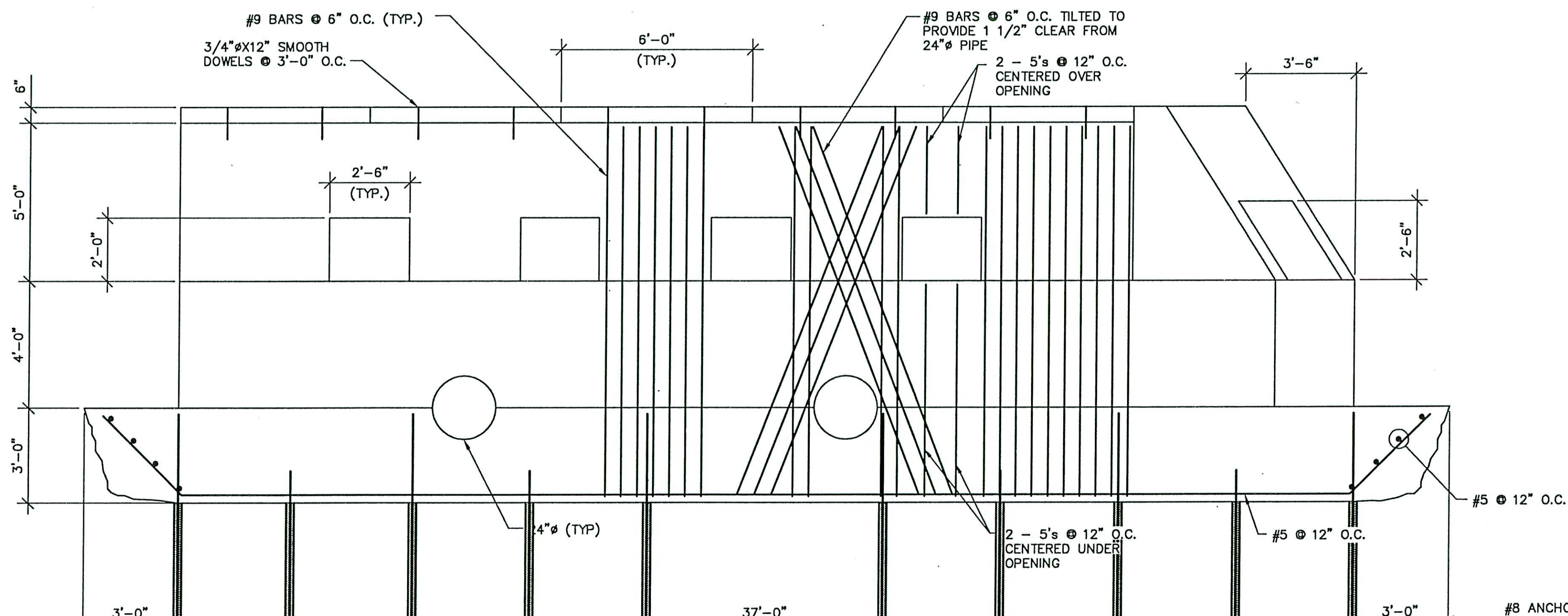


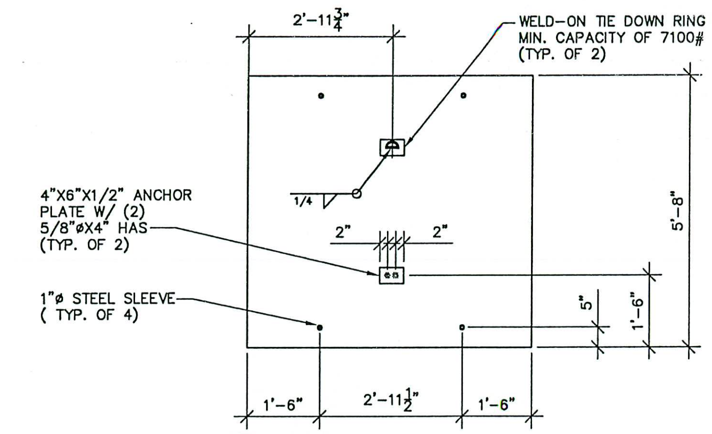
INTAKE STRUCTURE PLAN VIEW

1 0 1 2 3 4 5 6 7
scale feet
SCALE : 3/8"=1'-0"



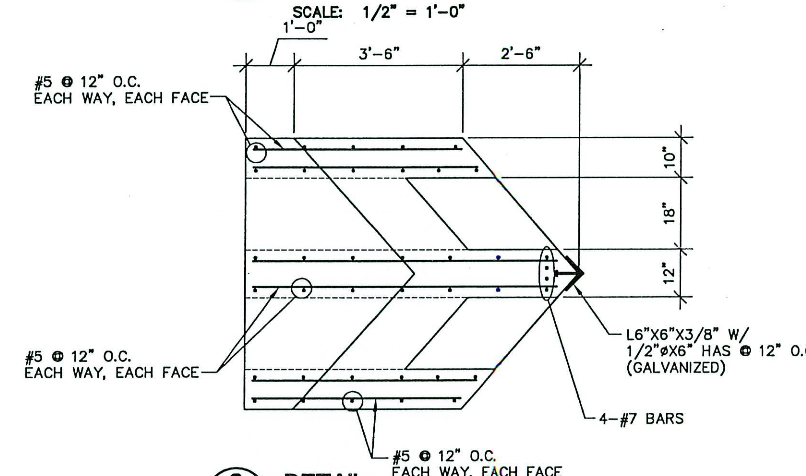
INTAKE STRUCTURE ELEVATION VIEW

1 0 1 2 3 4 5 6 7
scale feet
SCALE : 3/8"=1'-0"



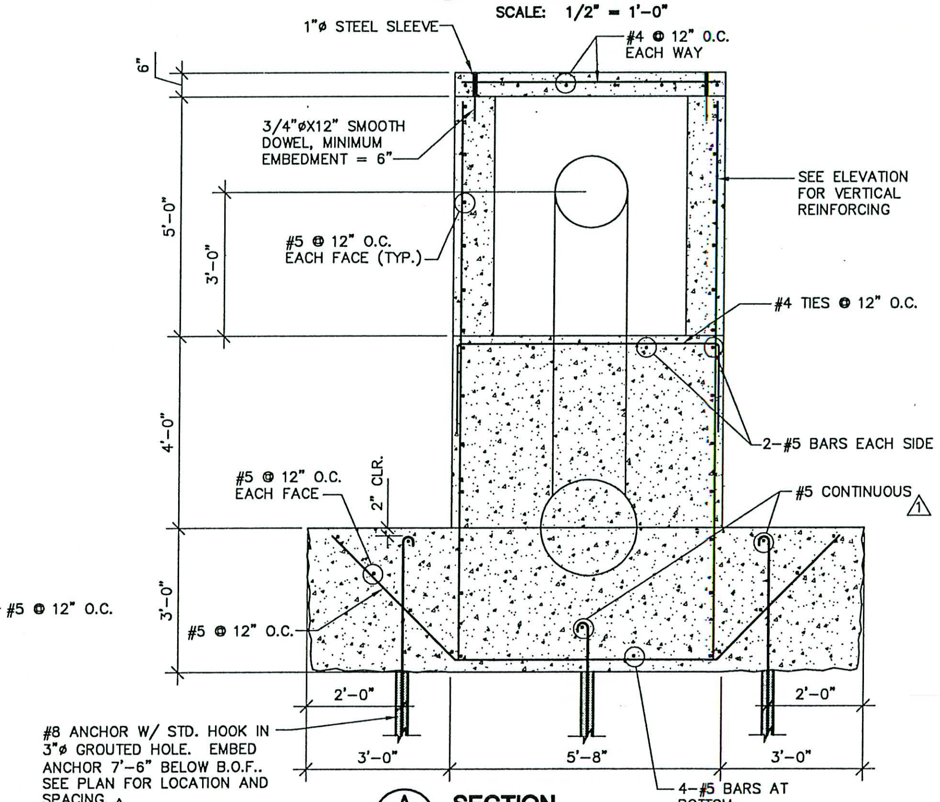
1 DETAIL S9 ROOF PANEL

SCALE: 1/2" = 1'-0"



2 DETAIL S9 ENLARGED PARTIAL PLAN

SCALE: 1/2" = 1'-0"



A SECTION S9 INTAKE STRUCTURE

SCALE: 1/2" = 1'-0"

RECORD DWG. APR. 2004

Q:\06\M069145\Archived\M069145\STRUCT\LRL_REV.dwg 4/6/2004 11:34:28 AM MDT

No.	Revision	By	Date
1	GROUTED ANCHORS	KF	2/11/03

● Approved CRS ● Checked KF ● Drawn RJA ● Designed KF ● Date SEPT. 2002 ● LAUREL.DWG ● Project No. 6M069.145

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

LAUREL INTAKE AND PUMP STATION LAUREL, MONTANA

INTAKE PLAN VIEW, ELEVATION SECTION AND DETAILS

MONTANA CLYDE R. SMITH 10622 PE LICENSED PROFESSIONAL ENGINEER

HKM Engineering Inc.
Granite Tower Building
222 N. 32nd St., Suite 700
P.O. Box 31318
Billings, MT 59107-1318
(406) 656-6399, FAX (406) 656-6398

HKM ENGINEERING

Sheet No. S9 of 0

APPENDIX L – HYDROLOGY DOCUMENTATION

06214500 YELLOWSTONE RIVER AT BILLINGS, MT

Upper Yellowstone Basin
Upper Yellowstone-Pompeys Pillar Subbasin

LOCATION.--Lat 45°48'00", long 108°28'05" referenced to North American Datum of 1983, in SE ¼ SE ¼ SE ¼ sec.27, T.1 N., R.26 E., Yellowstone County, MT, Hydrologic Unit 10070007, on right bank 0.3 mi downstream from bridge on U.S. Highway 87, 1 mi northeast of Billings, 10 mi upstream from Pryor Creek, and at river mile 360.3.

DRAINAGE AREA.--11,805 mi^2 of which 397 mi^2 probably is noncontributing.

SURFACE-WATER RECORDS

PERIOD OF RECORD.--May 1904 to December 1905 (gage heights only January to March, December 1905), August 1928 to current year. Monthly discharge only for some periods, published in Water Supply Paper (WSP) 1309. Published as "near Billings" 1904-5.

REVISED RECORDS.--Water Data Report (WDR) MT 1968: 1967, maximum discharge. WSP 1729: Drainage area. WDR-MT-2003-2: Drainage area.

GAGE.--Water-stage recorder. Elevation of gage is 3,080 ft, referenced to the National Geodetic Vertical Datum of 1929. May 1904 to December 1905, nonrecording gage at bridge 0.3 ft upstream at different elevation. Aug. 24, 1928, to June 30, 1932, nonrecording gage at bridge 0.3 mi upstream at elevation 2.0 ft higher. July 1, 1932, to Oct. 12, 1937, water-stage recorder at old diversion dam 3.3 mi upstream at different elevation. Oct. 13, 1937, to Jan. 9, 1963 and Dec. 2, 1967 to Sept. 12, 1990, water-stage recorder 0.3 mi upstream at elevation 3,081.36 ft. Jan. 10, 1963 to Dec. 2, 1967, water-stage recorder 2.1 mi upstream at elevation 3,069.9 ft.

REMARKS.--Records are good except estimated daily discharges, which are poor. Diversions for irrigation include about 350,000 acres upstream from station. U.S. Army Corps of Engineers satellite telemeter is located at the station. Several unpublished observations of water temperature and specific conductance were made during the year.

U.S. Department of the Interior
U.S. Geological Survey

Suggested citation: U.S. Geological Survey, 2013, Water-resources data for the United States, Water Year 2012: U.S. Geological Survey Water-Data Report WDR-US-2012, site 06214500, accessed at http://wdr.water.usgs.gov/wy2012/pdfs/06214500.2012.pdf

06214500 YELLOWSTONE RIVER AT BILLINGS, MT—Continued

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2011 TO SEPTEMBER 2012
DAILY MEAN VALUES
[e, estimated]

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3,860	4,380	3,760	3,190	3,200	2,670	3,240	9,530	12,900	15,900	4,830	2,270
2	3,850	4,430	3,600	3,010	3,200	2,700	3,450	9,050	16,400	15,300	4,510	2,280
3	3,830	4,480	3,430	3,190	3,110	2,680	3,880	8,610	22,600	14,700	4,350	2,320
4	3,820	4,270	3,270	3,300	3,010	2,710	3,760	7,700	30,400	14,100	4,240	2,370
5	3,850	4,330	e3,000	3,240	2,910	2,720	3,560	7,120	36,900	13,800	4,100	2,390
6	3,960	4,470	e2,700	3,180	2,770	2,780	3,720	7,090	42,100	12,900	3,870	2,330
7	4,560	4,400	e2,500	3,080	2,790	2,840	4,100	7,110	39,400	11,400	3,660	2,330
8	4,620	4,240	2,380	2,910	2,790	2,790	3,960	6,530	27,700	10,600	3,500	2,320
9	4,610	4,140	3,020	2,910	2,910	2,710	3,770	6,290	25,200	10,200	3,380	2,310
10	4,520	4,180	3,290	3,210	2,940	2,670	3,560	6,900	28,600	9,680	3,300	2,300
11	4,510	4,160	3,160	3,080	2,830	2,750	3,550	9,720	24,200	9,260	3,310	2,250
12	4,470	4,140	3,120	e2,800	2,560	2,770	3,790	9,940	20,000	9,020	3,370	2,230
13	4,520	4,130	2,980	2,720	2,760	2,820	4,460	9,220	18,200	8,660	3,400	2,240
14	4,590	4,170	2,990	2,800	3,170	2,820	5,220	9,520	18,800	8,340	3,240	2,270
15	4,680	4,120	3,080	2,960	2,920	2,820	4,970	11,100	20,300	8,510	3,130	2,250
16	4,660	4,030	3,050	2,670	2,810	2,880	4,660	14,400	20,100	8,750	3,140	2,240
17	4,790	3,920	3,070	1,920	2,810	2,950	4,480	17,900	19,300	8,970	3,070	2,260
18	4,990	3,990	3,160	1,890	2,810	3,080	4,330	20,300	21,300	9,050	2,930	2,260
19	5,030	e4,000	3,240	1,500	2,790	3,430	4,340	21,400	22,900	8,260	2,840	2,270
20	4,890	e3,700	3,110	1,190	2,780	3,560	4,330	18,100	21,800	7,680	2,810	2,260
21	4,770	e3,900	3,170	2,010	2,730	3,280	4,220	15,500	19,000	7,110	2,760	2,260
22	4,700	4,080	3,220	3,180	2,880	3,040	4,100	16,000	17,900	6,830	2,680	2,220
23	4,620	4,430	2,830	3,600	2,910	3,020	4,740	22,000	18,900	6,500	2,620	2,170
24	4,600	4,300	2,680	3,400	2,890	3,040	6,390	23,300	20,900	6,280	2,570	2,170
25	4,660	4,090	2,860	3,360	2,800	3,130	8,870	18,600	22,700	6,090	2,500	2,160
26	4,660	3,920	3,130	3,470	2,710	3,260	13,000	16,500	22,900	5,800	2,460	2,170
27	4,640	3,760	3,100	3,410	2,680	3,410	14,900	15,300	22,800	5,500	2,470	2,190
28	4,480	3,730	3,210	3,060	2,680	3,610	16,000	14,700	20,800	5,460	2,430	2,200
29	4,450	3,790	3,290	3,010	2,610	3,570	13,800	13,700	17,600	5,770	2,330	2,230
30	4,400	3,800	3,320	3,370	---	3,430	11,100	13,000	16,400	5,660	2,250	2,220
31	4,410	---	3,350	3,390	---	3,320	---	13,100	---	5,280	2,240	---
Total	139,000	123,480	96,070	90,010	82,760	93,260	178,250	399,230	689,000	281,360	98,290	67,740
Mean	4,484	4,116	3,099	2,904	2,854	3,008	5,942	12,880	22,970	9,076	3,171	2,258
Max	5,030	4,480	3,760	3,600	3,200	3,610	16,000	23,300	42,100	15,900	4,830	2,390
Min	3,820	3,700	2,380	1,190	2,560	2,670	3,240	6,290	12,900	5,280	2,240	2,160
Ac-ft	275,700	244,900	190,600	178,500	164,200	185,000	353,600	791,900	1,367,000	558,100	195,000	134,400

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1929 - 2012, BY WATER YEAR (WY)

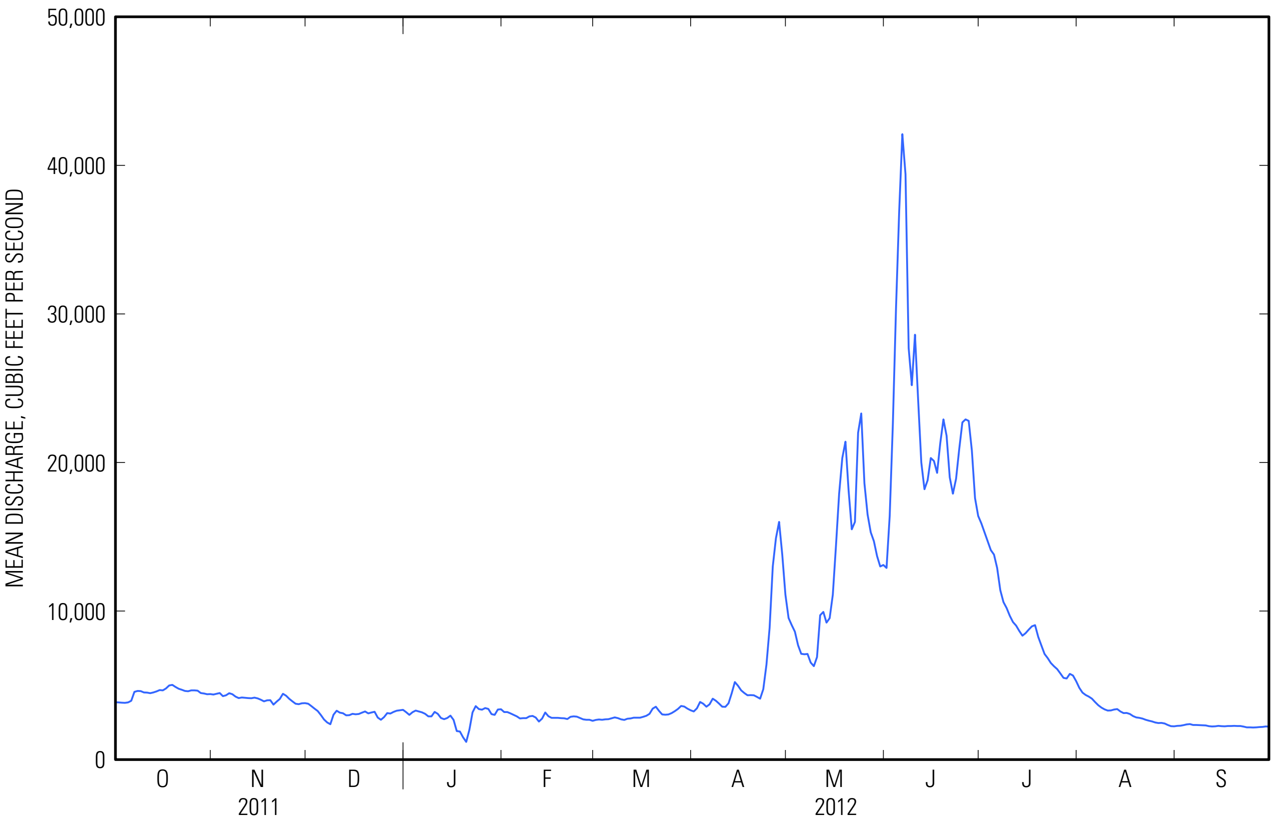
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	3,984	3,539	2,779	2,472	2,620	2,972	4,117	12,840	25,200	13,590	5,069	3,950
Max	6,803	5,163	4,451	3,834	4,382	5,478	8,799	24,070	53,910	38,150	9,894	7,301
(WY)	(1942)	(1984)	(1976)	(1984)	(1997)	(1979)	(1943)	(1997)	(1997)	(2011)	(2011)	(1968)
Min	2,128	2,283	1,579	1,363	1,559	1,767	1,438	5,635	9,849	3,410	1,462	1,527
(WY)	(2002)	(1932)	(1933)	(1940)	(1932)	(2002)	(1961)	(1953)	(1934)	(1934)	(2001)	(2001)

06214500 YELLOWSTONE RIVER AT BILLINGS, MT—Continued

SUMMARY STATISTICS

	Calendar Year 2011		Water Year 2012		Water Years 1929 - 2012	
Annual total	4,165,880		2,338,450			
Annual mean	11,410		6,389		6,935	
Highest annual mean					12,100	1997
Lowest annual mean					3,763	2001
Highest daily mean	67,400	Jul 2	42,100	Jun 6	80,100	Jun 12, 1997
Lowest daily mean	1,500	Jan 2	1,190	Jan 20	450	Dec 12, 1932
Annual seven-day minimum	2,020	Jan 1	2,020	Jan 15	794	Dec 10, 1932
Maximum peak flow			43,700	Jun 7	82,000	Jun 12, 1997
Maximum peak stage			11.19	Jun 7	15.00	Jun 12, 1997
Instantaneous low flow			[a]999	Jan 19	430	Dec 12, 1932
Annual runoff (ac-ft)	8,263,000		4,638,000		5,024,000	
10 percent exceeds	37,600		16,400		17,600	
50 percent exceeds	4,230		3,720		3,670	
90 percent exceeds	2,650		2,360		2,150	

[a]Gage height, 1.43 ft.



Analysis of USGS gage no. 06214500 Yellowstone River at Billings		
Year	Gage Lowest Mean Daily Flow (cfs)	76% of Gage Flows (cfs)
1904	2740	2082
1905	1540	1170
1928	2100	1596
1929	1500	1140
1930	1700	1292
1931	1660	1262
1932	450	342
1933	724	550
1934	1260	958
1935	970	737
1936	960	730
1937	1260	958
1938	1220	927
1939	1000	760
1940	1150	874
1941	1000	760
1942	1700	1292
1943	1500	1140
1944	1200	912
1945	1000	760
1946	2000	1520
1947	1600	1216
1948	1200	912
1949	1140	866
1950	820	623
1951	1300	988
1952	1850	1406
1953	1910	1452
1954	1300	988
1955	1050	798
1956	1500	1140
1957	835	635
1958	1450	1102
1959	500	380
1960	1000	760
1961	900	684
1962	900	684
1963	600	456
1964	750	570
1965	2200	1672
1966	1730	1315
1967	1580	1201
1968	1100	836

1969	1160	882
1970	1100	836
1971	1630	1239
1972	1180	897
1973	1930	1467
1974	1450	1102
1975	1200	912
1976	1900	1444
1977	775	589
1978	1300	988
1979	1300	988
1980	1100	836
1981	1100	836
1982	1300	988
1983	1200	912
1984	1600	1216
1985	1400	1064
1986	1100	836
1987	1400	1064
1988	931	708
1989	546	415
1990	1100	836
1991	1700	1292
1992	1100	836
1993	1200	912
1994	1000	760
1995	1100	836
1996	1700	1292
1997	1900	1444
1998	1050	798
1999	2150	1634
2000	1500	1140
2001	1070	813
2002	850	646
2003	1500	1140
2004	1450	1102
2005	1700	1292
2006	1870	1421
2007	1600	1216
2008	800	608
2009	1200	912
2010	1500	1140
2011	1500	1140
2012	1190	904
2013	1700	1292

APPENDIX M – HYDRAULICS DOCUMENTATION

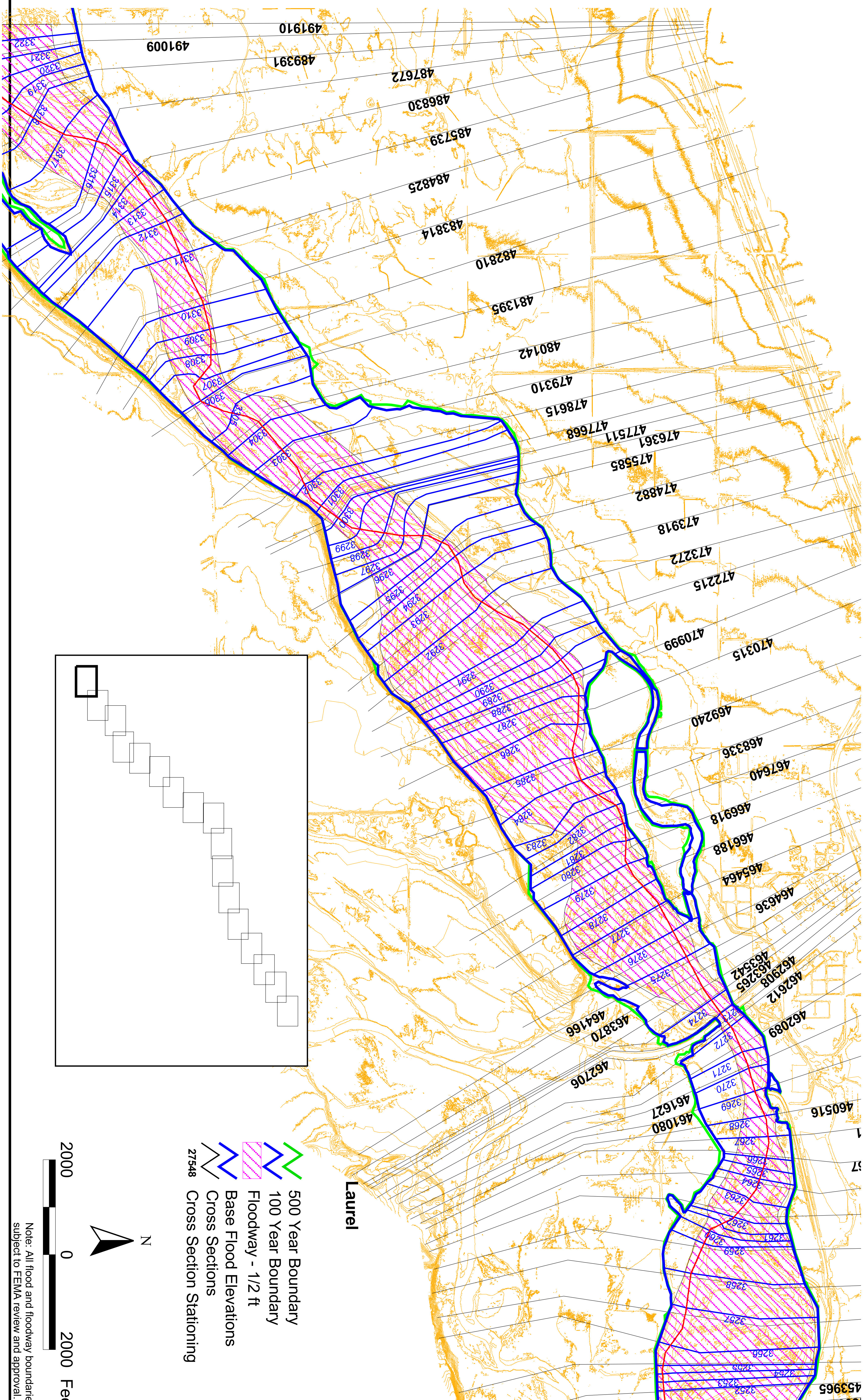
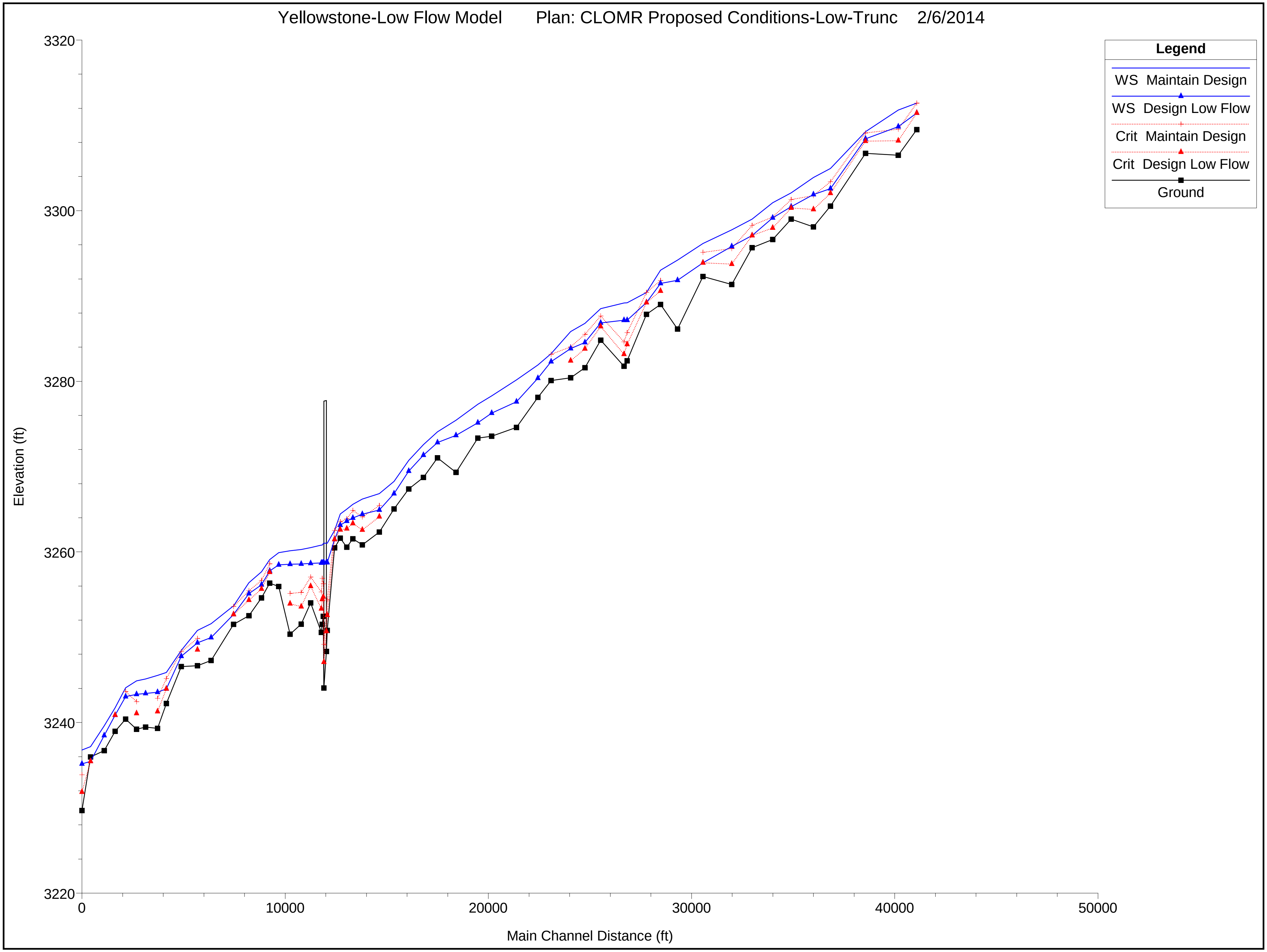


Plate No: 01	Date: October 2007	Yellowstone County Sheet 1 of 17	Yellowstone County, Montana Yellowstone River Corridor Study	US Army Corps of Engineers Omaha District	Submitted by: Randall Behm Floodplain Managment Services Section	Designed by: X.X.X.
	Scale: 1" = 2000'					Drawn by: X.X.X.
						Reviewed by: X.X.X.



Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/6/2014
Legend
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Elevation (ft)
3320
3300
3280
3260
3240
3220
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)

HEC-RAS Plan: CLOMR-Low-Trunc River: yellowstone Reach: allupstream

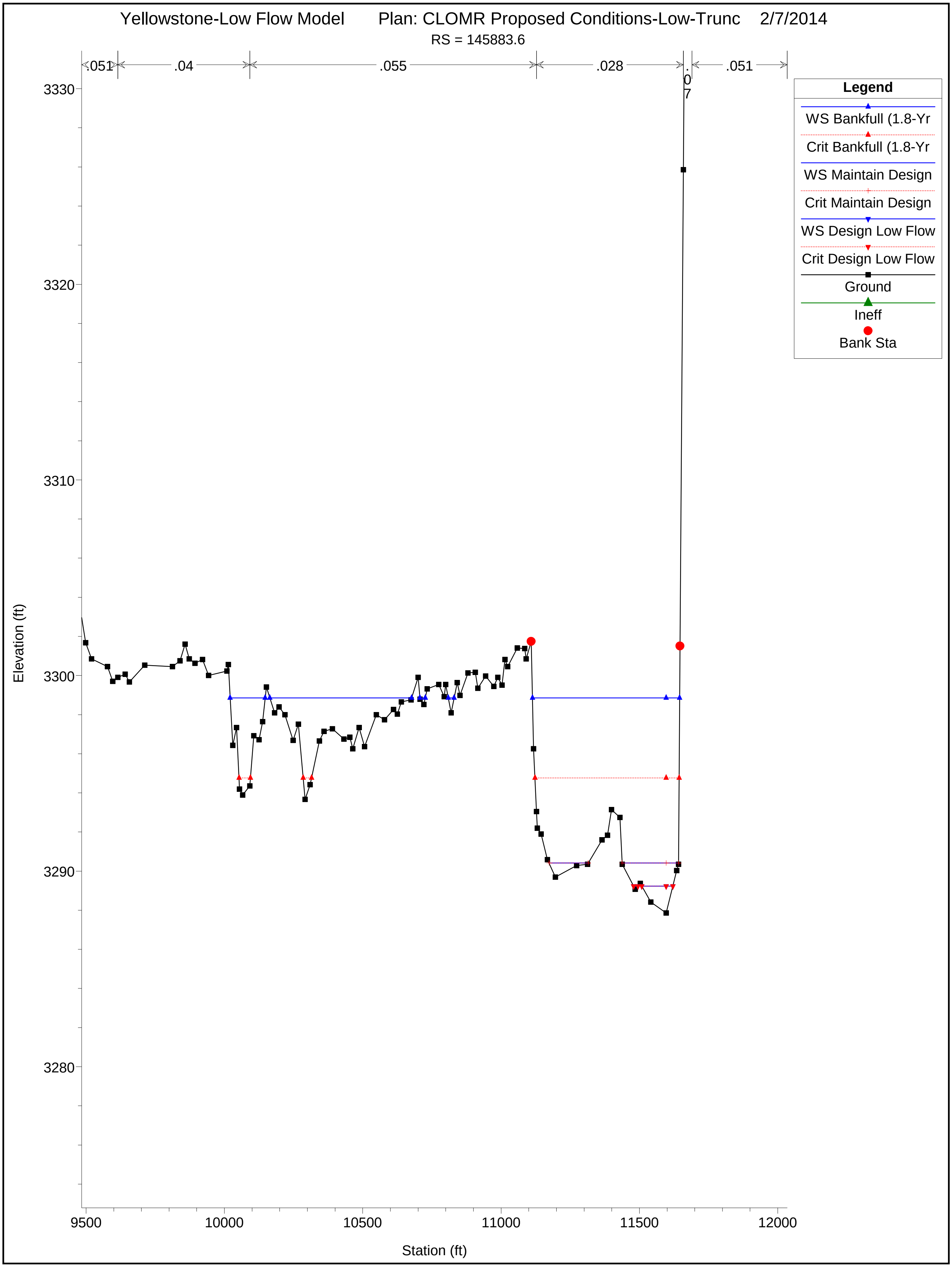
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
allupstream	149936.0	Maintain Design	1900.00	3309.51	3312.61	3312.61	3313.27	0.010471	6.53	291.01	220.39	1.00
allupstream	149936.0	Design Low Flow	450.00	3309.51	3311.45	3311.45	3311.83	0.013424	4.97	90.57	124.49	1.03
allupstream	149661.4	Maintain Design	1900.00	3306.50	3311.80	3309.55	3311.88	0.000492	2.31	821.44	296.00	0.24
allupstream	149661.4	Design Low Flow	450.00	3306.50	3309.85	3308.21	3309.88	0.000331	1.36	330.32	196.79	0.19
allupstream	149168.3	Maintain Design	1900.00	3306.73	3309.25	3309.10	3309.80	0.008019	5.95	319.09	218.95	0.87
allupstream	149168.3	Design Low Flow	450.00	3306.73	3308.43	3308.15	3308.57	0.004184	2.91	154.40	189.83	0.57
allupstream	148644.1	Maintain Design	1900.00	3300.53	3304.94	3303.40	3305.08	0.001318	3.03	640.22	362.06	0.35
allupstream	148644.1	Design Low Flow	450.00	3300.53	3302.58	3302.05	3302.73	0.002800	3.07	146.81	128.65	0.51
allupstream	148387.5	Maintain Design	1900.00	3298.10	3303.88	3301.76	3304.01	0.001230	2.82	674.87	256.29	0.31
allupstream	148387.5	Design Low Flow	450.00	3298.10	3301.89	3300.14	3301.93	0.000445	1.66	271.30	150.27	0.22
allupstream	148054.9	Maintain Design	1900.00	3299.02	3302.10	3301.30	3302.28	0.002104	3.43	553.70	330.68	0.47
allupstream	148054.9	Design Low Flow	450.00	3299.02	3300.45	3300.31	3300.65	0.007332	3.61	124.62	175.86	0.76
allupstream	147776.4	Maintain Design	1900.00	3296.62	3300.93	3299.25	3301.07	0.000905	3.04	624.54	244.57	0.34
allupstream	147776.4	Design Low Flow	450.00	3296.62	3299.16	3297.97	3299.21	0.000642	1.77	254.64	168.78	0.25
allupstream	147468.2	Maintain Design	1900.00	3295.67	3299.01	3298.27	3299.32	0.004356	4.47	424.62	250.14	0.61
allupstream	147468.2	Design Low Flow	450.00	3295.67	3297.09	3297.09	3297.45	0.012578	4.84	92.90	124.87	0.99
allupstream	147162.3	Maintain Design	1900.00	3291.34	3297.75	3295.56	3297.85	0.000680	2.60	730.33	278.42	0.28
allupstream	147162.3	Design Low Flow	450.00	3291.34	3295.82	3293.74	3295.85	0.000372	1.51	297.90	164.54	0.20
allupstream	146731.1	Maintain Design	1900.00	3292.29	3296.16	3295.12	3296.32	0.001966	3.27	581.32	372.80	0.46
allupstream	146731.1	Design Low Flow	450.00	3292.29	3293.89	3293.89	3294.28	0.012385	5.07	88.73	111.43	1.00
allupstream	146349.0	Maintain Design	1900.00	3286.12	3294.22		3294.35	0.001279	2.90	655.83	305.13	0.35
allupstream	146349.0	Design Low Flow	450.00	3286.12	3291.85		3291.89	0.000225	1.60	281.36	98.20	0.17
allupstream	146095.5	Maintain Design	1900.00	3289.01	3293.03	3291.82	3293.19	0.001508	3.20	594.16	307.11	0.41
allupstream	146095.5	Design Low Flow	450.00	3289.01	3291.46	3290.59	3291.53	0.001143	2.07	217.36	175.25	0.33
allupstream	145883.6	Maintain Design	1900.00	3287.86	3290.41	3290.41	3290.90	0.011397	5.60	339.24	344.97	1.00
allupstream	145883.6	Design Low Flow	450.00	3287.86	3289.24	3289.24	3289.60	0.012971	4.86	92.59	128.35	1.01
allupstream	145594.9	Maintain Design	1900.00	3282.42	3289.20	3285.72	3289.28	0.000258	2.19	867.84	207.67	0.19
allupstream	145594.9	Design Low Flow	450.00	3282.42	3287.15	3284.33	3287.17	0.000083	0.95	474.54	170.24	0.10
allupstream	145547.0	Maintain Design	1900.00	3281.76	3289.19	3284.61	3289.23	0.000175	1.76	1077.79	233.37	0.14
allupstream	145547.0	Design Low Flow	450.00	3281.76	3287.15	3283.17	3287.16	0.000038	0.69	652.36	184.61	0.06
allupstream	145196.7	Maintain Design	1900.00	3284.81	3288.52	3287.66	3288.72	0.002386	3.63	522.94	314.90	0.50
allupstream	145196.7	Design Low Flow	450.00	3284.81	3286.85	3286.43	3287.00	0.003457	3.10	144.95	145.99	0.55
allupstream	144960.1	Maintain Design	1900.00	3281.59	3286.80	3285.51	3287.04	0.001958	3.98	477.25	215.84	0.47
allupstream	144960.1	Design Low Flow	450.00	3281.59	3284.56	3283.82	3284.73	0.002508	3.29	136.77	99.09	0.49
allupstream	144745.8	Maintain Design	1900.00	3280.41	3285.82	3284.03	3286.02	0.001103	3.55	534.51	193.17	0.38
allupstream	144745.8	Design Low Flow	450.00	3280.41	3283.83	3282.41	3283.90	0.000644	2.05	219.59	123.88	0.27
allupstream	144452.0	Maintain Design	1900.00	3280.09	3283.23	3283.18	3283.72	0.007697	6.04	378.91	368.46	0.87
allupstream	144452.0	Design Low Flow	450.00	3280.09	3282.31		3282.52	0.005211	3.71	126.67	169.94	0.67
allupstream	144255.2	Maintain Design	1900.00	3278.12	3281.92		3282.04	0.001173	2.84	687.63	378.09	0.36
allupstream	144255.2	Design Low Flow	450.00	3278.12	3280.36		3280.44	0.002116	2.29	200.53	243.59	0.43
allupstream	143932.9	Maintain Design	1900.00	3274.61	3280.16		3280.42	0.002136	4.11	462.81	212.63	0.49
allupstream	143932.9	Design Low Flow	450.00	3274.61	3277.59		3277.85	0.002834	4.09	109.93	62.50	0.54
allupstream	143562.1	Maintain Design	1900.00	3273.56	3278.29		3278.47	0.001221	3.39	559.98	259.77	0.41
allupstream	143562.1	Design Low Flow	450.00	3273.56	3276.28		3276.34	0.000653	2.05	219.32	116.90	0.26
allupstream	143353.9	Maintain Design	1900.00	3273.33	3277.31		3277.53	0.001521	3.77	504.09	231.29	0.45
allupstream	143353.9	Design Low Flow	450.00	3273.33	3275.13		3275.34	0.005425	3.73	120.64	129.33	0.68
allupstream	143026.2	Maintain Design	1900.00	3269.32	3275.43		3275.79	0.001697	4.82	394.52	141.84	0.51
allupstream	143026.2	Design Low Flow	450.00	3269.32	3273.66		3273.74	0.000658	2.27	197.94	91.29	0.27
allupstream	142750.4	Maintain Design	1900.00	3271.03	3274.07		3274.20	0.001662	2.91	651.81	415.44	0.41
allupstream	142750.4	Design Low Flow	450.00	3271.03	3272.82		3272.88	0.001482	1.97	227.89	239.30	0.36
allupstream	142538.5	Maintain Design	1900.00	3268.73	3272.57		3272.74	0.002727	3.38	562.57	401.56	0.50
allupstream	142538.5	Design Low Flow	450.00	3268.73	3271.35		3271.45	0.003034	2.48	181.36	231.52	0.49
allupstream	142318.4	Maintain Design	1900.00	3267.39	3270.73		3270.91	0.002361	3.45	551.52	356.63	0.49
allupstream	142318.4	Design Low Flow	450.00	3267.39	3269.46		3269.55	0.002284	2.38	189.10	207.70	0.44

HEC-RAS Plan: CLOMR-Low-Trunc River: yellowstone Reach: allupstream (Continued)

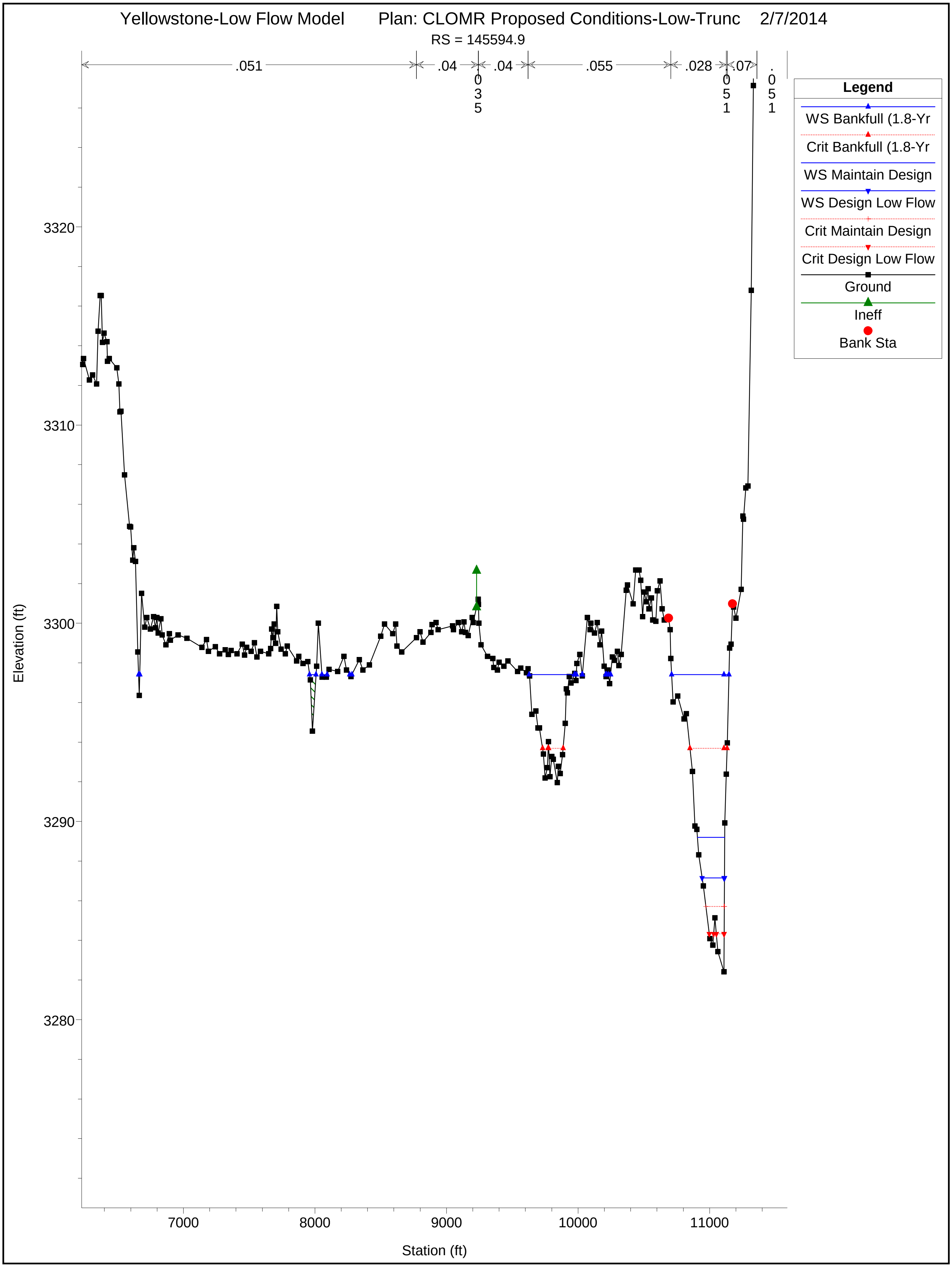
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
allupstream	142095.8	Maintain Design	1900.00	3265.03	3268.25		3268.61	0.004327	4.80	395.87	245.47	0.67
allupstream	142095.8	Design Low Flow	450.00	3265.03	3266.83		3267.04	0.005680	3.67	122.56	139.29	0.69
allupstream	141875.1	Maintain Design	1900.00	3262.34	3266.84	3265.43	3267.02	0.001259	3.39	561.02	232.31	0.38
allupstream	141875.1	Design Low Flow	450.00	3262.34	3264.91	3264.13	3265.00	0.001640	2.43	185.27	154.06	0.39
allupstream	141622.7	Maintain Design	1900.00	3260.83	3266.20	3264.11	3266.30	0.000593	2.55	745.33	287.27	0.28
allupstream	141622.7	Design Low Flow	450.00	3260.83	3264.43	3262.57	3264.46	0.000331	1.39	323.56	186.80	0.19
allupstream	141479.6	Maintain Design	1900.00	3261.55	3265.57	3264.87	3265.77	0.002835	3.60	527.44	341.37	0.51
allupstream	141479.6	Design Low Flow	450.00	3261.55	3263.99	3263.35	3264.12	0.002295	2.90	155.13	127.19	0.46
allupstream	141389.2	Maintain Design	1900.00	3260.56	3265.01	3263.88	3265.15	0.001522	2.97	638.89	361.80	0.39
allupstream	141389.2	Design Low Flow	450.00	3260.56	3263.60	3262.72	3263.65	0.001057	1.91	236.01	207.38	0.31
allupstream	141289.2	Maintain Design	1900.00	3261.61	3264.45	3263.52	3264.60	0.001874	3.10	612.83	352.40	0.41
allupstream	141289.2	Design Low Flow	450.00	3261.61	3263.14	3262.60	3263.21	0.001814	2.06	218.94	227.65	0.37
allupstream	141204.9	Maintain Design	1900.00	3260.47	3262.52	3262.52	3263.17	0.035591	6.49	292.68	221.38	0.99
allupstream	141204.9	Design Low Flow	450.00	3260.47	3261.48	3261.48	3261.78	0.045080	4.45	101.01	160.50	0.99
allupstream	141096.0	Maintain Design	1900.00	3250.80	3261.03	3254.36	3261.07	0.000355	1.57	1207.03	443.88	0.12
allupstream	141096.0	Design Low Flow	450.00	3250.80	3258.75	3252.58	3258.76	0.000081	0.65	695.33	181.48	0.06
allupstream	141053		Bridge									
allupstream	141034.4	Maintain Design	1900.00	3252.44	3260.97	3256.27	3261.02	0.000642	1.79	1060.09	270.10	0.16
allupstream	141034.4	Design Low Flow	450.00	3252.44	3258.74	3254.73	3258.75	0.000153	0.78	577.75	174.97	0.08
allupstream	141020.2	Maintain Design	1900.00	3251.52	3260.79	3256.91	3260.93	0.004767	3.02	629.41	237.51	0.33
allupstream	141020.2	Design Low Flow	450.00	3251.52	3258.70	3254.45	3258.73	0.000553	1.38	324.97	87.11	0.13
allupstream	141006.0	Maintain Design	1900.00	3250.58	3260.79	3255.31	3260.85	0.000500	2.00	950.72	179.65	0.15
allupstream	141006.0	Design Low Flow	450.00	3250.58	3258.71	3253.33	3258.72	0.000090	0.76	593.99	153.05	0.07
allupstream	140846.5	Maintain Design	1900.00	3254.03	3260.51	3257.05	3260.56	0.000593	1.80	1053.78	237.27	0.15
allupstream	140846.5	Design Low Flow	450.00	3254.03	3258.65	3255.96	3258.65	0.000176	0.72	621.29	224.75	0.08
allupstream	140705.5	Maintain Design	1900.00	3251.54	3260.27	3255.26	3260.32	0.000468	1.69	1121.31	239.39	0.14
allupstream	140705.5	Design Low Flow	450.00	3251.54	3258.59	3253.58	3258.60	0.000088	0.61	739.34	214.89	0.06
allupstream	140538.8	Maintain Design	1900.00	3250.36	3260.14	3255.14	3260.16	0.000186	1.21	1569.55	434.18	0.11
allupstream	140538.8	Design Low Flow	450.00	3250.36	3258.56	3253.91	3258.57	0.000036	0.48	941.01	297.91	0.05
allupstream	140367.1	Maintain Design	1900.00	3255.94	3259.92		3259.98	0.000633	2.01	945.15	511.31	0.26
allupstream	140367.1	Design Low Flow	450.00	3255.94	3258.49		3258.51	0.000460	1.33	337.51	266.25	0.21
allupstream	140231.3	Maintain Design	1900.00	3256.33	3259.10	3258.60	3259.38	0.003928	4.30	442.34	294.19	0.62
allupstream	140231.3	Design Low Flow	450.00	3256.33	3257.76	3257.63	3257.98	0.007618	3.69	121.95	171.49	0.77
allupstream	140108.3	Maintain Design	1900.00	3254.63	3257.67	3256.66	3257.89	0.003427	3.75	511.79	291.45	0.46
allupstream	140108.3	Design Low Flow	450.00	3254.63	3256.13	3255.65	3256.23	0.002715	2.47	182.44	179.04	0.43
allupstream	139921.2	Maintain Design	1900.00	3252.53	3256.39	3255.45	3256.52	0.001504	3.03	647.39	384.76	0.40
allupstream	139921.2	Design Low Flow	450.00	3252.53	3255.10	3254.34	3255.16	0.001188	1.99	229.89	262.77	0.33
allupstream	139688.7	Maintain Design	1900.00	3251.51	3253.69	3253.61	3254.18	0.009075	5.66	335.96	282.08	0.91
allupstream	139688.7	Design Low Flow	450.00	3251.51	3252.67	3252.67	3252.97	0.013768	4.36	103.09	175.61	1.00
allupstream	139352.1	Maintain Design	1900.00	3247.28	3251.59		3251.72	0.000926	2.92	650.80	251.20	0.32
allupstream	139352.1	Design Low Flow	450.00	3247.28	3249.95		3250.00	0.000555	1.66	271.77	189.30	0.24
allupstream	139146.9	Maintain Design	1900.00	3246.65	3250.80	3249.85	3250.93	0.001481	3.08	676.54	461.00	0.40
allupstream	139146.9	Design Low Flow	450.00	3246.65	3249.35	3248.52	3249.44	0.001355	2.38	210.32	214.81	0.36
allupstream	138904.5	Maintain Design	1900.00	3246.56	3248.45	3248.31	3248.76	0.006126	3.29	450.97	501.52	0.58
allupstream	138904.5	Design Low Flow	450.00	3246.56	3247.77		3247.89	0.002837	1.35	187.52	319.32	0.36
allupstream	138682.4	Maintain Design	1900.00	3242.22	3245.86	3245.17	3246.06	0.002697	3.77	528.04	349.45	0.51
allupstream	138682.4	Design Low Flow	450.00	3242.22	3243.96	3243.96	3244.35	0.011889	5.05	89.15	109.13	0.98
allupstream	138551.1	Maintain Design	1900.00	3239.30	3245.52	3242.83	3245.60	0.000553	2.41	869.41	393.05	0.24
allupstream	138551.1	Design Low Flow	450.00	3239.30	3243.55	3241.30	3243.58	0.000211	1.32	340.02	150.98	0.16
allupstream	138370.3	Maintain Design	1900.00	3239.47	3245.12		3245.22	0.000747	2.69	776.03	388.89	0.28
allupstream	138370.3	Design Low Flow	450.00	3239.47	3243.40		3243.43	0.000299	1.44	312.82	159.27	0.18
allupstream	138235.3	Maintain Design	1900.00	3239.21	3244.88	3242.45	3244.96	0.000453	2.41	888.33	488.05	0.24
allupstream	138235.3	Design Low Flow	450.00	3239.21	3243.31	3241.07	3243.33	0.000153	1.10	407.61	186.50	0.13

HEC-RAS Plan: CLOMR-Low-Trunc   River: yellowstone   Reach: allupstream (Continued)

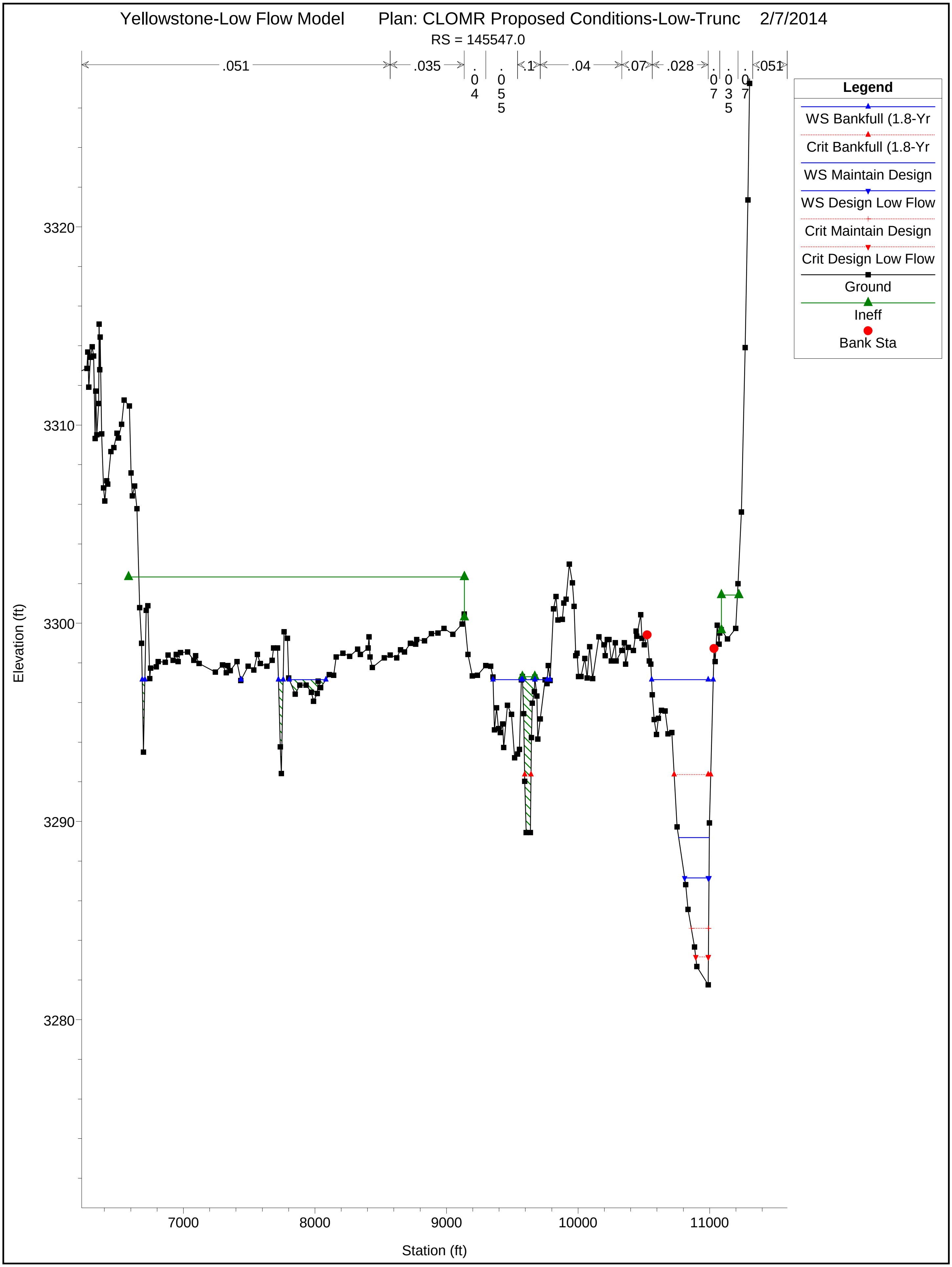
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
allupstream	138072.3	Maintain Design	1900.00	3240.39	3244.08	3243.63	3244.40	0.003946	4.87	428.31	291.45	0.64
allupstream	138072.3	Design Low Flow	450.00	3240.39	3243.03		3243.13	0.001740	2.68	183.36	189.35	0.41
allupstream	137914.6	Maintain Design	1900.00	3238.98	3241.73		3241.96	0.005432	3.92	497.65	521.43	0.69
allupstream	137914.6	Design Low Flow	450.00	3238.98	3240.86	3240.86	3241.09	0.015163	3.93	118.25	273.97	1.01
allupstream	137749.9	Maintain Design	1900.00	3236.71	3239.60		3239.84	0.002679	2.57	512.40	298.89	0.38
allupstream	137749.9	Design Low Flow	450.00	3236.71	3238.47		3238.54	0.001838	2.03	209.87	231.82	0.38
allupstream	137544.5	Maintain Design	1900.00	3235.96	3237.16		3237.59	0.004017	2.47	374.35	224.56	0.55
allupstream	137544.5	Design Low Flow	450.00	3235.96	3235.44	3235.44	3235.86	0.012728		86.20	105.79	0.00
allupstream	137415.7	Maintain Design	1900.00	3229.69	3236.77	3233.86	3236.92	0.000716	3.14	605.85	198.39	0.32
allupstream	137415.7	Design Low Flow	450.00	3229.69	3235.14	3231.85	3235.16	0.000133	1.25	359.75	122.26	0.13



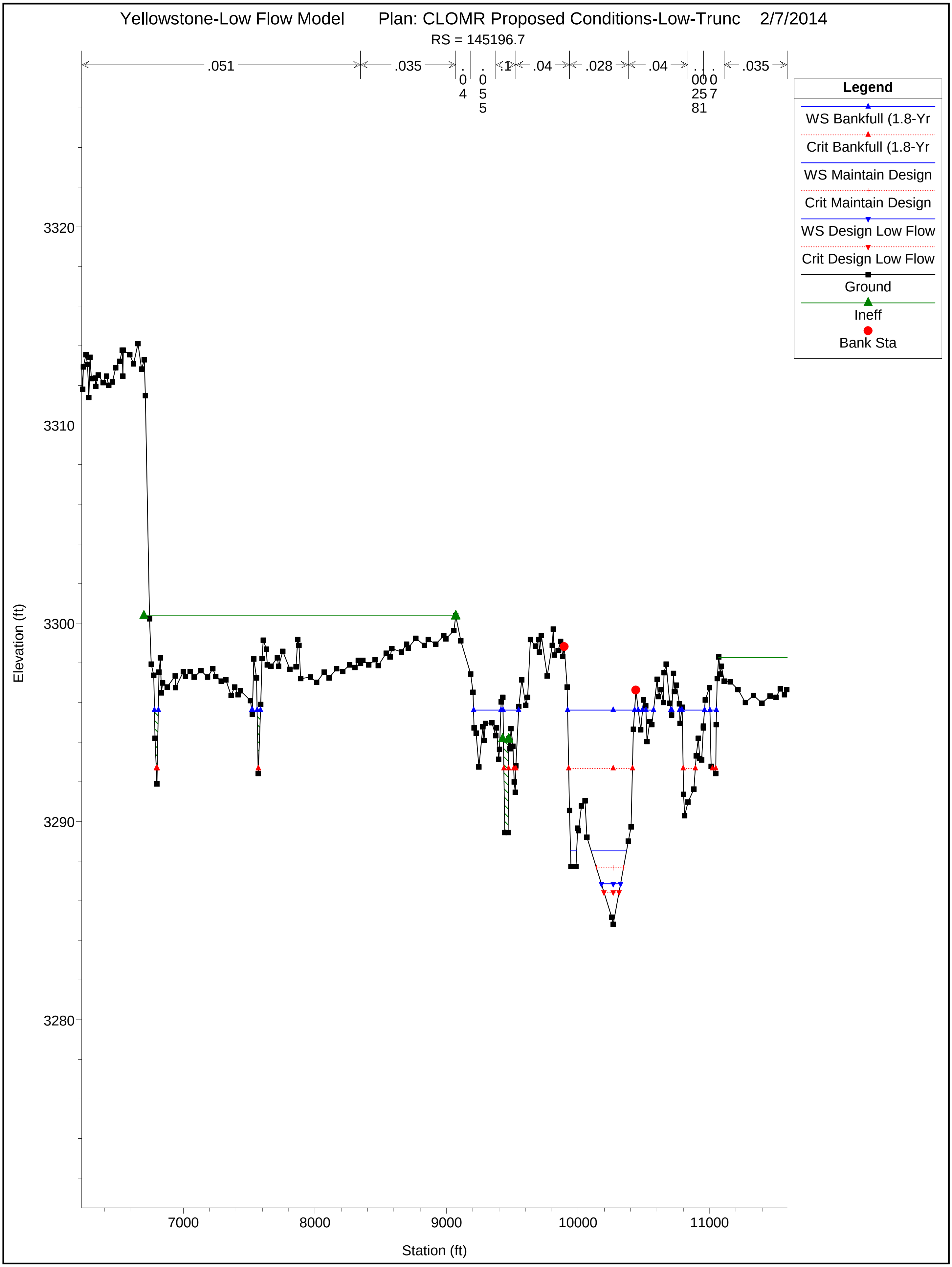
Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 145883.6
.051
.04
.055
.028
.07
.051
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
Crit Maintain Design
WS Design Low Flow
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3330
3320
3310
3300
3290
3280
Station (ft)
9500
10000
10500
11000
11500
12000



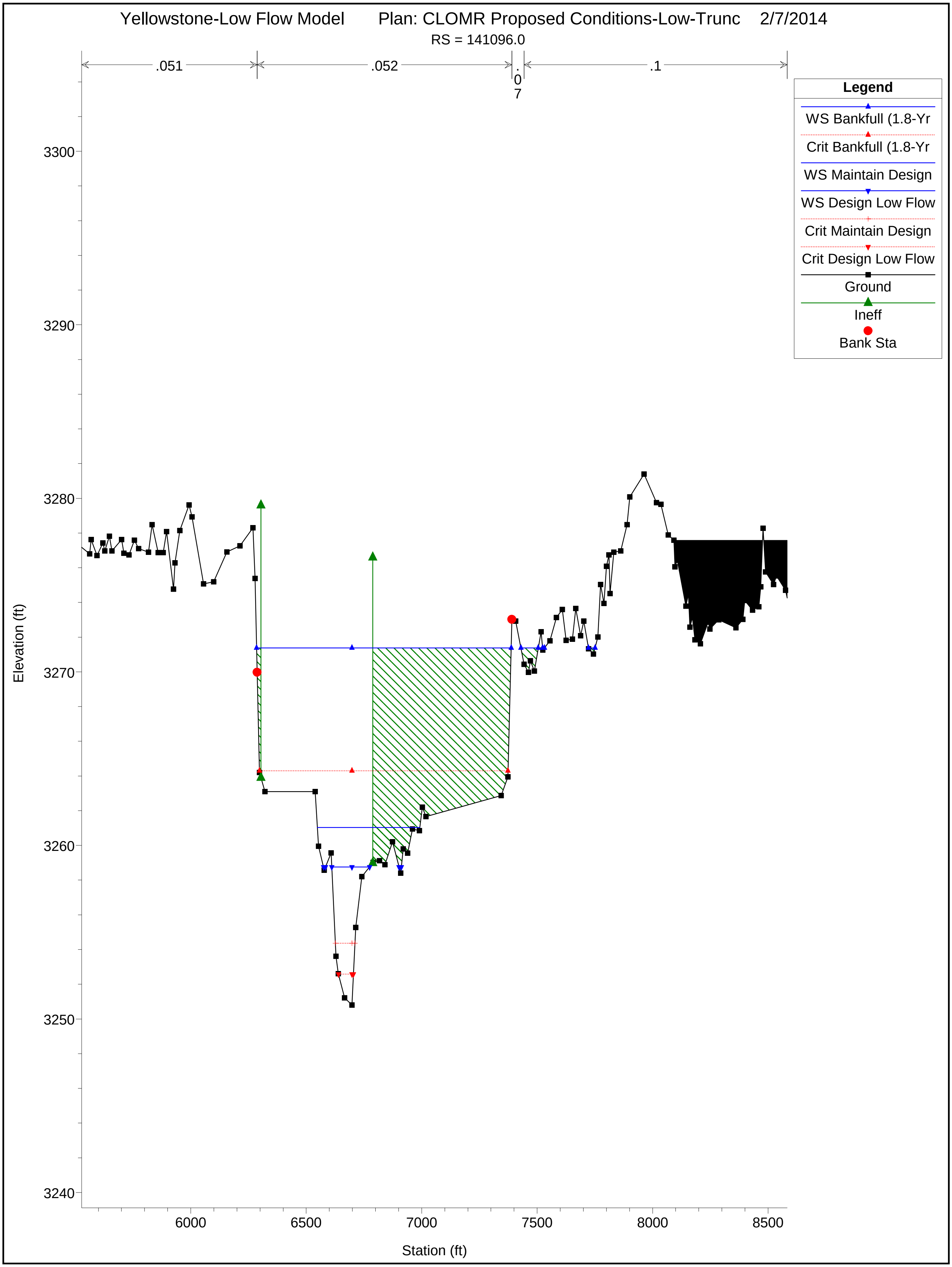
Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 145594.9
.051
.04
.035
.04
.055
.028
.051
.07
.051
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3320
3310
3300
3290
3280
7000
8000
9000
10000
11000
Station (ft)



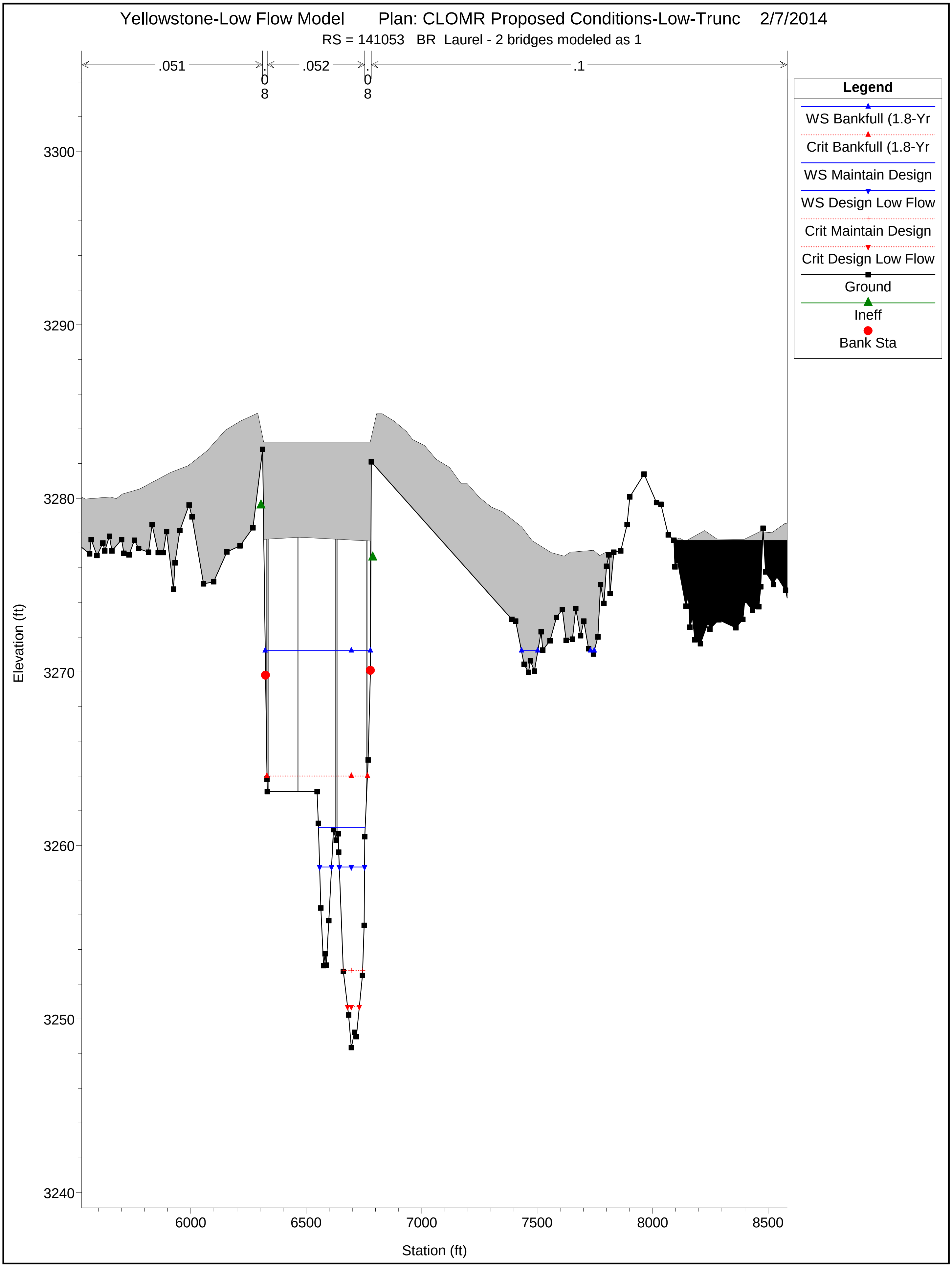
Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 145547.0
.051
.035
.04
.055
.1
.04
.07
.028
.07
.035
.07
.051
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3320
3310
3300
3290
3280
7000
8000
9000
10000
11000
Station (ft)

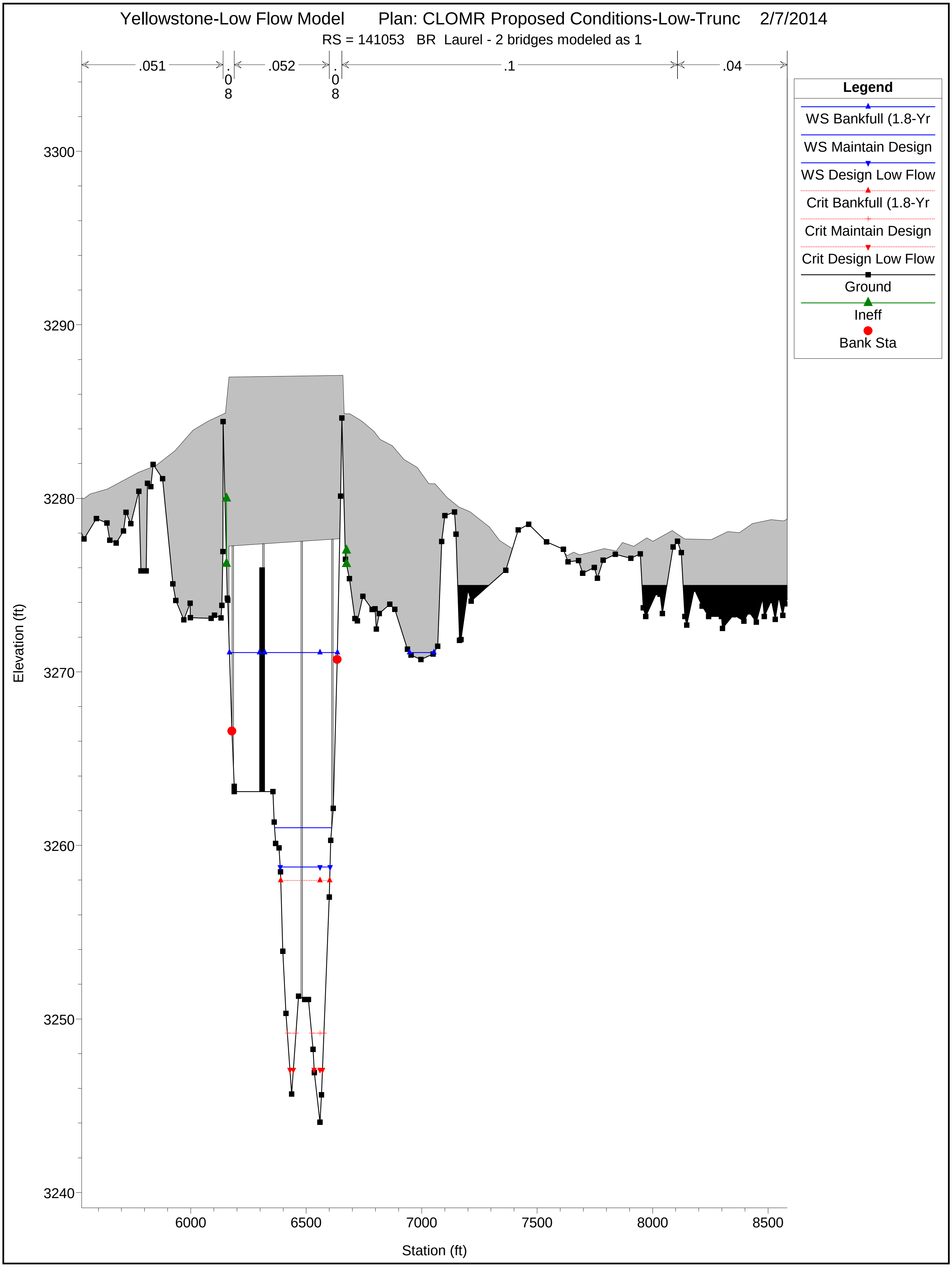


Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 145196.7
.051
.035
.04
.028
.04
.035
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
Crit Maintain Design
WS Design Low Flow
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3320
3310
3300
3290
3280
7000
8000
9000
10000
11000
Station (ft)

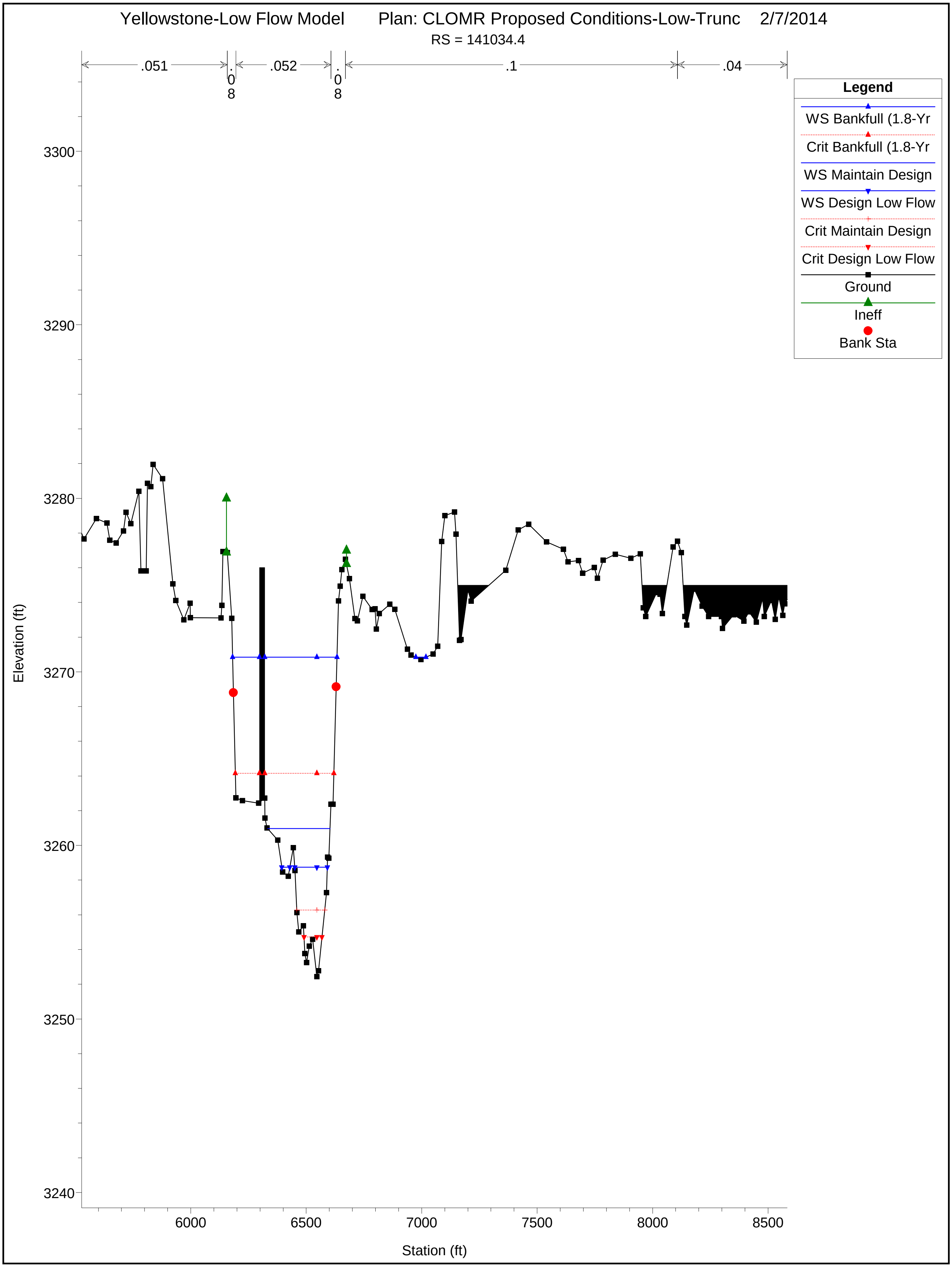


Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141096.0
.051
.052
.07
.1
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
6000
6500
7000
7500
8000
8500
Station (ft)

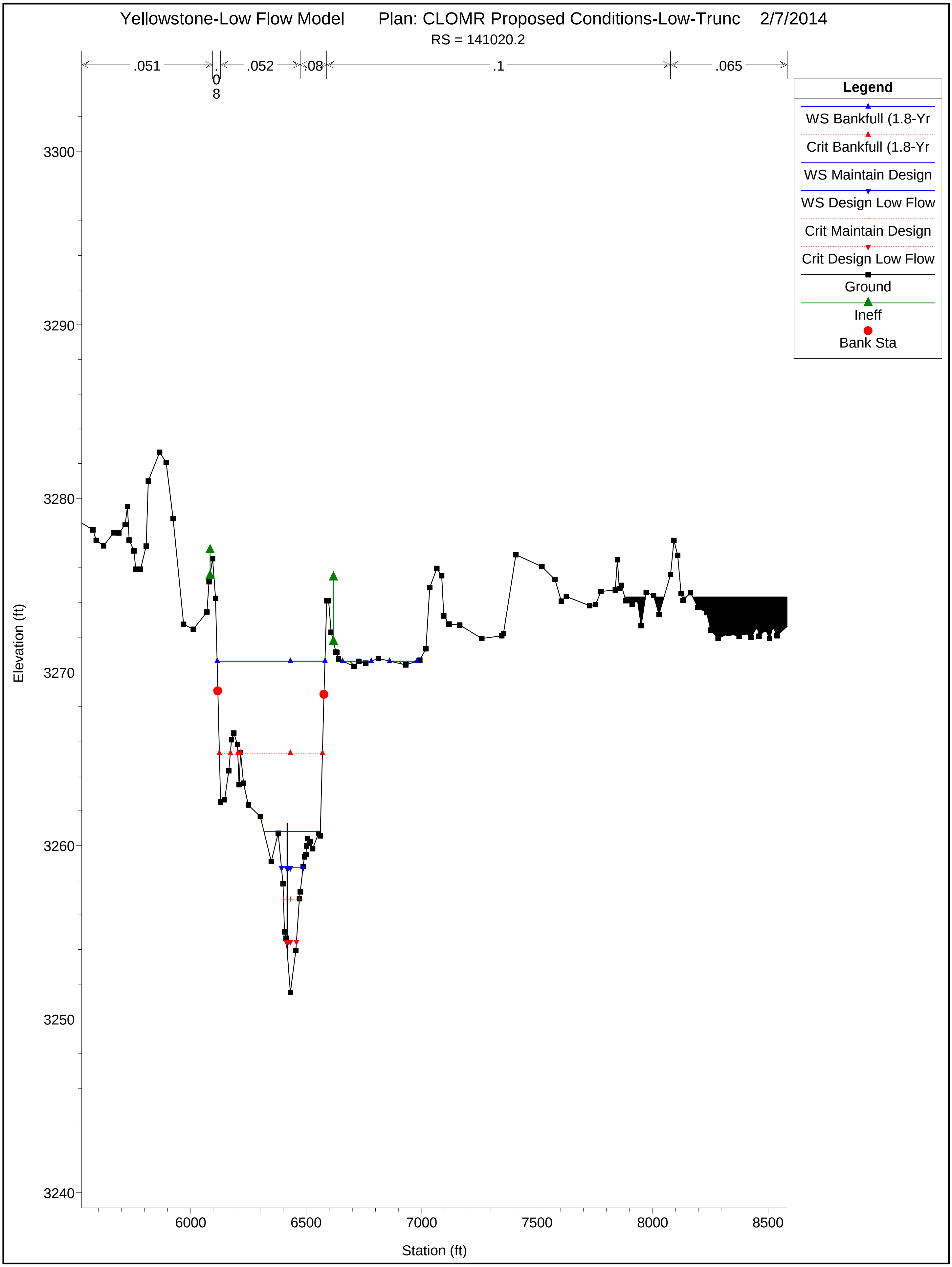

Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141053 BR Laurel - 2 bridges modeled as 1
.051
.052
.1
.08
.08
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
Station (ft)
6000
6500
7000
7500
8000
8500

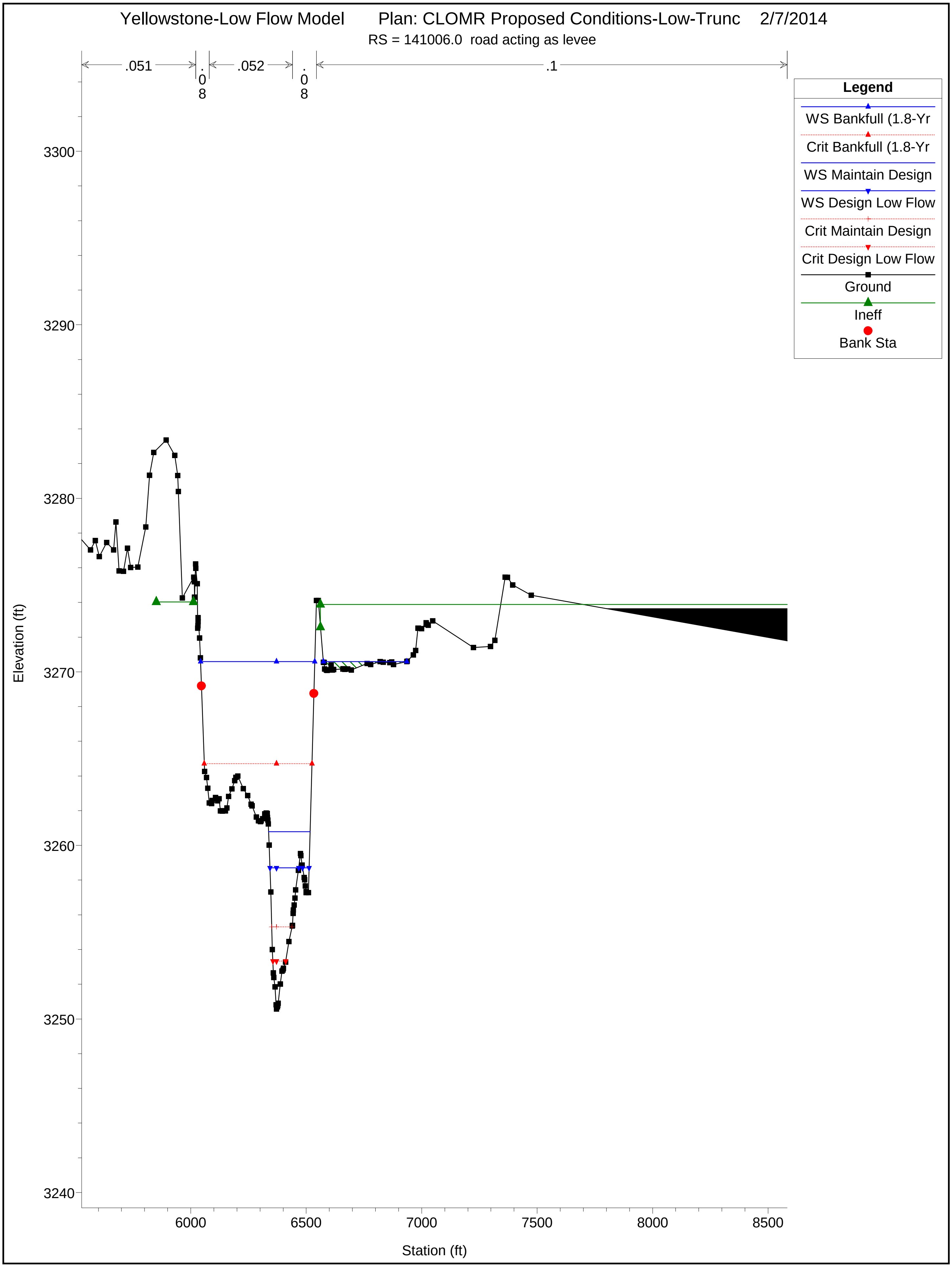


Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141053 BR Laurel - 2 bridges modeled as 1
.051
.08
.052
.08
.1
.04
Legend
WS Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Bankfull (1.8-Yr
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
6000
6500
7000
7500
8000
8500
Station (ft)

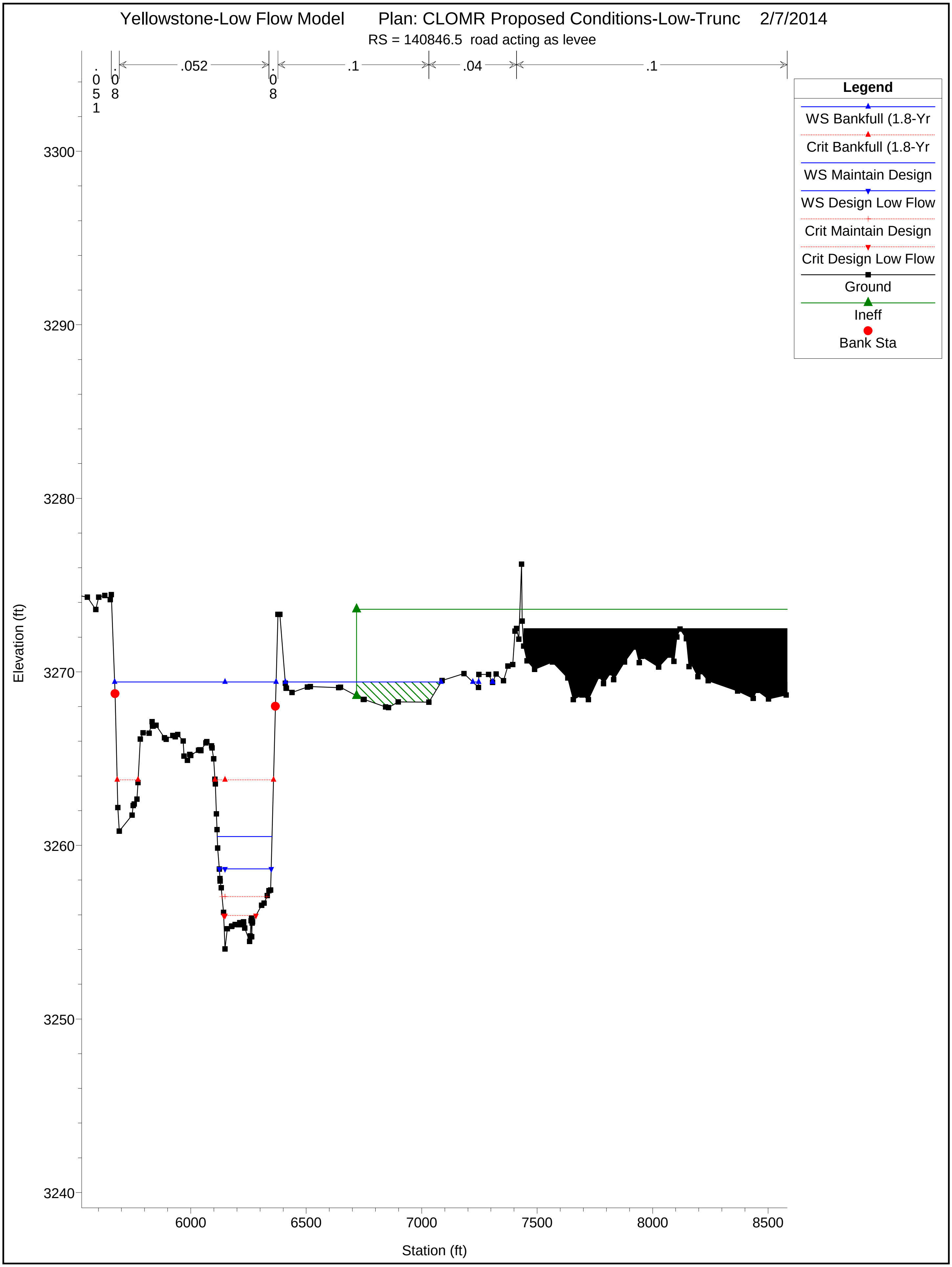


Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141034.4
.051
.08
.052
.08
.1
.04
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
6000
6500
7000
7500
8000
8500
Station (ft)


Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141020.2
.051
.08
.052
.08
.1
.065
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3240
3250
3260
3270
3280
3290
3300
Station (ft)
6000
6500
7000
7500
8000
8500



Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 141006.0 road acting as levee
.051
.08
.052
.08
.1
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
6000
6500
7000
7500
8000
8500
Station (ft)



Yellowstone-Low Flow Model Plan: CLOMR Proposed Conditions-Low-Trunc 2/7/2014
RS = 140846.5 road acting as levee
.051
.08
.052
.08
.1
.04
.1
Legend
WS Bankfull (1.8-Yr
Crit Bankfull (1.8-Yr
WS Maintain Design
WS Design Low Flow
Crit Maintain Design
Crit Design Low Flow
Ground
Ineff
Bank Sta
Elevation (ft)
3300
3290
3280
3270
3260
3250
3240
6000
6500
7000
7500
8000
8500
Station (ft)

APPENDIX N – HISTORICAL DOCUMENTATION OF LAUREL’S RAW WATER INTAKE

This document provides information collected from the City of Laurel's Council Minutes. There may be more information in the records but this shows that the City of Laurel has had issues with water intakes in the Yellowstone River.

The 1997 Flood caused the river to shift and a new intake was installed in 2003.

WATER INTAKE COUNCIL MINUTES

1916-1996

Kurt Markegard

Table of Contents

December 19, 1916

The intake at the pumping plant was discussed and referred to the Water Committee on motion duly made, seconded and carried

January 2, 1917

A motion was made, and seconded and carried that the cost of remodeling the water intake at the pumping plant be paid for by creating a Special Improvement District and if it could not be financed in this manner a special election shall be held to vote bonds. Upon roll call the vote stood as follows;

Yes: Lamb; Horen; Davis; Hanner and Jocobs.

No: none

Absent: Dix.

September 4, 1917

Plans, specification and proposals for construction of new intake to water supply system for Laurel, Montana, was read. A motion was made by Dix, seconded by Ryan, that the plans, specifications and proposal, s read be passed and approved. Upon roll call the vote stood as follows:

Aye: Lamb, Price, Ryan and Dix.

Nay: None.

Absent: Hannar and Davis

Carried.

October 2, 1917

Motion made, seconded and carried that City Engineer be instructed to draw up plans for extending intake pipe farther into river.

December 4, 1917

Motion made, seconded and carried that the city order 14 lengths of intake pipe and have same installed when it arrives.

August 27, 1919

The matter of extending the water intake was taken up. Mr. Hastings of the Security Bridge Company, having been asked by the City Engineer and the Water Commissioner to submit an estimate on the probable cost of the extension at this time, was present, and stated to the Council that he was unable at this date to submit such an estimate, but would be able to do so in a short time. By unanimous vote of the Council this matter was laid on the table until such time as more definite information as to the plan of construction and probable cost of the extension could be obtained.

June 15, 1920

It was moved by Vordahl , that a committee be appointed to go to Billings and secure the necessary pipes and fittings for the completion of the installation of the pipe at the intake of the City Water System. Seconded and carried. The Mayor appointed the already existing finance and purchasing committee.

July 6, 1920

It was moved and seconded, that the rule of the council providing for the auditing of bills on the first meeting of each month, only be waived, as to the bill of G.H. Mirerl, for work on the intake, and that the Auditing committee audit such bill and make report at this session. Motion carried. The auditing committee reported back reporting that they had audited said bill and recommended that the same be allowed. Moved and seconded, that the report of the auditing committee be adopted and that the Clerk be instructed to draw warrant upon the proper fund in payment thereof. Motion carried.

November 3, 1920

The City Clerk was instructed to write the County Commissioners relative to placing the Intake construction east of the south pier of the county bridge in the Yellowstone River, asking them to write him in acquiescence thereof.

November 16, 1920

The Clerk read to the Council, Permit from the Yellowstone County Commissioners to attach a new intake basin to the east end of the central pier of the Laurel Bridge crossing the Yellowstone River about a mile and a half south of the City of Laurel. Permit having been received in duplicate, motion was made that the Clerk and Mayor execute both permits, returning the copy to the County Commissioners and filing the original along with other City of Laurel records.

December 7, 1920

There being no bids for the installation of the Intake structure for the water system, the Mayor appointed Alderman Vordahl to interview persons familiar with such construction work, with a view to securing their services for the installation of this structure.

Alderman Brohaugh suggested that the Council consider the purchase of a certain parcel of land, approximately one-third of an acre in size, adjacent to the present pump-house site for the purpose of using the soil thereon for filling necessary for the installation of the new Intake. On motion duly made, seconded and carried, the Mayor and Clerk were instructed to enter into a contract with J.F. Jackson, owner, for the purchase of said strip of land, same to be paid for by warrants drawn upon the Water Fund, subject to his furnishing a merchantable title and abstract.

December 19, 1930

It was moved by Vordahl and seconded by Perry that the Water Commissioner be instructed to continue work at the river until a better quality of water could be gotten to the intake. The motion carried.

February 17, 1935

It was moved by Law and seconded by Bray that as a last resort and in order to locate the bridge over the Yellowstone River at or near its present site the Council is willing to grant to the State Highway Department an easement for a highway to be constructed over the City pump house, provided, however, that the total cost of any changes to be made in the pump house or water works intake well and intake line shall be borne by the Montana State Highway Commission and the City relieved of any expenditure by reason of granting said easement. Upon roll call, all Aldermen present voted aye and said motion was declared passed and adopted.

October 20, 1936

The City Engineer presented the matter of making a teat on an island above the pump house for a new water intake, building a keeper's house at the reservoir and a wave wall at settling basin. It was moved by L.L. Smith and seconded by Conrad application be made to the W.PA. for a project to include testing the island, building house at reservoir and a wave wall at settling basin. The motion carried.

October 17, 1944

Mr. J.S. Brohaugh, Water Commissioner, requested permission to obtain labor and equipment to install pipe and do other work at the river intake. A motion was made by Feuerbacher and seconded by Wieber the permission be granted. The motion carried.

March 6, 1945

A motion was made by McMauns and seconded by Parker the Mayor be given authorized to have a drawing made of the completed work on the river intake. The motion carried.

February 19, 1946

Mr E.M. Grime and Mr. Schudlig from the N.P. Water Division were present at the meeting. Mr. Grime appeared before the council, and gave his views on how the water from the stream, known as the Nutting Slough, could be diverted and carried far enough away from the intake, to prevent any polluted water to be drawn into it, by erecting a longer wing down the river. He guessed the approximate cost of the construction of a 100 foot wing down the river would be $4,000, and thought that the N.P. might pay half of the bill for the construction. Sounding to be obtained by the City Engineer and a report to be made on the findings.

February 14, 1956

Mr. Thomas Robinson of Black & Veatch appeared before the Council, to discuss the report of the Water Committee meeting of February 14th, in regard to the Intake at the river. He stated that the present intake was not setting on anything solid, a and the rock bottom had been undercut. The plan for the new Intake would be on the same site, but the rock would be undercut, to put the entire length of the pipe on solid bottom, which would make it on a lower level. He also stated that Black & Veatch would prepare a new drawing of intake and send it to Cop Construction for submitting figures on cost.

February 21, 1956

It was moved by Scott and seconded by Rodgers that the changes on Intake submitted by Cop Construction be approved in the amount of $45,352.00 total bid. The motion carried.

April 17, 1956

Mr. Robert Banker, the Engineer from Black & Veatch, who is supervising the construction work on the filtration plant, gave a report on the progress. He stated that the appearance of the work scene would be remedied very shortly. The work on the Intake would probably be delayed until after high water season, or about July 15th.

It was moved by Scott and seconded by Leuthold the claim of Cop Construction in the amount of $9920.18 be paid. The motion carried.

The claim of Black & Veatch in the amount of $15,571.80 was presented. It was moved by Scott and seconded by Williams that the claim be paid on the presentation of the properly signed claim. The motion carried.

August 7, 1956

Mr Banker gave a progress report on the work being done on the filtration plant at the River. He stated that that masonry work is being started, that the piping work in the basement will be finished about the end of the month; that a road is being built over the intake and that probing for the intake pipes will be undertaken as the work progresses. Also stated that a weekly progress report is filed in the office of the City Engineer, and is available for examination at any time.

February 6, 1960

Mr. Talmadge Robinson, the new employee who started with the City on February 1, 1960, reported that dynamite is very expensive. He suggested that one man with a drag line could clear certain obstructions in the river away from the intake. It was his opinion that it would be less expensive in the long run.

October 4, 1960

Dick stated that the City Employees would be working down at the intake. He reported that the City should have a few hard hats for safety purposes, and requested that he be allowed to purchase a few. Motion was made by Ruff and seconded by Beslanwitch that the City purchase six of these hats, on the condition that the employees be instructed to wear them if needed. Motion carried.

October 8, 1960

Dick reported on the intake at the water plant and stated the a sludge pump was needed. He says that item would cost about $325.00. Freebury recommended that this pump be purchased. Motion was made by Ruff and seconded by Freebury in this connection. Motion carried.

November 2, 1965

Ruff reported on the slush ice problem at the water plant in the winters. After discussion, motion was made by Ruff and seconded by Yovetich that a perforated tank be buried on the North bank of the river, connected to the intake manifold, motion carried.

November 4, 1969

The aldermen were informed that Carl Manweiler received a broken leg while cleaning debris from the intake pier at the water plant.

January 5, 1971

Yovetich reported that the water plant was in good shape, and the new intake pier was working well in taking care of the slush ice problem.

May 15, 1972

Mr. Lloyd Lee was presented a plaque to John Daley who won first place in an American Water Works Association contest for his outstanding technical paper on the City's solution to the slush ice problem at the water intake pier. In addition, Daley also won a watch. All aldermen congratulated John for such a fine job.

October 6, 1981

WATER PLANT DREDGING – DAVE MICHAEL : The intake pier is not in the main flow of the river. The Montana Fish and Game has been contacted to a get permit for dredging to divert the flow by the intake pier. Mr. Bishop of the Fish and Game and Mr. Jones of the Fish and Wildlife Service came out and looked the situation over. A permit has to be obtained from the Corps of Engineers before anything can be done and hopefully this can be accomplished in about fifteen days.

The bid for doing this work was $3,480, and this was budgeted for in this years budget.

January 5, 1982

DAVE MICHAEL reported on a problem at the water plant.

Last week the water level in the river dropped approximately one foot. It left our intake pier with very little water running by it. At this time we have a deep hole by the pier and we are presently getting an adequate supply of water. It all depends what happens to the river. It would take extensive work to bring the water back by the pier.

September 21, 1993

The intake pier at the Water Plant is being prepared for winter.

April 2, 1996

WATER INAKE LINES – ADDITIONAL EXPENDITURES:

A RESOLUTION WILL BE ON THE April 16, 1996 agenda.

April 16, 1996

Water Plant Intake Suction Line Project

Dave Michael explained the project to the council. The project will involve completing the manifold, new lines and valves into the building. This project can be budgeted for in the future, possibly within the next five years.

EMERGENCY EXITS REQUIRING ADDITIONAL EXPENDITURES:

RESOLUTION NO. R96-9

BEING A RESOLUTION DECLARING AN EMERGENCY EXITS REQUIRING ADDITIONAL EXPENDITURES NECESSARY FOR REPAIRING THE WATER INTAKE LINES AT THE WATER PLANT

Motion by Alderman Marshall that Resolution No. R96-9 is passed and adopted, seconded by Aldermen Dickerson. Motion carried 8—0.

FINANCE EMERGENCY REPAIRS – WATER INTAKE LINES:

RESOLUTION NO. R96-10

AUTHORIZING AGREEMENT WITH 1ST SECURITY BANK TO FINANCE EMERGENCY REPAIRS TO WATER INTAKE LINES AT THE WATER PLANT

Motion by Alderwoman Kilpatrick that Resolution No. R96-10 is passed and adopted, seconded by Alderman Dickerson. Motion carried 8—0.

APPENDIX O – CULTURAL RESOURCES SURVEY

Big Sky. Big Land. Big History.
Montana
Historical Society

Historic Preservation
Museum
Outreach & Interpretation
Publications
Research Center

June 27, 2014

Mr. Charles Bello
Environmental Planning/Historic Preservation Section
FEMA, Region VIII
Denver Federal Center
Building 710, Box 25267
Denver, CO 80225-0267

RE: City of Laurel Water Treatment Plant Intake Feasibility Study
Yellowstone County, Montana

Dear Mr. Bello:

Thank you for the response (received June 19, 2014) to the concerns listed in our June 3, 2014 letter regarding the proposed City of Laurel Water Treatment Plant Intake in Yellowstone County, Montana. We appreciate the time and effort that went into developing a clear argument for the ineligibility of the Canyon Creek Ditch (24YL0171) and the Clarks Fork Irrigation Ditch (24YL0172). It was a pleasure to review. Please pass our appreciation on to the author of the argument.

Based on the received documentation we concur with the initial determination that the Canyon Creek Ditch and Clarks Fork Irrigation Ditch are not eligible for listing in the National Register of Historic Places. Therefore, we also agree that no historic properties will be affected as a result of the proposed undertaking.

Please note that our concurrence does not substitute for a good faith effort to consult with interested parties, local government authorities, or American Indian tribes. If you have any questions or concerns, do not hesitate to contact me at (406) 444-0388 or kore@mt.gov. Thank you for consulting with us.

Sincerely,

Kathryn Ore
Review and Compliance Officer
Montana State Historic Preservation Office

File: FEMA – 2014 – 2014062704

225 North Roberts Street
P. O. Box 201201
Helena, MT 59620-1201
(406) 444-2694
(406) 444-2696 FAX
montanahistoricalsociety.org

Response to the SHPO comment letter for the Laurel Water Intake Project dated June 3, 2014.

- 24YL0171 is the Canyon Creek Irrigation Ditch
- 24YL0172 is the Clarks Fork Irrigation Ditch
- 24YL1192 is the Nutting family farmstead (also referenced as 24YL1992)

SHPO Comment: "24YL0171 is directly associated with 24YL1992 [sic], a NRHP-eligible farmstead."

Response: There is *no connection* between 24YL0171 and 24YL1192. The land associated with the Nutting farm (24YL1192) is irrigated from the Old Mill Ditch (24YL986), *not* the Canyon Creek Ditch (24YL0171). The Canyon Creek Ditch merely transits the Nutting property because the coincidence of topography necessitated constructing the gravity flow canal at that location. The Canyon Creek Ditch does not irrigate any land west of U.S. Highway 212. Additionally, 24YL1192 is recommended NRHP eligible because of the architecture of a barn (Feature 8) and a granary (Feature 17), neither of which are associated with irrigation in any manner.

SHPO Comment: "24YL0171 was vital to the agricultural development and settlement pattern of the area."

Response: "The significance of a historic property can be judged and explained only when it is evaluated within its historic context" (National Park Service 1997).

Historic Context

There is no evidence indicating Canyon Creek Ditch (24YL0171) was "vital" to the agricultural development and settlement of the Yellowstone Valley area near Laurel and Billings. Dry farming in the Yellowstone Valley in the late 1870s and early 1880s had already proven successful in the region prior to creation of the Canyon Creek Ditch. Orson N. Newman, for example, kept a diary in 1880 describing ranch life in the area using dry farming techniques (West 1993:91-93). Planting began in late April and continued to early June. Crops included oats, potatoes, onions, corn and cabbage. Grass was mowed for hay throughout the spring and summer, often on the bench above the valley. Harvest began in August and continued to October. Newman hauled 1,354 pounds of vegetables and grain to Bozeman for sale, some of which he sold along the way to travelers or small outposts along the Bozeman Trail. The only evidence of irrigation at the time was a small ditch constructed by Perry McAdow to satisfy the requirements of his Desert Land Act claim (West 1993:94). Thus, dry farming was a proven agricultural technique in the Yellowstone Valley by the time the Northern Pacific (NP) railroad reached the area in 1882.

The NP railroad brought surge of settlers to the region. Irrigation projects soon followed, including Canyon Creek Ditch, which began construction in 1883 and was completed in 1886 (Oravetz 1943:9). The incentive for constructing irrigation systems was mixed. They provided construction work for area residents and increased land value for speculators, as well as provide some added security for farmers and ranchers against drought. There is no evidence, however, that availability of irrigated land drew settlers to the area. Area population actually dropped briefly in the late 1880s as people moved on after the initial population surge that arrived with the railroad (West 1993). Access to irrigated farmland, such as was available at the time along Canyon Creek Ditch (24YL0171), failed to attract any significant increase in settlement over non-irrigated land. A review of General Land Office (GLO) records indicate settlement of land irrigated by Canyon Creek Ditch stretched from 1882, prior to ditch construction, to 1910, more than two decades after the ditch became active (GLO 2014). Although the specific settlement pattern of NP land grant property served Canyon Creek Ditch is unknown, it is known that NP property sales in Montana were slow in the late 1800s because of the relatively high prices asked by the railroad for bottomland or land with available irrigation (Cotroneo 1979). This 20-year settlement span indicates the availability of irrigated land along Canyon Creek Ditch did not serve as a unique draw for settlement.

Sluggish settlement along the Canyon Creek Ditch corridor may also account for the relatively slow construction of the irrigation system. Construction of the ditch took three years before it become operational in 1886 (Oravetz 1943:9). This is an unusually lengthy construction period compared to other irrigation projects of the era, further supporting the idea that irrigation alone was not necessarily a strong incentive for settlement in the area. Also, irrigation was usually not developed to its maximum (Oravetz 1943:e-g), and dry farming remained common.

Canyon Creek Ditch was not associated with any notable agricultural activities or events of the late nineteenth and early twentieth centuries. In contrast, the Big Ditch (24YL0664) constructed in 1882-1883 was the first major irrigation project in Yellowstone County. It supplied irrigation to over 17,000 acres, including the large mixed farming “model farm” founded by Frederick Billings in 1882 to showcase a variety of regionally suitable farming techniques (West 1993:168, 192-193). I. D. O’Donnell acquired the farm, known as the Hesper farm, in 1892 and continued its use as a promotional vehicle for agriculture (West 1993:192-193). The Yellowstone County Fair, established by I. D. O’Donnell in 1892, further promoted the agricultural reputation of the region (West 1993:193). The Billings Bench Water Association (BBWA) Canal (24YL0161), was one of the few successful Carey Land Act Projects in Montana (Oravetz 1943:5). It was organized by I. D. O’Donnell under the Billings Land and Irrigation Company in 1903 and brought irrigation to over 19,000 acres, most of which is on the bench above the valley rim. The BBWA irrigation system did have a notable impact on agriculture and settlement patterns in the area. The Huntley Project Irrigation District (24YL1504), authorized in 1905, was one of the first and most successful Reclamation Service early western irrigation projects (Axline and Brownell 2013:11). It ultimately became the largest irrigation system in Yellowstone County, serving over 28,000 acres (Oravetz 1943:e). By comparison, the Canyon Creek Ditch served about 7,000 acres and was merely one of many irrigation systems in the county that had a general association with the agricultural development and settlement of the area.

No particular individuals are associated with the Canyon Creek Ditch Company (Oravetz 1943:8-10). This is not unusual. Most irrigation ditch companies of the era were formed by a mix of local investors with no particular ties to irrigation development, along with occasional outside investors (Oravetz 1943). The only individual who stands out in relation to regional irrigation development is I. D. O'Donnell, a prominent Billings entrepreneur and land developer who was associated with the Big Ditch, BBWA Canal and the Suburban Ditch (Oravetz 1943). He was *not* associated with Canyon Creek Ditch.

The architecture and construction methods of the Canyon Creek Ditch conveyance system are common. The canal and lateral distribution system is comprised of open, unlined ditches. The headgate and checks recently observed are replacements of the original components (Wagers 2014). They are made of concrete with cast iron fittings, which are still utilized in modern irrigation component manufacture. The irrigation system is not known to have any unique design or construction methods. In contrast, the BBWA Canal has a tunnel under the Rimrock, which is an unique feature built in response unusual engineering needs for bringing irrigation to the bench. By comparison, the Canyon Creek Ditch conveyance system has no unusual architectural features and no unique engineering design problems to overcome.

Conclusion

Construction of Canyon Creek Ditch (24YL0171) was simply one of at least 42 irrigation systems developed in Yellowstone County in the late nineteenth and early twentieth centuries (Oravetz 1943:e-g). Most of these systems are situated in the Yellowstone Valley. Thus, irrigation systems are relatively common in the area. A review of the historic context associated with Canyon Creek Ditch reveals the site has no unique or significant association with the agricultural development and settlement of the Laurel and Billings area in Yellowstone County. Further, it does not have any association with important individuals nor does it exhibit unique architecture or engineering. Information indicates there are historically significant irrigation systems in the area, but that Canyon Creek Ditch is *not* one of them.

Recommendations

Canyon Creek Ditch is recommended not eligible for NRHP listing under Criterion A because it has only a ***general association*** with the trends of agricultural development and settlement in the area. Irrigated bottomland is such as that served by Canyon Creek Ditch, is unquestionably prime agricultural land in the region. Yet, the fact that land served by this system remained available for patent as late as 1910 indicates other available agricultural land options were at least equally attractive to settlers. The three year construction period for the system is relatively long, considering most irrigation system built in the 1880s and 1890s were completed within a year, including the earlier and much larger Big Ditch irrigation system. A possible reason for the slow construction of Canyon Creek Ditch may be that area population actually declined in the late 1880s, which further supports the idea that Canyon Creek Ditch had no unique influence on area settlement. Thus, there is no indication the Canyon Creek Ditch has direct association with any *specific* significant events associated with the agricultural development and settlement of the area. The NRHP guidelines clearly state "Mere association with historic events or trends is not enough, in and of itself, to qualify under Criterion A" (National Park Service 1997).

Canyon Creek Ditch is recommended not eligible for NRHP listing under Criterion B because there is no particular individual associated with the project. This is common for most irrigation project in Yellowstone County.

Canyon Creek Ditch is recommended not eligible for NRHP listing under Criterion C because it has no unique design characteristics as a water conveyance system, which refers to the irrigation system infrastructure that diverts water from a source and carries it to its destination. Many of the original structures have also been replaced due to normal operation wear.

Canyon Creek Ditch is recommended not eligible for NRHP listing under Criterion D because there is no indication the site has potential to yield significant information about the history of the area. Everything about the irrigation system history, association and construction indicates there is nothing unique about it.

***SHPO Comment*:** "prior to concurring with the determination that it [Clarks Fork Irrigation Ditch (24YL0172)] is ineligible, we would like to know if it is directly associated with any NRHP-eligible homestead/farmsteads.

Response: There are no NRHP-eligible homestead/farmsteads *directly* associated with the Clarks Fork Irrigation Ditch (24YL0172). Homestead/farmsteads do not have direct significant association with irrigation ditches because irrigation systems operate in two distinct parts: the water conveyance system and the application of water to land (i.e., farming methods) [Etcheverry 1916]. The first part, water conveyance system, refers to the irrigation system infrastructure that diverts water from a source and carries it to its destination. The second part, application of water to land, refers to the use of irrigation water once it leaves the conveyance system. Administratively, water conveyance systems are usually the responsibility of government or corporate entities that create and maintain them, and the application of water to land is the responsibility of individual farmers.

Irrigation sites, such as 24YL0172, only include the conveyance system (e.g., canal and laterals) because that is the extent of the site's design and administrative function, which defines the site boundary. This is all that is needed for recording and evaluating the NRHP eligibility of an irrigation system. Application of water to land is separate not only because it is administratively independent, but also because the individual application methods and water use needs of each farmer served by the conveyance system change frequently. Land may go years or decades with no active irrigation and then suddenly be irrigated again, or the land water use may change significantly on a yearly basis. Thus, the application of water to land aspect of irrigation is not directly associated with the water conveyance system.

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June 3, 2014

Mr. Charles Bello
Environmental Planning/Historic Preservation Section
FEMA, Region VIII, Denver Federal Center
Building 710, Box 25267
Denver, CO 80225-0267

RE: City of Laurel Water Treatment Plant Intake Feasibility Study
Yellowstone County, Montana

Dear Mr. Bello:

Thank you for the letter (received May 16, 2014) regarding the proposed City of Laurel Water Treatment Plant Intake in Yellowstone County, Montana. We concur with the determination that 24YL1992 (farmstead) is eligible for listing in the National Register of Historic Places (NRHP) and that 24YL1991 (farmstead) is not eligible. We have a couple of questions and comments regarding the two identified ditches, 24YL0171 (Canyon Creek Irrigation Ditch) and 24YL0172 (Clarks Fork Irrigation Ditch).

We do not agree the determination that 24YL0171 is ineligible for listing in the NRHP. According to the provided information, 24YL0171 is directly associated with 24YL1992, a NRHP-eligible farmstead. Furthermore, although not the oldest or largest irrigation ditch in the district, 24YL0171 was vital to the agricultural development and settlement pattern of the area.

In regard to 24YL0172 (Clarks Fork Irrigation Ditch), we agree that it is a minor irrigation system compared to others in Yellowstone County. However, prior to concurring with the determination that it is ineligible, we would like to know if it is directly associated with any NRHP-eligible homestead/farmsteads.

If you have any questions or concerns, do not hesitate to contact me at (406) 444-0388 or kore@mt.gov. Thank you for consulting with us.

Sincerely,

Kathryn Ore
Review and Compliance Officer
Montana State Historic Preservation Office

File: FEMA – 2014 – 2014051613

City of Laurel Water Treatment Plant Intake Feasibility Study: Results of a Class III Cultural Resource Inventory in Yellowstone County, Montana

Prepared by:
Scott Wagers
Ethnoscience, Inc.
4140 King Avenue East
Billings, MT 59101

Prepared for:
Great West Engineering
P.O. Box 4817
Helena, MT 59604

May 2014

Confidential information submitted under 10 CFR 2.390. Disclosure is limited under the National Historic Preservation Act, Section 304 (16 USC 470w-3(a)

Abstract

A recent Yellowstone River channel shift compromised the City of Laurel water intake structure to draw sufficient water from the river on a consistent year-round basis. This problem has adversely affected the city water supply system, resulting in water shortages that pose a sever threat to public health and safety. The Federal Emergency Management Agency (FEMA) Public Assistance Program proposes the construction of a new water intake structure within the main channel of the Yellowstone River upriver from its present location to ensure sufficient water supply and alleviate this threat to public health and safety. The proposed water intake replacement project involves the installation of a pair of buried 30-inch diameter water pipelines over a distance of approximately three miles between the proposed new intake location and the City of Laurel water treatment plant.

Ethnoscience was contracted by Great Western Engineering to conduct a Class III cultural resource inventory along the proposed Laurel Water Intake replacement project corridor to meet National Historic Preservation Act Section 106 compliance prior to construction. The cultural resource inventory examined about 73 acres. Four historic sites were identified within the project corridor: two irrigation ditches (24YL0171 and 24YL0172) and two historic homesteads (24YL1991 and 24YL1992).

One site is recommended eligible for National Register listing. Site 24YL1992 (farmstead) is recommended eligible under Criterion C. The remaining three sites, 24YL0171 (Canyon Creek Irrigation Ditch), 24YL0172 (Clarks Fork Ditch) and 24YL1991 (farmstead) are recommended not eligible for National Register listing.

The current pipeline alignment presented in this report is preliminary, and may be realigned during the final design phase. The current alignment crosses the Canyon Creek Ditch (24YL0171) once and the Clarks Fork Ditch (24YL0172) twice. The alternative alignment crosses the Canyon Creek Ditch four times and the Clarks Fork Ditch four times. Pipeline construction will involve trenching through the ditches. The ditches will then be restored to their pre-trenching condition upon completion of construction. It is recommended the project will have no adverse effect on sites 24YL0171 and 24YL0172 provided the ditches are restored at the end of construction.

Table of Contents

Figures

1. INTRODUCTION

Flooding on the Yellowstone River in the spring of 2011 caused a river channel shift, compromising the ability of the City of Laurel (City) water treatment plant raw water intake to draw sufficient water from the river to supply the City's needs on a consistent year-round basis. In January 2012, low water over the submerged intake resulted in excessive ice buildup on top of the intake structure. Slush ice developed on the intake screen temporarily shut down the water intake line to the CHS Oil Refinery because the City was unable to meet their domestic water demand. Subsequent developments concerning City water availability due to intake unreliability pose a severe threat to public health and safety and must be corrected as soon as possible. This project seeks to implement a long-term solution that will provide a reliable municipal water supply to the residents and businesses of the City of Laurel. Project funding will come from the Federal Emergency Management Agency (FEMA) Public Assistance Program.

The proposed project undertaking includes construction of a new water intake structure within the main channel of the Yellowstone River upriver from its present location, and the installation of a pair of buried 30-inch diameter water pipelines over a distance of approximately 3-miles to the City water treatment plant (Figure 1.1). The water pipelines would be buried to a depth of 6-feet beneath ground surface. Great West Engineering contracted Ethnoscience, Inc., (Ethnoscience) to conduct cultural resource investigations to identify the presence or absence of significant cultural properties within the project area. This report documents the results of the 2014 field investigations.

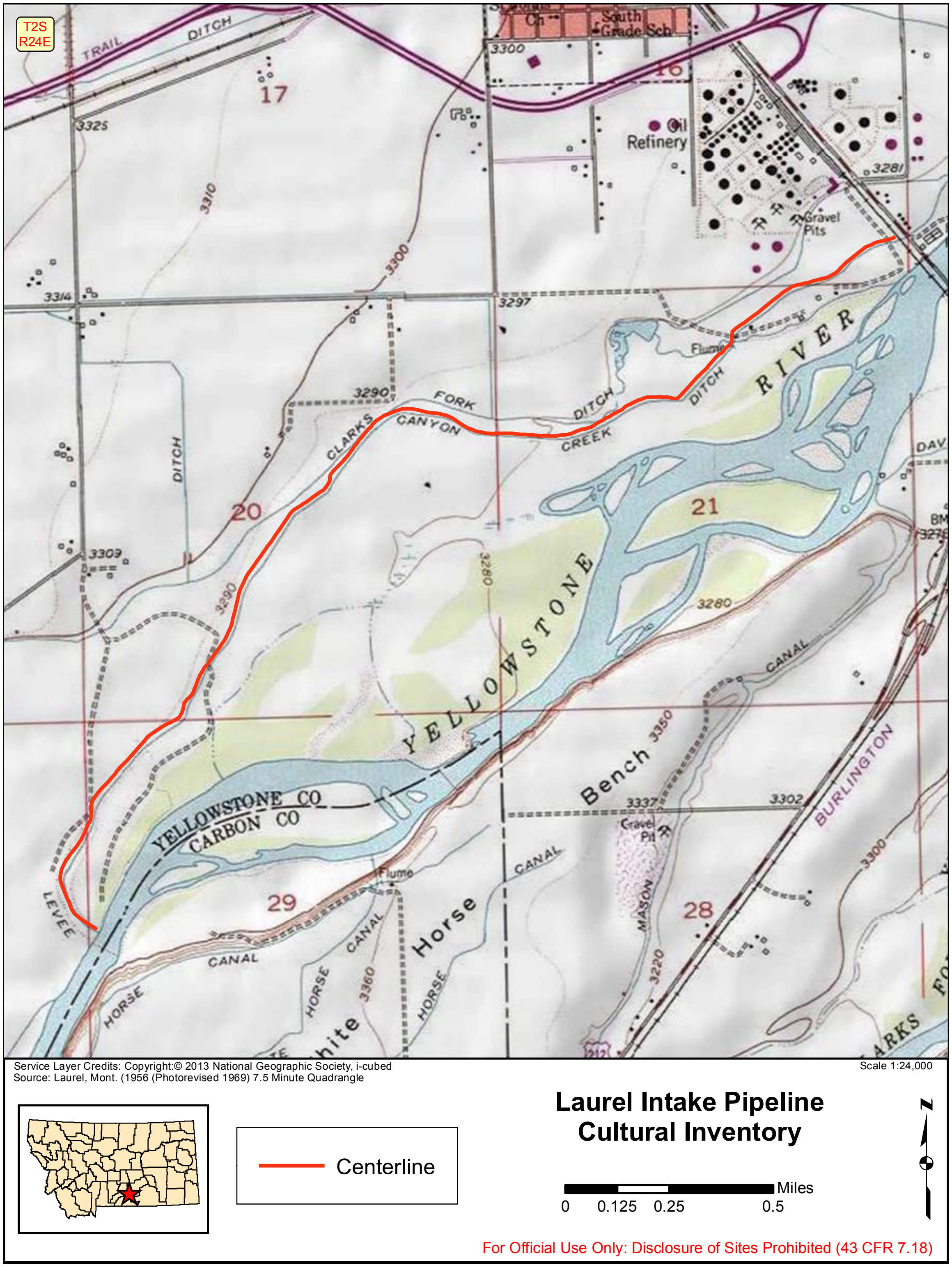

Figure 1.1. Topographic map showing cultural resource inventory centerline

2. ENVIRONMENTAL SETTING

The project area is located within the Yellowstone River valley adjacent to the city of Laurel, Montana. The underlying geology of the area is characterized by exposures of Late Paleozoic and Mesozoic Formations. Haverson loams, Glenberg loams and Alluvial land (mixed, wet, and seeped) soils typify the project area (USDA 1972).

The project area crosses Undifferentiated Stream and Lake Bottoms vegetative environment (Payne 1973). This vegetation environment typically consists of western wheatgrass, bluegrass, cheatgrass broam, needle-and-thread, blue gamma, saltgrass, lambsquarter, goosefoot, sunflower, stickseed, willow, and cottonwood. Some of this vegetation still exists; however, much of the valley is cultivated or associated with residential areas that do not exhibit this vegetation (Figure 2.1).

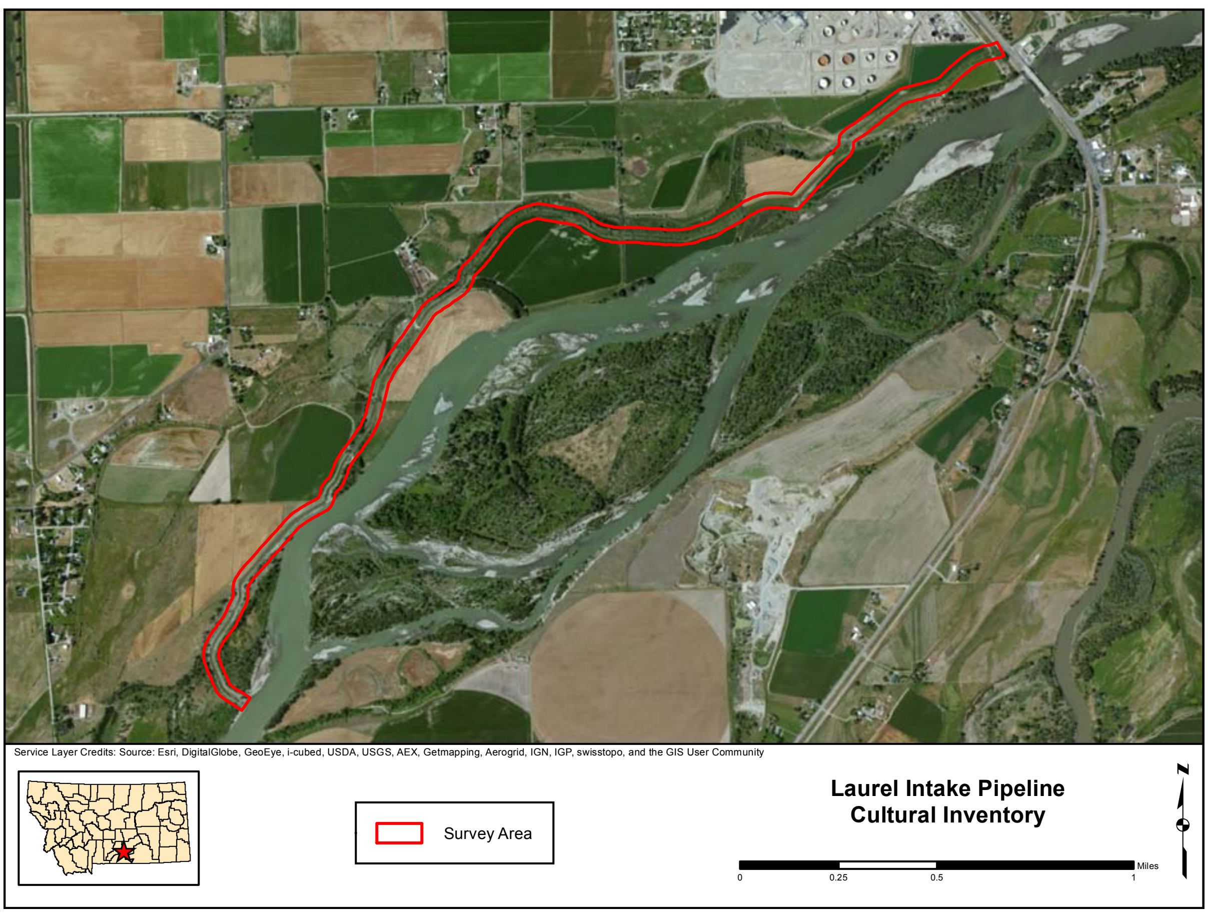

Figure 2.1. Aerial photograph showing the environment within the cultural resource inventory area

3. CULTURAL SETTING

The Corps of Discovery is the first known Euro-American expedition to explore the vicinity of the project area. While returning from the West Coast in June 1806, William Clark rendezvoused with Sergeant Nathaniel Pryor and camped at the mouth of the Clarks Fork River, near the present site of Laurel, Montana (Lewis and Clark 1965:III:1146-1147). The Corps of Discovery brought back information regarding the abundance of resources in the west. This inspired numerous companies to investigate the economic potential of the Missouri and Yellowstone River valleys in Montana.

Fur traders came to the region immediately after the Corps of Discovery's return. Manuel Lisa established Fort Raymond in 1807 at the confluence of the Bighorn and Yellowstone rivers in the hopes of controlling the fur trade in the region. The venture quickly failed because of hostilities with the Blackfoot Indians. However, Fort Raymond is important not only because it represents an early occupation of Euro-Americans along the Yellowstone River, but also because it revolutionized the manner in which trade was conducted in the region. For the first time, permanent trading posts were placed at strategic locations that functioned as depots for furs coming in and supplies going out (Hunt 1989). This became a standard business model for subsequent fur trade companies in the region.

John Colter, veteran of the Corps of Discovery, made two trips up the Yellowstone to the Three Forks area of Montana working for Manuel Lisa in 1808-1809 (Brown 1969:59). These trips acerbated the already strained relationship with the Blackfoot Indians. Two of Lisa's partners in the Missouri Fur Company attempted to establish a fort at Three Forks in the summer of 1809, but were unsuccessful. Others soon followed. Although there are no documents of specific activities in the present-day Laurel area during the fur trader era, traders and trappers were likely quite familiar with the area.

In 1851, several treaties between the federal government and regional Plains Indian tribes were signed at Fort Laramie in present-day Wyoming. These treaties delineated the boundaries of tribal territories and allowed passage across the territories in exchange for payments to the tribes. The area of present-day Laurel was situated within Crow territory.

On March 31, 1853, the Army Appropriation Act directed the Army Corps of Engineers to "make such explorations and surveys as [the army] might deem advisable, in order to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific Ocean" (Hunt 1989:46). Isaac Stevens, governor of Washington Territory, led the northernmost exploration party. A portion of his party, led by Lieutenant John Mullen, explored the Yellowstone River from the east and came near present-day Laurel before heading north to Fort Benton.

By 1856, the Yellowstone River was a well-known travel route for trappers and traders. The U.S. War Department, however, required accurate maps of the region for military planning. The government formed two Yellowstone Expeditions in the late 1850s and charged them with mapping the Yellowstone River. The mapping project was begun by Lieutenant Governor K. Warren in 1856 and completed by Captain William F. Reynolds in 1859. Lieutenant Henry E. Maynadier primarily compiled the Yellowstone River map of the Laurel area in 1859 (Brown 1969:116-117). Maynadier noted that the broad valley of the Yellowstone was most suitable for a railroad (Brown 1969:123).

Travel along the Yellowstone increased dramatically in the 1860s, after the discovery of gold in southwestern Montana at Bannack in 1862. Gold discoveries in Montana also occurred along Alder Gulch in 1863 and Last Chance Gulch, near Helena, in 1864. The finds triggered a rush of prospectors into western Montana and northern Wyoming. Transportation routes crossed prime Indian hunting grounds and the federal government built army posts to protect them (Kooistra-Manning et al. 1993). Most prospectors travelled to the previously identified gold fields, but some explored areas within Indian Territory for fresh opportunities. The Homestead Act also began attracting settlers to the region, including the Yellowstone Valley.

The Homestead Act of 1862 (12 Stat. 392) allowed for settlers to claim 160 acres of public land. A settler received a patent for the property if he or she had resided on the property for five years and made sufficient property improvements. Ranches appeared in eastern Montana in the mid 1860s to supply foodstuffs for the growing population of gold miners in southwest Montana. Tensions soon mounted between settlers and Indians, and by 1865 angry Crow Indians began threatening settlers invading their territory. Fearing for their safety, many early settlers moved out, but also protested to the government for further Indian containment.

The Fort Laramie Treaty was revised in 1868 in response to the gold rush and westward settlement. The revised treaty terms reduced the Crow Reservation to an area south of the Yellowstone River. Laurel was now open to settlement, but the continuing hostilities in the region kept settlers away.

The Yellowstone Wagon Road and Prospecting Expedition was formed in 1874 to identify a toll road route along the Yellowstone Valley from the Tongue River to the Gallatin Valley. This private venture sought to improve trade in and out of the Gallatin Valley and establish a trade post along the Tongue River. The expedition was unsuccessful, however, and only succeeded in increasing tension between regional White and Indian populations (Hutchins 1958).

Tensions between Whites and Indians came to a head in 1876. On June 25, 1876, George Armstrong Custer and 210 men under his command were killed in the Battle of the Little Bighorn. News of their deaths was received in the east a week later, during the centennial Independence Day celebrations. Public outrage led to the increase of military effort on the Northern Plains to subdue the Indian populations.

In 1877, a band of 700 Nez Perce Indians resisting settlement on a reservation in Idaho attempted to escape military pursuit by fleeing to Canada. Under the leadership of Chief Joseph, the Nez Perce group crossed the Yellowstone River at Laurel during their attempt to reach Canada. An army pursuit force under the command of Colonel Samuel Sturgis caught up with the Nez Perce at Canyon Creek, six miles north of present-day Laurel. A battle ensued, but the Nez Perce escaped and continued fleeing north. Their desperate attempt to reach Canada ended on October 5 after their defeat at the Battle of the Bear Paw near present-day Chinook, Montana (Josephy 1965; Malone et al. 1991).

The Indian Wars effectively ended in 1877, opening the western Yellowstone Valley for settlement. The demand for the land along the Yellowstone River led to a further reduction in the Crow Reservation in 1882. At this time, the Crow gave up all rights to land west of the Boulder River. More land was removed in 1891, reducing the Crow Reservation to its present size. The additional land in the Yellowstone Valley was soon available for homesteading (Burlingame and Toole 1957:1:115).

Charlie R. Rugg was the first homesteader to settle in the Laurel area in 1879 (Johnston 1979:3). O. C. Bundy (1880), Lou A. Nutting (1881) and Ed L. Fenton (1882) soon followed him [Johnston 1979:3]. One of the most colorful people to occupy the area around Laurel was Martha Jane Canary, better known as Calamity Jane. In the early 1880s, Calamity Jane settled near the location of the 1877 Canyon Creek battlefield, where she cooked for stagecoach passengers and sold timber. In 1883, she was involved with horse rustling (Johnston 1979:43). She lived on the property until 1895. When she died in 1903, she bequeathed the property to her daughter Janey Hickock O'Neil.

The town of Laurel did not form until after the arrival of the railroad in the 1880s. The Northern Pacific railroad (NP) constructed its main line through the area in 1882 and established a station two miles west of present-day Laurel. The station, known as Carlton, was described in the 1883 NP guidebook as "an unimportant station" 18 miles west of Billings (Johnston 1979:3). The station name was changed to Laurel later that year, but the source of the name change remains uncertain.

The town of Laurel was first platted in 1889 about one mile west of the current location (Johnston 1979:3). The town was situated at the junction of the NP and the Rocky Fork and Cooke City railroad (Johnston 1979:11). The businesses that had formed near the previous station location soon followed. The community of Laurel moved to its present location in 1902, when the NP constructed a new depot. A new town plat was filed and the previous town site became locally known as Old Laurel. The new town of Laurel grew rapidly, due in part to the NP placement of a section house, switchyard and car shop there. The town of Laurel was incorporated in 1908 (Johnston 1979:4). As the town of Laurel grew around the railroad, farming and ranching grew around the town of Laurel.

One of the attractions to farming in the vicinity of Laurel was the development of irrigation projects. Irrigation systems were constructed in the vicinity of Laurel beginning in the early 1880s. The Canyon Creek Irrigation Ditch was built by the Yellowstone and Canyon Creek Ditch Company (Oravetz 1943:8). Construction began in 1883 and was completed in July 1886. It was first used to irrigate fields in April 1886. The ditch has appropriation rights to 4000 miner inches (100 cubic feet per second) of water from the Yellowstone River. The ditch empties into the Billings Bench Water Association Canal. The ditch is capable of irrigating over 7,000 acres. The Clarks Fork Ditch was built by the Clarks Fork Ditch Company in 1891 (Oravetz 1943:10). L. Nutting, L. A. Nutting and William Bode of Laurel excavated the Clarks Fork Ditch. The ditch originates in Section 19, T2S R24E, at what was once a small slough. Much of the slough has been converted into a small residential development. The ditch was constructed to be nearly four miles in length. At its peak, the ditch provided irrigation to six customers for a combined total of only 661 acres. The ditch empties into the Billings Bench Water Association irrigation system in Section 14, T2S R24E, Yellowstone County. Both of these ditches are within the project area.

The presence of irrigated lands allowed the development of the sugar beet industry in Laurel area of the Yellowstone valley. The Great Western Sugar Company constructed a sugar beet refining plant in Billings in 1906. It began operation that same year. The first crop of sugar beets was planted near Laurel in 1906 (Johnston 1979:6). The sugar beet industry attracted a new wave of settlers to the region, including many ethnic German-Russians.

Evangelical Volga Germans came to Laurel both directly from Kautz, Russia, and by way of Nebraska and Colorado to work the beet fields and establish their own farms (Sallet 1974:51). Sallet (1974:81) argues the “Volga German sugar beet workers owe their economic success only to their family ties.” The families were patriarchal and had a strong work ethic. Until the sons were married, they often hired out for wages and sent the money home to rent or buy land for the family to farm. Within five years of moving to the United States, most German-Russian families owned their own home; and by the 1930s, more than half of the sugar beet farms in Montana were in the hands of Volga German farmers (Sallet 1974:83). Many of the German families moved to the south side of the tracks in Laurel and the area was referred to as German Town (Johnston 1979:4).

Continued railroad development in Laurel was a key factor of community growth in the early 20th century. By 1906, James Hill, president of the Great Northern railroad (GN), had gained control of the NP and the Chicago, Burlington and Quincy (CB&Q) railroads. He decided to make Laurel a juncture for these three railroads, and developed new railroad facilities at Laurel over the next decade. When completed, Laurel boasted the largest railroad terminal yards, roundhouse, machine shops and switching yards between St. Paul, Minnesota and Seattle, Washington. The NP also constructed many houses at the east end of town in 1909 to house the expanded workforce. This area was referred to as Railroad Town until the 1940s (Johnston 1979:4). Boxcars were also placed in rows on the south side of the tracks to house railroad families. Many of the Chinese railroad workers also lived in this section of Laurel (Johnston 1979:4).

In 1927, oil was discovered in the Oregon Basin field south of Cody, Wyoming. This led to the creation of the Laurel Oil and Refining Company plant in 1930. The new plant had an oil refining capacity of 2,500 barrels of crude per day. Laurel was a natural choice for a refinery because the junction of three railroads allowed finished products to be shipped by rail in every direction (Johnston 1979:99). Unfortunately, the plant immediately ran into problems. The sulfur content of the oil was too high, and the refiners could not find a way to correct the problem. In 1931, the refinery was closed down and went bankrupt. In 1933, the Independent Refining Company was organized and took over the refinery. Other sources of crude with lower sulfur rates were found and trucked to the Laurel plant. For the next two years, the refinery produced automobile gasoline, asphalt and road oil. In 1935, the refinery was converted to a Donnelly Thermal Cracking Unit. The largest outlet for the refinery products was to the Farmers Union Central Exchange (Farmers Union). In 1943, Farmers Union bought the refinery and enlarged the plant. In 1972, Farmers Union officially changed its name to CENEX (Burlingame and Toole 1957:1:124-125; Johnston 1979:99-103). CENEX merged with Harvest States

Cooperative in 1998 to form CHS, Inc., which currently owns the Laurel refinery. In 2005, the refinery became the first in Montana to produce ultra-low sulfur diesel fuel. Today, the refinery is the largest employer in Laurel.

4. METHODS

Ethnoscience requested a files search from the Montana State Historic Preservation Office (SHPO) prior to fieldwork. The files search included Sections 16, 20, 21, 29, and 30, T2S R24E, Yellowstone County (Files Search # 2013030611). All reports and site forms associated with the current project area were obtained and reviewed. General Land Office (GLO) maps and their associated surveyor notes were also examined to identify possible site leads.

Ethnoscience archaeologist Scott J. Wagers and technician Spencer Propp conducted the inventory on April 21-22, 2014. The project area is located on an agricultural landscape of cultivated fields and pastures immediately north of the Yellowstone River. Very little natural prairie remains within the project area. The inventory corridor is 200 feet wide and extends 100 feet on either side of the Canyon Creek Ditch. The inventory corridor totaled nearly 3 miles in length. Survey transects were spaced at 30 m intervals. The project area consists of approximately 73 acres.

Prehistoric sites are defined as one stone feature and/or five artifacts within a 50 square meter area. Historic sites are defined as any cultural feature (buildings, foundation, etc.) or five or more historic cultural materials of at least three different material types within a 50 square meter area that are at least 50 years old. Exceptions are fence lines and application-to-field ditches, which are not recorded as sites. Also, the Rocky Fork and Cooke City railroad (24YL1533) is adjacent to, but outside of the cultural inventory area and is not addressed in this report. The proposed water pipeline will bored under the railroad, thus having no effect on the site. U.S. Highway 212 will also be bored under.

When sites were encountered, they were described and documented on Montana Cultural Resources Information System forms. Named irrigation ditches were documented on Historic

Irrigation Ditch Inventory forms. Site area was based on surface distributions of features and artifacts. A scaled sketch map of each site was drawn, and photographs were taken of each feature within a site and a site overview. No cultural material was collected or removed from the sites.

Historic information about the sites was obtained from a variety of sources**.** Water resource records were reviewed to obtain information regarding the irrigation ditches. Deed and assessor records in the Yellowstone County Court House were used to document historic site ownership and development. Finally, the Montana Historical Society archives in Helena, the Western Heritage Center in Billings, and the Billings Public Library were consulted for information regarding the project area.

5. PREVIOUS INVESTIGATIONS

Two previous cultural resource investigations were conducted within portions of the current inventory area.

In 1983, Historical Research Associates conducted a cultural resource inventory of a proposed power line corridor (Caywood et al. 1984). The 1983 inventory did not identify any cultural resources within the current project area.

In 1985, GCM Services conducted a cultural resource inventory for a proposed Yellowstone River bridge replacement along U.S. Highway 212 (Fredlund 1986). The 1985 inventory documented two irrigation ditch sites, 24YL0171 and 24YL172, east of Highway 212. Portions of both of these ditch sites are within the current project corridor, but are located west of and outside of the 1985 project area

6. RESULTS

The cultural resource inventory for the Laurel Water Intake Project investigated approximately 73 acres. Four sites were identified within the project corridor (Figure 6.1). Two sites are irrigation ditches, and the other two are a historic residence and a historic farmstead.

Site 24YL0171 Update

Site 24YL0171 is the Canyon Creek Irrigation Ditch. Approximately three miles of the ditch was examined for this project, starting at the Point of Diversion (POD) in Section 29, T2S R24E, and ending at a culvert under the BNSF railroad and US Highway 212/310 in Section 16, T2S R24E, Yellowstone County. The site is a well-maintained, operational irrigation system, which was active at the time of the inventory.

The main canal consists of an unlined ditch that measures 14 feet wide at its top. Historic records state the ditch is 10 feet wide at the bottom and 2 feet deep (Oravetz 1943:9). Subsequent investigation of the canal, however, indicates it is 10 feet deep (Fredlund 1986).

The headgate at the POD is a large concrete structure with three steel lift gates. The headgate measures 13 feet north-south by 44 feet east-west. It is situated along the north bank of the Yellowstone River.

Two checks, used to control water depth and flow within the system, were encountered along the inspected segment of the main canal. Check 1 and Check 2 are large concrete structure with three steel lift gates. Check 1 measures 30 feet north-south by 13 feet east-west. Check 2 measures 20 north-south by 6 feet east-west.

The main canal also has a flume and a crossing. The flume is a corrugated steel half-pipe that carries water across Canyon Creek, a natural drainage that empties into the Yellowstone River.

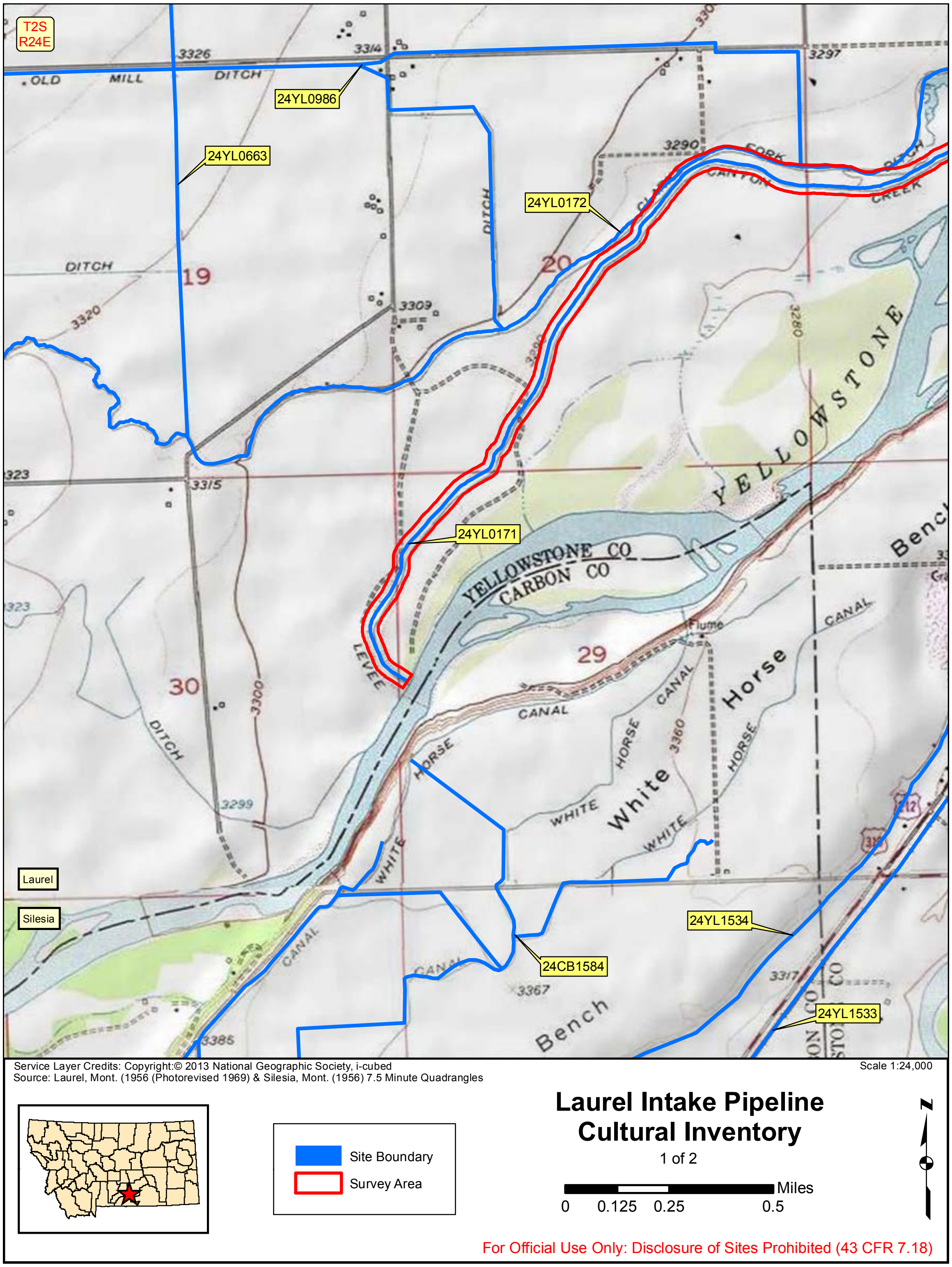

Figure 6.1. 1:24,000 topographic map of the project area showing new and previously recorded sites

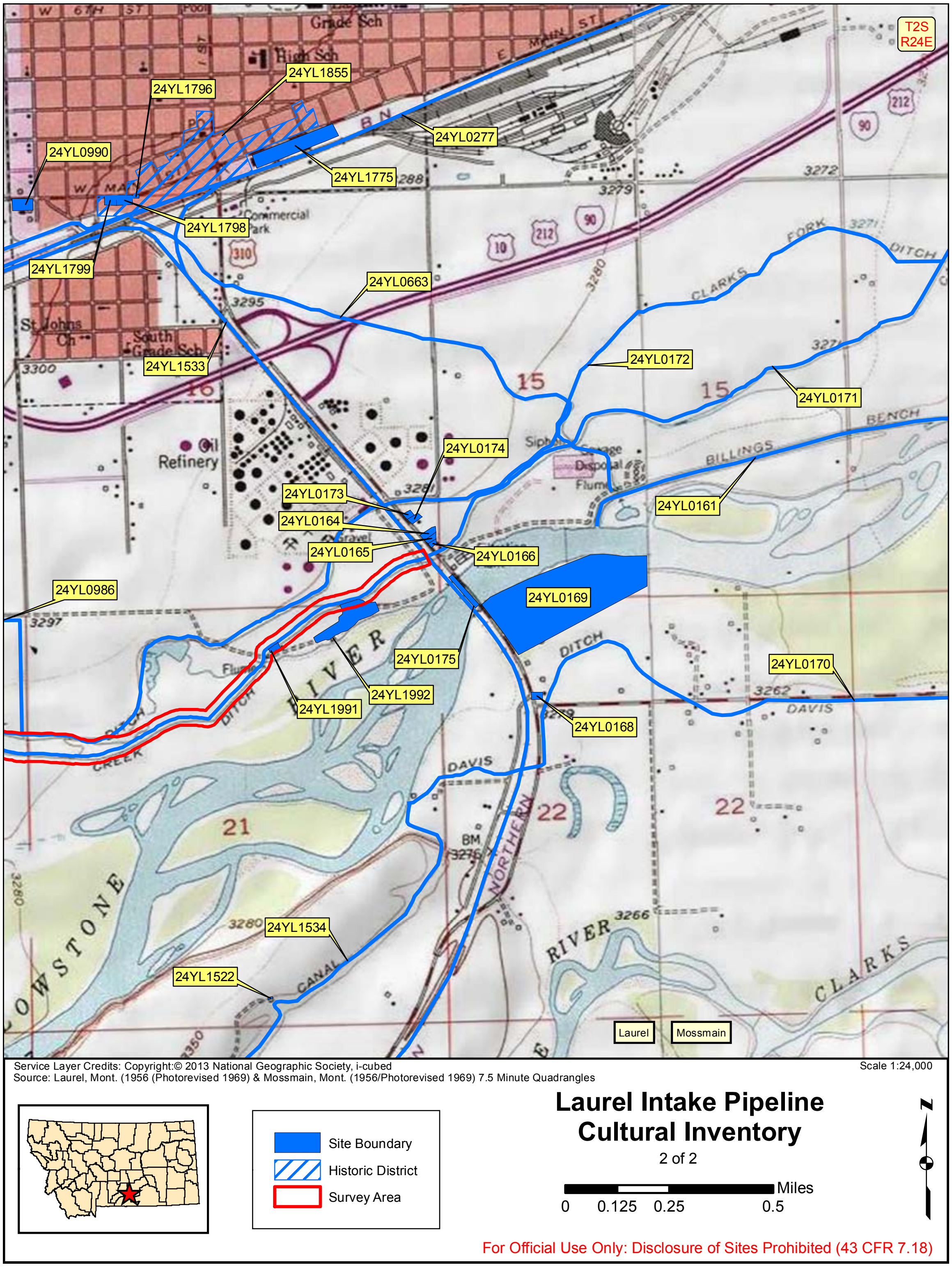

Figure 6.1. 1:24,000 topographic map of the project area showing new and previously recorded sites- concluded

The flume measures 70 feet north-south by 10 feet east-west. The crossing consists of a steel pipe with a concrete wing wall and a steel lift gate. The crossing pipe extends beneath a 12-foot wide field access 2-track and empties into a natural drainage that flows into the Yellowstone River.

History

The Yellowstone and Canyon Creek Ditch Company built the Canyon Creek Irrigation Ditch. Construction began in 1883 and was completed in July 1886. It was first used to irrigate fields in April 1886. The ditch has appropriation rights to 4000 miner inches (100 cubic feet per second) of water from the Yellowstone River. The irrigation system is capable of irrigating over 7,000 acres. The ditch empties into the Billings Bench Water Association Canal.

Integrity

The site retains integrity of location, design, setting, and feeling and association as an irrigation ditch. The site lacks integrity of materials and workmanship because most of the original structures have been replaced or because they are not relevant to an unlined ditch.

Recommendation

The site's current NRHP eligibility status is officially listed as unresolved. Previous site eligibility recommendations are mixed, with recommendations of not eligible under any Criteria, eligible under Criterion A, and unknown pending further work. The current investigation recommends the site as not eligible for listing in the NRHP under Criteria A, B, C, and D. Canyon Creek Ditch is the second oldest and fourth largest irrigation system in Yellowstone County. Although these facts lend some credibility to historic significance, they do not lend sufficient weight for eligibility under Criterion A because these facts merely address a general association with the historic settlement and agricultural development of the region. In contrast, the Billings Bench Water Association canal brought irrigation onto the bench, which had significant effect of the agriculture and settlement pattern of the region. Furthermore, the Huntley Irrigation Project was the only successful Carey Act irrigation project in the county, and one of only a handful in the state. Thus, the Canyon Creek Irrigation system's claim of being almost the oldest system and a fairly large system are merely general historical associations, which are not sufficient for NRHP eligibility. The site is therefore recommended not eligible for NRHP listing under Criterion A. The site is not associated with any specific individual and is therefore recommended not eligible for NRHP listing under Criterion B. The unlined ditch construction is typical of irrigation systems in the region, and the structures observed are common and exhibit no distinct design or method of construction. The site is therefore recommended not eligible for NRHP listing under Criterion C. The site is unlikely to provided significant information about the history of the area, and is thus recommended not eligible for NRHP listing under Criterion D.

Site 24YL0172 Update

Site 24YL0172 is the Clark Forks Irrigation Ditch. A 1,400-foot segment of the ditch was examined in Section 20, T2S R24E, Yellowstone County. The inspected segment consists of an unlined earthen ditch. The ditch measures 15 feet wide at the top. The ditch depth and bottom width are unknown because it was filled with water at the time of inventory. The ditch segment is part of a well-maintained, operational irrigation system. The proposed undertaking will avoid this irrigation ditch.

History

The Clarks Fork Ditch Company built the Clarks Fork Ditch in 1891. The ditch originates in Section 19, T2S R24E, at what was once a small slough. Much of the slough has since been converted into a small residential development. The ditch was constructed to be nearly four miles in length. At its peak, the ditch served six customers and provided water to a combined total of only 661 acres. The ditch empties into the Billings Bench Water Association irrigation system in Section 14, T2S R24E, Yellowstone County.

Integrity

The site retains integrity of location, design, setting, and feeling and association as an irrigation ditch. The site lacks integrity of materials and workmanship because most of the original structures have been replaced or because they are not relevant to an unlined ditch.

Recommendation

The current site NRHP eligibility status is officially listed as undetermined. It is previously recommended not eligible for listing in the NRHP under Criteria A, B, C, and D. The current investigation supports this recommendation. The Clarks Fork Ditch is a minor irrigation system in Yellowstone County. At its peak, the system irrigated only 661 acres. In contrast, irrigation systems such as the Big Ditch or the Billings Bench Water Association irrigate over 18,000 and 22,000 acres respectively. Thus, the Clarks Fork Ditch did not make a significant contribution to an event or pattern of events important to history of the local community (Criterion A). It is not associated with an important person (Criterion B). The method of construction is an open, unlined ditch, which is not unique (Criterion C). Finally, the site is unlikely to contribute any relevant information to further our understanding of the past (Criterion D).

Site 24YL1991

The site is a historic residence consisting of a cabin, a livestock shed, and three pieces of abandoned farm machinery (Figure 6.2). The site is located immediately adjacent to Canyon Creek Irrigation Ditch (24YL0171) on the south side. The cabin appears to have been abandoned for a few decades and is in a state of severe neglect. The proposed undertaking will avoid this site.

Feature 1 is a cabin (with a lean-to addition) constructed between 1900 and 1920. The main cabin measures 16 feet north-south by 13 feet east-west. It has a wood frame clad with wood plank siding and sits upon a foundation constructed of stacked wood timbers. The south elevation is the front of the cabin and has one door opening and one window opening. The east elevation has one window opening. The west elevation has no features and a lean-to has been added to the north elevation. The cabin has a front gable roof clad with wood shingles and has the remnants of a metal ridge cap; the roof has open eaves and exposed rafters. A lean-to addition is attached to the north elevation of the cabin. It measures 10 feet north-south by 10 feet east-west. It has a wood frame clad with vertical wood plank siding and lacks a foundation. The east elevation has one window opening. The south elevation is attached to the cabin and the west and north elevations lack features. The lean-to has a shed roof covered with wood planks and has close eaves. It appears the lean-to was a later addition to the cabin.

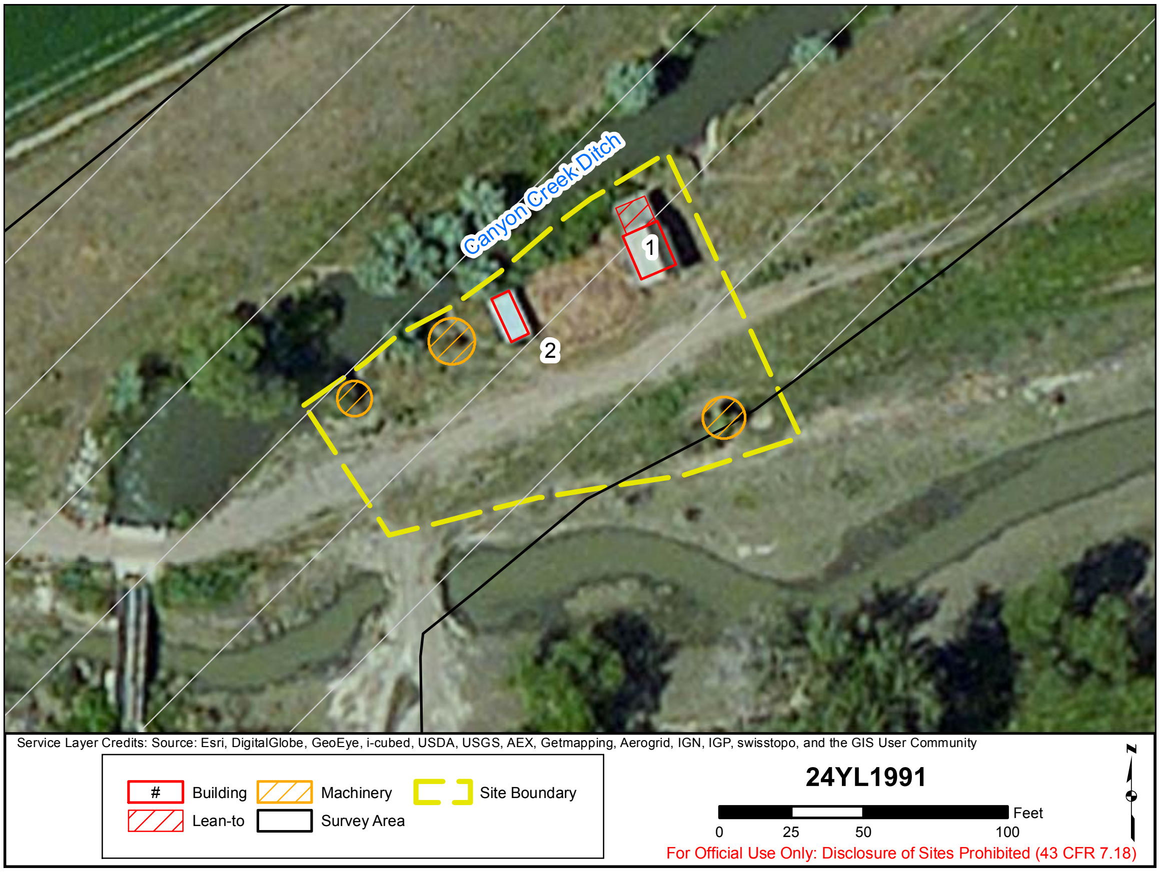

Figure 6.2. Sketch map of 24YL1991

Feature 2 is a small livestock shed that is likely less than 20 years old. It measures 16 feet north-south by 7 feet east-west and has a pole frame clad with plywood with no foundation. The east elevation is open and the remaining three elevations have no features. It has a shed roof covered with corrugated sheet metal. The shed is marked with the S-Bar-S Building Supply Center logo. The S-Bar-S has been in business in Billings from 1971 to the present and it carries several different lines of manufactured sheds.

There are three pieces of farm machinery associated with the site. The first is what appears to be a pre-1920 portable steam engine driven corn husker. There are no identifying makers' marks on the machinery. The second machinery is a pre-1920 horse-pulled reaper frame that a large bush has overgrown and become entangled with it. There are no identifying makers' marks on the machinery. The third machinery is a pre-1920 steam engine-pulled thresher of unknown manufacture.

History

The Northern Pacific Railroad as part of its land grant originally acquired this parcel of land. Lucius and Lillie Nutting obtained the property around 1900, but this date is speculative. Lucius Nutting had settled near Laurel in 1881 on his homestead claim in Section 10, T2S R24E, Yellowstone County. He married Lillie Ellis in 1891 and they had two children, Ruth and Bryant. Lillie died in a car accident in 1926 and Lucius died of natural causes in 1953. The property in Section 21 was given to their son, Bryant, in 1939. Bryant Nutting was born in Laurel in 1894. He and his wife, Sarah, lived at 24YL1992 (a nearby farm) for many years. The Nuttings sold the property in 1973 to George and Marie Streck. By 1992, Robert and Julie Streck owned the property. They sold it to the current owner, CHS, Inc., in 2010.

It is unknown who lived at the cabin, which appears to have been constructed prior to 1920. The context of the site suggests it was a migrant farm labor residence. The migrant laborers likely tended sugar beet fields for the Nuttings. It is uncertain how long the cabin has been abandoned, but estimates range from circa 1940 to circa 1973. The function of the site later shifted to livestock shelter.

Integrity

The site appears to retain integrity of location and setting, but it uncertain if the buildings have been moved. The integrity of design, materials, workmanship, feeling and association has been compromised by a combination of neglect, deterioration and site function change.

Recommendation

The site is recommended not eligible for listing in the NRHP under Criteria A, B, C, and D. The site has a general association with local agriculture development, but that is not sufficient for NRHP eligibility. There is no evidence that the site is directly associated with any significant event or pattern of events (Criterion A). The property owners were typical representatives of regional farmers. The site is not associated with any important person (Criterion B). The buildings lack distinctive style and method of construction (Criterion C). The site is unlikely to contribute any relevant information to our understanding of the past (Criterion D).

Site 24YL1992

The site is a farmstead consisting of 18 features, 16 of which are standing buildings constructed between 1930 and 2002 (Figure 6.3). The property is located on a terrace adjacent to and immediately north of the Yellowstone River. Only Features 1, 2, and 3 are in good condition. The remaining buildings are in various stages of neglect and/or partial collapse. The property retains integrity of location. The proposed undertaking will avoid this site.

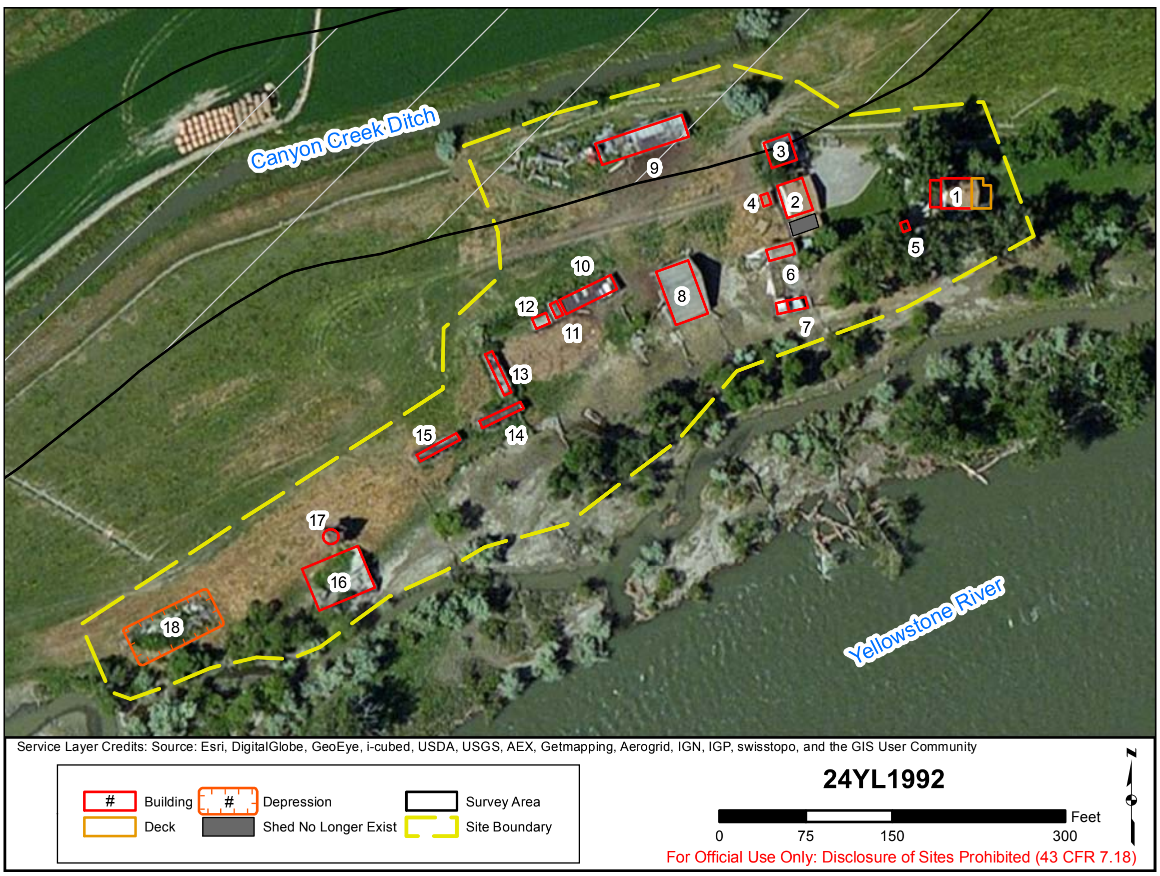

Figure 6.3. Sketch map of 24YL1992

Feature 1 is a two-story Gable-Front style house constructed in 1930 and modified by the placement of new siding and construction of a deck addition circa 1992. The main footprint of the house measures 26 feet north-south by 26 feet east-west. An enclosed one-story porch measuring 23 feet north-south by 10 feet east-west is attached to the west elevation. Feature 1 has a wood frame clad with vinyl siding and is set on a concrete foundation. The east elevation has four 3/1 windows and one 6-light wood door. The north elevation has three 3/1 windows, one 4/1 window, and four 9-light casement windows. The west elevation has two 3/1 windows, eight 9-light casement windows, and one 3-light wood door. The south elevation has four 3/1 windows, one 1-light fixed window, two 1/1 windows, one 2-panel wood door, two 9-light casement windows, and one overhead garage door. The house has a front gable roof, enclosed eaves, and asphalt shingles. A modern wood deck measuring 26 feet north-south by 16 feet east west is attached to the east elevation. The house is oriented to the east.

Feature 2 is a garage constructed in 1991. It measures 30 feet north-south by 23 feet east-west. It has a wood frame clad with composite wood siding and is set on a concrete foundation. The east elevation has one 1-panel steel door and one overhead garage door. The north, south, and west elevations lack features. The garage has a front gable roof, enclosed eaves, and asphalt shingles. The garage is oriented to the east.

Feature 3 is a garage constructed in 2002. It measures 23 feet north-south by 23 feet east-west. It has a wood frame clad with corrugated metal and is set on a concrete foundation. The east elevation has one overhead garage door. The south elevation has one 1-panel steel door while the north and west elevations lack features. The garage has a front gable roof with no eaves and is covered with corrugated metal. The garage is oriented to the east.

Feature 4 is a small pre-fabricated shed made in 1989. It measures 10 feet north-south by 6 feet east-west. It has a wood frame clad with composite wood siding and lacks a foundation. The north elevation has one composite wood door. The remaining three elevations lack features. The shed has a front gable roof, no eaves, and asphalt shingles.

Feature 5 is a small pre-fabricated livestock shed of unknown age. It measures 8 feet north-south by 6 feet east-west. It has a pole frame clad with composite wood siding and lacks a foundation. The north elevation has one door opening. The remaining three elevations lack features. It has a front shed roof, no eaves, and corrugated metal.

Feature 6 is a granary with an estimated construction date of circa 1930. It measures 10 feet north-south by 23 feet east-west. It has a wood frame clad with simple drop wood siding and is set on a concrete foundation. The north elevation has one boarded up door opening; the east elevation has one 4/4 window with no glass; the west elevation has one 1/2 window with no glass; and the south elevation has one window opening and one door opening. The granary has a side gable roof with open eaves and exposed rafters, and is covered with wood shingles.

Feature 7 is a small shed/cabin with an estimated construction date of circa 1930. It measures 10 feet north-south by 10 feet east-west. It has a wood frame clad with simple drop wood siding with corner boards and lacks a foundation. The north elevation has one 1-panel wood door; the west elevation has one boarded up windows; the south elevation has one 4-panel wood door; and the east elevation has an attached partially collapsed livestock shed addition. The shed/cabin has a front gable roof, open eaves and exposed rafters, and is partially covered with corrugated metal. The addition measures 10 feet north-south by 16 feet east-west. The roof has collapsed into the addition. The shed addition is open to the north.

Feature 8 is a Salt Box style bank barn constructed in 1930. It measures 50 feet north-south by 30 feet east-west. It has a post and beam frame clad with board-and-batten wood siding on the north and east elevations, and vertical wood planks on the south and west elevations. The barn has a concrete foundation. The east elevation has one barn door opening and three window openings, and one 2-panel wood door. The south elevation has one barn door opening and one window opening. The north elevation has two window openings. The west elevation has one barn door opening and two window openings. It has a front gable roof with open eaves, wood shingles, and a metal ridge cap with metal end balls. The barn is oriented to the east.

Feature 9 is a partially collapsed machine shed constructed in 1930. It measures 21 feet north-south by 80 feet east-west. It has a pole frame clad with wood plank siding and lacks a foundation. The south elevation is open while the north and east elevations lack features. The west end of the building is collapsed. It has a shed roof covered with wood planks.

Feature 10 is a livestock shed of unknown age. It measures 13 feet north-south by 50 feet east-west. It has a pole frame clad with wood plank siding and lacks a foundation. The south elevation has one door opening and the north, south, and west elevations lack features. It has a shed roof covered with corrugated metal and has open eaves and exposed rafters.

Feature 11 is a small shed with an estimated construction date of circa 1930. It measures 13 feet north-south by 6 feet east-west. It has a wood frame clad with simple drop wood siding and lacks a foundation. The north elevation has one door opening while the remaining elevations have no features. The shed has a front gable roof covered with wood shingles and has open eaves with exposed rafters.

Feature 12 is a small prefabricated shed purchased from the S-Bar-S Building Supply store in Billings in the 1970s or 1980s. It measures 10 feet north-south by 13 feet east-west. It has a wood frame covered with plywood and has no foundation. The south elevation is open and the remaining elevations lack features. It has a shed roof covered with asphalt shingles; the roof is partially collapsed.

Feature 13 is a wooden railroad boxcar converted to a livestock shed. The exterior is covered with wood planks and lacks a foundation. It measures 40 feet north-south by 6 feet east-west. It has a door opening on both the east and west elevations, and no features on the north and south elevations. It has a barrel roof covered with wood shingles. Wood boxcar manufacture ceased around 1920 in favor of steel boxcar construction. As railroads upgraded their equipment, it was common practice to sell the old rail cars to local farmers, who convert them into other uses. Old converted boxcars are a common sight throughout the Yellowstone River valley. It is unknown when this boxcar was moved onto the property.

Feature 14 is a wooden railroad boxcar that has been converted to a livestock shed. The exterior is covered with wood planks and lacks a foundation. It measures 6 feet north-south by 40 feet east-west. It has a door opening on both the north and south elevations, and no features on the east and west elevations. It has a barrel roof covered with wood shingles. Wood boxcar manufacture ceased around 1920 in favor of steel boxcar construction. As railroads upgraded their equipment, it was common practice to sell the old rail cars to local farmers, who converted them into other uses. Old converted boxcars are a common sight throughout the Yellowstone River valley. It is unknown when this boxcar was moved onto the property.

Feature 15 is a wooden railroad boxcar that has been converted to a livestock shed. The exterior is covered with wood planks and lacks a foundation. It measures 6 feet north-south by 40 feet east-west. It has a door opening on both the north and south elevations, and no features on the east and west elevations. It has a barrel roof covered with wood shingles. Wood boxcar manufacture ceased around 1920 in favor of steel boxcar construction. As railroads upgraded their equipment, it was common practice to sell the old rail cars to local farmers, who convert them into other uses. Old converted boxcars are a common sight throughout the Yellowstone River valley. It is unknown when this boxcar was moved onto the property.

Feature 16 is a collapsed barn with an estimated construction date of circa 1930. The debris pile measures 40 feet north-south by 52 feet east-west. The structure is entirely collapsed making the identification of the barn style impossible. An examination of aerial photographs indicates the barn collapsed between May and August 2002.

Feature 17 is an octagon-shaped wooden grain bin with an estimated construction date of circa 1930. It has a diameter of 13 feet. The grain bin was built using the stacked lumber construction method with offset 2x4 corners. The upper half of the building is partially collapsed. The original height of the grain bin was about 25 feet. An examination of aerial photographs indicates the upper portion collapsed between 2006 and 2011.

Feature 18 is a large rectangular depression that has been filled with a variety of debris. The depression measures 30 feet north-south by 75 feet east-west and the depth is unknown due to the debris pile within it. Most of the observed debris is the trunks and limbs of several cottonwood trees. Historic debris included two electric meter boxes, a few sheets of corrugated metal, one iron bed frame, numerous strands of barbed wire, fence posts, a garden hose, one wood pallet, and various fragments of unidentified metal.

Two pieces of farm machinery are located near Feature 9. The first is a McCormick International 151 combine that dates from 1959 to the early 1960s. The second is a New Holland 195 manure spreader, which have been in production since the early 1980s.

History

The Northern Pacific Railroad as part of its land grant originally acquired this parcel of land. Lucius and Lillie Nutting obtained the property around 1900, but this date is speculative. Lucius Nutting had settled near Laurel in 1881 on his homestead claim in Section 10, T2S R24E, Yellowstone County. He married Lillie Ellis in 1891 and they had two children, Ruth and Bryant. Lillie died in a car accident in 1926 and Lucius died of natural causes in 1953. The property in Section 21 was given to their son, Bryant, in 1939. Bryant Nutting was born in Laurel in 1894. He and his wife, Sarah, lived at 24YL1992 (a nearby farm) for many years. The Nuttings sold the property in 1973 to George and Marie Streck. By 1992, Robert and Julie Streck owned the property. They sold it to the current owner, CHS, Inc., in 2010.

Features 1, 8, and 9 are known to have been constructed in 1930 and are related to the Bryant and Sarah Nutting occupation of the property. Features 6, 7, 9, 11, 16, and 17 appear to have been constructed circa 1930, and are also associated with the Bryant and Sarah Nutting ownership of the property. Features 13, 14, and 15 were probably moved onto the property in the 1940s or 1950s. It is unknown when Features 5, 10, and 18 were constructed. Features 2, 3, and 12 are modern and are associated to the Streck ownership of the property.

Integrity

The site retains integrity of location, design, setting, materials and workmanship. The integrity of feeling and association has been compromised because it is no longer an active farm.

Recommendation

The site is recommended eligible for listing in the NRHP under Criterion C. The site has two contributing features. Feature 8 is a Salt Box style bank barn, which is a rare architectural style for the area. Feature 17 is an octagon-shaped wood grain bin, which is a rare architectural style that also exhibits a unique method of construction (stacked lumber with off-set 2x4 corners).

Although both features show deterioration or damage, they are able to convey their historic character. The site is recommended not eligible under Criteria A, B, and D. The site is not associated with an event or pattern of events (Criterion A). It is not associated with an important person (Criterion B). The site is unlikely to contribute any relevant information to further our understanding of the past (Criterion D).

7. CONCLUSIONS

A recent Yellowstone River channel shift compromised the City of Laurel water intake structure to draw sufficient water from the river on a consistent year-round basis. To alleviate this threat to public health and safety, FEMA proposes the construction of a water intake structure within the main channel of the Yellowstone River upriver from its present location, and the installation of a pair of buried 30-inch diameter water pipelines over a distance of approximately three miles between the proposed new intake location and the City of Laurel water treatment plant.

The cultural resource inventory examined about 73 acres. Four historic sites were identified within the project corridor: two irrigation ditches (24YL0171 and 24YL0172) and two historic homesteads (24YL1991 and 24YL1992).

Site 24YL1992, a historic farmstead, is recommended eligible for NRHP listing under Criterion C. The remaining three sites (24YL0171, 24YL0171 and 24YL1991) are recommended not eligible for NRHP listing (Table 7.1). It should also be noted the current official NRHP eligibility status for site 24YL0171 is unresolved, and for site 24YL0171 is unknown.

The current proposed project alignment crosses the Canyon Creek Ditch (24YL0171) one time and the Clarks Fork Ditch (24YL0172) two times. The final alignment may cross both ditches up to four times. The crossings will involve trenching through the ditches. Both ditches are part of active, operational irrigation systems and will be restored to their pre-trenching condition upon completion of the project.

Sites 24YL1991 and 24YL1992 will not be impacted by the proposed undertaking.

Table 7.1. NRHP Eligibility Recommendations

Site	Township	Range	Section	Site Type	NRHP Recommendation
24YL0171	T2S	R24E	16, 20, 21, 29, 30	Irrigation Ditch	Official status unresolved; recommended Not Eligible
24YL0172	T2S	R24E	20	Irrigation Ditch	Official status undetermined; recommended Not Eligible
24YL1991	T2S	R24E	21	Historic Residence	Recommended Not Eligible
24YL1992	T2S	R24E	21	Historic Farmstead	Recommended Eligible (Criterion C)

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APPENDIX P – PUBLIC NOTICES AND PUBLIC MEETING AGENDA